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# Welfare Gains of Bailouts in a Sovereign Default Model \*

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## Abstract

We examine the welfare effects of bailouts in economies exposed to sovereign default risk. When a government of a small open economy requests a bailout from an international financial institution, it receives a non-defaultable loan of size  $G$  that comes with imposed debt limits. The government endogenously asks for the bailout during recessions and repays it when the economy recovers. Hence, the bailout acts as an imperfect state contingent asset that makes the economy better off. The bailout duration is endogenous and increases with its size. The bailout size creates non-trivial tradeoffs between receiving a larger amount of relatively cheap resources precisely in times of need on the one hand, and facing longer-lasting financial constraints and accumulated interest payments, on the other hand. We characterize and quantify these tradeoffs and document that welfare gains of bailouts are hump-shaped in the size of bailout loans.

**Keywords:** Default, Sovereign Risk, Bailouts.

**JEL Classification:** E44, F32, F34.

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# 1 Introduction

In this paper we analyze the role of bailouts in economies exposed to sovereign default risk. When a government of a small open economy requests a bailout, it receives a one-time loan of size  $G$  from a third-party, an international financial institution (IFI, henceforth). The loan comes with conditions attached to it: the IFI provides loans below the market rate but imposes debt limits on the government. The economy remains in the program until the loan is fully repaid. We address two main questions. First, what are the tradeoffs induced by these bailout policies and how do they vary with the exogenous bailout size,  $G$ ? Second, how do they affect welfare gains of bailouts?

To answer these questions, we develop a quantitative small-open economy model with endogenous default decision, financial frictions, and a non-trivial endogenous bailout choice. We first augment the standard endogenous default decision as in [Arellano \(2008\)](#) with an endogenous bailout decision. Specifically, the government decides to enter in the bailout program by requesting a loan from an IFI. The loan is of a fixed size,  $G$ , and is non-defaultable. While in the program, the country pays a below-market interest rate in each period and faces borrowing restrictions. The restrictions reflect a fiscal conditionality clause imposed on its debt limit, i.e. while the country can still borrow from the market, it cannot increase its debt position. In order to exit the bailout program, the country has to fully repay the loan. Notice that while the country can default on its outstanding external debt, we assume that bailout loans are perfectly enforceable.<sup>1</sup> Hence, in our setting, the bailout is equivalent to a long-term contract, in which the borrower receives all the resources  $G$  at the time she requests the loan, and repays an interest for the duration of the contract; the length of the contract is endogenous, as it depends on when the borrower fully repays the IFI loan.

Let us describe the implications of the existence of the bailout option. There are several forces at play. First, during crisis periods, when borrowing on the market is costly, the government asks for a bailout as it relaxes its budget constraints and allows the government to honor its debt and avoid default. Therefore, in the presence of bailouts, when the country is outside the program, international investors recognize that default risk is smaller and offer a higher price on sovereign bonds. As a consequence, the government can borrow more. Second, bailouts are requested during crisis times, because it is precisely during these periods that they are relatively cheaper than the outside option, market debt, and because they are particularly beneficial to the risk-averse government as they relax its budget constraint. Third, entering the bailout program

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<sup>1</sup>The enforceability assumption is quite standard in the literature that considers loans from international financial institutions (see, for example, [Boz \(2011\)](#) and [Fink and Scholl \(2016\)](#)), and is in line with the empirical evidence provided by [Jeanne and Zettelmeyer \(2001\)](#) who document quite low default risks on loans from international financial institutions.

implies periods of financial constraints and continuous interest payments. The duration of these constraints is directly linked to the bailout loan size,  $G$ . On the one hand, if the bailout loan is small, the intervention period is relatively short, because it is relatively easy to repay this small loan when the economy exogenously recovers. On the other hand, if the bailout loan is large, the intervention period is relatively long, because it is much harder to repay the loan and it takes a much better realization of the exogenous economic conditions for the government to find it optimal to repay it. Notice that, in any case, the bailout mimics, albeit imperfectly, a state-contingent asset: it provides resources in bad times, and is repaid in good times.

In summary, a larger bailout size  $G$  is associated with: *i*) better borrowing conditions when outside the program, as investors expect that the government avoids default in crisis times by requesting bailouts; *ii*) a larger amount of resources available in times of need; *iii*) a longer bailout program, which implies longer-lasting borrowing constraints and higher overall interest payments; *iv*) a larger amount of resources to be repaid. While the first two features are welfare beneficial, the last two are not. The overall welfare effects of the bailouts depend on the magnitude of each of these forces, which are driven by the equilibrium behavior of the economy. We quantify these tradeoffs in a calibrated model.

The forces described above are a function of the fact that, as mentioned, a bailout in our setting is equivalent to a long-term contract between the IFI and the borrower and that its duration is endogenous. This feature is a key difference with respect to [Fink and Scholl \(2016\)](#). In their setting the country decides in each period whether to borrow from the IFI and how much; instead, in our setting, given the amount of the loan,  $G$ , the government decides whether to borrow from the IFI and how long to remain in the program. In other words, while in Fink and Scholl's framework a government decides the size of the IFI loan taking the duration of the program as given (one period), in our framework a government decides the duration of the program taking the size of the IFI loan as given. The fact that the duration is chosen endogenously and depends upon the size of the bailout deeply affects the welfare implications of bailouts by creating non-trivial tradeoffs between receiving larger loans and being locked in the constrained program for longer.

In order to give the model the best chance to incorporate various costs of default, we also augment the model with a financial intermediation channel in order to account for the observed relationship between sovereign spreads and domestic private credit conditions.<sup>2</sup> In particular, we

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<sup>2</sup>The relationship between sovereign spreads and private credit markets is widely recognized in the policy circles. For instance, Mario Draghi, president of the ECB, addressed this issue (Wall Street Journal, 22 February 2012) by highlighting that "Backtracking on fiscal targets would elicit an immediate reaction by the market. Sovereign spreads and the cost of credit would go up". This fact serves as one of the underlying motives for the ECB's 2012 introduction of Outright Monetary Transactions. In addition, Emma Marcegaglia, former president of the General Confederation of Italian Industry, stated that "the spread should decline, otherwise there is a risk of credit freeze to households and businesses" (LaPresse, 11 Nov. 2011).

assume that firms face a working capital constraint on their wage bill as in [Mendoza and Yue \(2012\)](#). To meet the constraint firms must borrow funds from international financial intermediaries (banks) that buy government bonds on the secondary market. These sovereign bond holdings on the banks' balance sheet generate an endogenous relationship between the price of government debt and the interest rate that banks charge to firms, as pointed out by [Gennaioli et al. \(2018\)](#). The model is able to replicate the data in several dimensions, namely default frequency, average sovereign spreads, average private credit rates, etc. As such, the model is suitable for evaluating the effects of bailout interventions, also accounting for how they affect the private credit market.

We show that while different bailout sizes do not alter the long-run average levels of consumption (and labor), they affect their standard deviations. Therefore, the welfare properties of bailouts are mainly driven by how they alter the second moments of consumption. Our main result is that the relationship between welfare gains of bailouts and the bailout size  $G$  is non-monotonic. For relatively small values of  $G$  welfare gains increase substantially with  $G$ . The existence of bailouts improves market conditions, allowing the economy to borrow more and to use asset market as a good buffer against shocks. In addition, during crisis times, small bailouts allow for a good consumption smoothing profile, while not constraining the economy too much as they are easier to repay. In contrast, when  $G$  becomes relatively large, bailouts are still beneficial, but welfare gains decline. As bailouts are generous and cheap, the economy substitutes debt from the market with the IFI loans; however, as it is harder to repay these loans, the economy will be locked in the bailout program for a longer time, which limits its consumption smoothing ability.

In the process of decomposing this result, we show how the peak of the welfare gain, as a function of the bailout size, is associated with: (i) the peak of average borrowing from the market; (ii) the trough of the standard deviation of consumption; and (iii) the peak of the unconditional default frequency. The explanation for these links is the following. The existence of small bailouts leads to a relaxation of the endogenous borrowing limit that characterizes endogenous default models: when bailout option is present, investors understand that, if the government has not yet asked for a bailout, their investment has higher chance to be repaid and, therefore, they offer better financing conditions to the small open economy, which can, then, increase its borrowing. A higher level of borrowing has two implications: first, the borrower can use financial markets at a larger extent for consumption smoothing purposes, and, second, the borrower is more prone to defaults if the economic outlook becomes grim. It turns out that, in our setting, the gains of the former effect are larger than the costs of the latter.

Finally, we provide back-of-the-envelope calculations regarding the size of the amounts offered by the European Financial Stability Facility (EFSF) and European Stability Mechanism (ESM) to Ireland, Portugal and Greece in the recent sovereign crisis. These programs were different from the

traditional International Monetary Fund (IMF) loans in that they were provided at significantly lower rates and longer maturities. In addition, most of the disbursements were front loaded, making our modelling choice of receiving funds all at once at the beginning of the program quite reasonable. The implied ranges for bailout sizes are in line with the values that we consider in our welfare analysis. While for Ireland and Portugal the size of the bailout is rather small, in a range close to the peak of the welfare function, the bailout size for Greece, if read under the lens of our exercise, might have been too large as Greece might be under the conditionality clause for a long time before being able to repay the loan.

**Related Literature** Our paper relates to the growing literature on debt crisis and policy interventions by international financial institutions. In addition to the already mentioned work of [Fink and Scholl \(2016\)](#), our paper relates to [Boz \(2011\)](#) who investigates how the presence of the IFI loans affects the decisions of the sovereign, in a framework where the government can repeatedly borrow from these institutions even when it does not honor its debt to private international creditors. In her framework, fiscal conditionality is accounted for by a higher discount factor in periods when the sovereign is indebted to the international institutions. As in both [Fink and Scholl \(2016\)](#) and [Boz \(2011\)](#), we abstract from the decision-making process of the creditor. This is also similar to [Aguiar and Gopinath \(2006\)](#) who model bailout originating from an unmodeled third party. In their setup, however, the bailout comes in the form of an unconditional transfer, while in our setup bailout comes in the form of a non-defaultable loan and with imposed borrowing regulations, leading to more relevant trade offs. Moreover, a novel finding of our paper relates to the ex-post consequences of a bailout program conditional on the economic performance upon its implementation.

This paper is also related to the work of [Guler et al. \(2014\)](#) and [Hatchondo et al. \(2017\)](#). While the first paper studies bailouts in a two country version of the [Eaton and Gersovitz \(1981\)](#) model, the second paper considers the impact of introducing non-defaultable debt in a standard open economy endogenous default model; while that paper looks at the welfare consequences at the time of an unexpected introduction of bailouts (ex-post analysis), we are concern on the welfare consequences as a function of the bailout size, assuming that there is always full knowledge of the bailout possibility (ex-ante analysis).

Our work also relates to the work of [Corsetti et al. \(2006\)](#), [Roch and Uhlig \(2018\)](#), [Bianchi and Mendoza \(2011\)](#), [Pancrazi and Zavalloni \(2019\)](#), and [Kirsch and Rühmkorf \(2015\)](#) who study the role of official lending in various settings. We also related to [Jeanne and Zettelmeyer \(2001\)](#) who, in a policy oriented paper, discuss the implications of international bailouts and conditionality in relation to moral hazard. More generally, this paper relates also to the literature on strategic default such as [Eaton and Gersovitz \(1981\)](#), [Arellano \(2008\)](#), [Aguiar and Gopinath \(2006\)](#) and

Mendoza and Yue (2012), and to papers that study the impact of different types of debt on the dynamics of sovereign spreads such as Hatchondo et al. (2017). To the best of our knowledge, our paper complements existing literature by analyzing welfare implications of bailouts in economies subject to financial constraints considering realistic tradeoffs arising from fiscal conditionality.

We relate to the literature that studies the impact of spread changes in high leveraged economies, such as Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez, and Uribe (2011) and others. In particular, we highlight the interaction between financial intermediaries and sovereign risk, such as Bianchi (2016) and Acharya et al. (2014). Also, sovereign default and banking crisis have raised the attention of many recent papers in the international macroeconomics literature. For instance, Reinhart and Rogoff (2011) and Gennaioli et al. (2018) conduct empirical studies to uncover the relationship between sovereign debt and banking crisis, using aggregate and cross-country panel data on banks, respectively. In addition, Sosa-Padilla (2018) develops a model where banks are exposed to the risk of sovereign default as they lend both to the government and to the corporate sector. Mallucci (2013) uses a similar model with wholesale funding to study the implications of a relaxation of collateral eligibility requirements by a central bank.

The remainder of the paper is as follows. Section 2 describes the model. Section 3 discusses the calibration and the empirical strategy. Section 4 evaluates the welfare properties of bailouts. Section 5 concludes.

## 2 The Model

This section describes the endogenous sovereign default model that we later use for welfare evaluation. Our framework consists of a small open economy populated by households, firms, and a government. In addition, there are international lenders and financial intermediaries (banks), which are international entities.

### 2.1 Households

Households are identical, risk averse, with the present value of their expected utility given by:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t - g(h_t)).$$

Here  $\beta \in (0, 1)$  is the discount factor,  $c_t$  represents households' consumption in period  $t$ ,  $h_t$  represents labor supply and the term  $-g(h)$  captures disutility of labor.  $\beta \in (0, 1)$  is the discount factor. The utility function  $u(\cdot)$  is strictly concave, strictly increasing, and satisfies the Inada conditions.



We assume a utility function as proposed in [Greenwood et al. \(1988\)](#):<sup>3</sup>

$$u(c, h) = \frac{1}{1-\sigma} \left( c - \frac{h^{1+\zeta}}{1+\zeta} \right)^{1-\sigma}, \quad (1)$$

with  $\zeta$  representing the inverse of the Frisch labor supply elasticity and  $\sigma$  representing the constant relative risk aversion.

Households decide how much to consume and how much labor to supply for an hourly wage of  $w_t$ . They receive government transfers,  $\tau_t$ , and own firms, which distribute profits,  $\pi_t^f$ . Given these assumptions, the budget constraint of the households at any period  $t$  is the following:

$$c_t = h_t w_t + \tau_t + \pi_t^f.$$

## 2.2 Firms

Perfectly competitive firms produce a single good and rent capital and labor services taking all prices as given. The production function is given by:

$$y_t = \varepsilon_t F(k, h_t),$$

where  $\varepsilon_t$  represents an exogenous productivity process,  $y_t$  denotes output and  $F(\cdot)$  satisfies the assumptions of the neoclassical production function. The production function is Cobb-Douglas:

$$Y_t = \varepsilon_t k^\alpha h_t^{1-\alpha}, \quad (2)$$

with  $\alpha$  representing income share of capital. We assume that capital is fixed and owned by the firm.<sup>4</sup> Technology  $\varepsilon_t$  is assumed to follow a mean zero log-normal  $AR(1)$  process.

While the market for capital services is frictionless, the market for labor services is subject to financial frictions in the form of a working capital constraint as in [Neumeyer and Perri \(2005\)](#) and [Mendoza and Yue \(2012\)](#). In particular, firms have to advance a share  $\eta$  of the wage bill at the beginning of the period, before production takes place. Workers receive their full wage bill,  $w_t h_t$ , at the end of the period after production becomes available. Therefore, the firms need to borrow  $\eta w_t h_t$  units of goods at the beginning of each period and repay it at the end. The amount of intra-period borrowing,  $L_t^d$  that is needed to finance working capital constraint is given by:

$$L_t^d \geq \eta w_t h_t.$$

Borrowing above this amount would be suboptimal, because firms need loans only to finance the working capital constraint. This equation, therefore, will always hold with equality. Accounting for this fact, firms' profits are:

$$\pi_t^f = y_t - w_t h_t - r_t^d \eta w_t h_t,$$

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<sup>3</sup>The use of this functional form of the utility function is quite standard in the international real business cycle literature, because the absence of the wealth effect on labor supply prevents models of having counterfactual predictions whereby output increases in default periods. See, for example, [Mendoza \(1991\)](#) and [Mendoza and Yue \(2012\)](#).

<sup>4</sup>We follow [Meza and Quintin \(2005\)](#) and [Mendoza \(2010\)](#), who find that changes in the capital stock play a small role in output dynamics around financial crises.

where  $r_t^d$  denotes the net interest rate that firms face when financing the working capital constraint.

Firms choose labor according to the first order condition:

$$\varepsilon_t F_h(k, h_t) = w_t [1 + \eta r_t^d].$$

This condition equates the marginal product of labor with the marginal cost of hiring an additional unit of labor, which is affected by the degree of financial friction in the private sector,  $\eta$ , and by the private lending rate,  $r_t^d$ , that will be determined on the credit market. The equilibrium level of employment, therefore, will be affected by the conditions on the private credit market. All firms profits are distributed in a lump sum fashion to the households.

## 2.3 Financial Intermediaries

Firms finance the working capital constraint by raising funds from financial intermediaries (banks) who produce within-period loans. In the spirit of [Sosa-Padilla \(2018\)](#) and [D'Erasmus et al. \(2014\)](#), banks hold sovereign debt to fund loans to firms. This setup intends to capture, admittedly in a stylized form, the relationship between banks' holdings of sovereign debt and loans during crisis, as documented by [Gennaioli et al. \(2018\)](#). Specifically, banks are competitive, international, and face an intratemporal profits maximization problem.<sup>5</sup> Since this problem is intratemporal, we omit the time- $t$  subscript in its exposition. In order to keep the financial intermediary environment as stylized as possible we will focus on the production of loans to domestic firms, and consequently we focus on the banks asset position of their balance sheets, rather than on the banks liabilities. We assume that the production function of loans,  $L^s$ , is linear and is given by:

$$L^s = \phi(A + q\Delta),$$

where  $A$  denotes an endowment portfolio of risky assets and  $\Delta$  are the banks' holdings of newly issued sovereign bonds valued by the market at price  $q$ .<sup>6</sup> Hence, one should interpret the two assets as inputs in the production of loans for banks. The parameter  $\phi$  is a technology parameter for the production of loans.

Banks purchase sovereign bonds in the secondary debt market at the beginning of the period (after the government decides to default or not) and sell these bonds at the end of the period in the same market before the government takes the new default/repayment decision. The acquisition of bonds is subject to portfolio adjustment costs. These bonds, however, are part of banks' capital

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<sup>5</sup>The assumption that banks are international implies that their profits are not distributed to the domestic households. Moreover, this assumption is convenient because in this case the planner does not consider the utility of bankers when taking decisions.

<sup>6</sup>As a consequence, there is an implicit physical restriction that  $\Delta \leq |b_{t+1}|$ , where  $b_{t+1}$ , as it will be clear later, denotes the quantity of bonds issued in the current period, as the bank cannot buy more sovereign bonds than the amount that actually exists.

that is used to finance loans.<sup>7</sup> The bank's problem is to maximize its profits,  $\pi_t^b$ , given by:

$$\begin{aligned} \max \pi_t^b &= A + r^d L^s - \Psi(\Delta - \bar{\Delta}), \\ \text{s.t. } L^s &= \phi(A + q\Delta), \end{aligned}$$

where  $\Psi(\Delta - \bar{\Delta})$  denotes portfolio adjustment costs, and  $r^d$  is the rate charged on the loans extended to firms. The optimality condition for this problem is:

$$\phi r^d q - \Psi'(\Delta - \bar{\Delta}) = 0.$$

Assuming a quadratic adjustment cost function,  $\Psi(\Delta - \bar{\Delta}) = \frac{\psi}{2}(\Delta - \bar{\Delta})^2$ , we have:

$$r^d = \psi \frac{L^s - \phi A}{(\phi q)^2} - \psi \frac{\bar{\Delta}}{\phi q}.$$

Notice that the supply of loans depends positively on the price of sovereign bonds,  $q$ ; with favorable conditions on the sovereign credit market (high  $q$ ), there is a large supply of loans, and, as a consequence, the interest rate charged to the firms is low.

In equilibrium, banks' loan supply,  $L^s$ , equals firms' demand for loans,  $L^d$ . Therefore, the equilibrium level of the private loan interest rate when the country is not in default solves the following non-linear equation:

$$r^d = \psi \frac{\eta \left( \frac{\varepsilon(1-\alpha)k^\alpha}{1+\eta r^d} \right)^{\frac{1+\zeta}{\zeta+\alpha}} - \phi A}{(\phi q)^2} - \psi \frac{\bar{\Delta}}{\phi q},$$

where here we have used the functional form for the utility function in equation (1) to compute the optimal labor supply, and for the production function in equation (2) to compute the optimal labor demand.

**Private loan market in default state** We assume that during default the government still allows the bank to keep sovereign bonds on their balance sheet. We do it in the following way: if the government defaults, the existing debt of the government vanishes so intertemporal debt is not available in this scenario. Instead, the government issues a new intraperiod bond that is only sold to the banks at a regulated price  $\tilde{q}$ . As this bond is intraperiod we assume it is sold at the beginning of the period and repurchased by the government at the end of the period, hence, it is not traded in financial markets but appears in the bank's balance sheet. Moreover, it does not have any effect on the budget constraint of the government. This has been shown as an extended practice, to cope with the deterioration of banks' balance sheets, as shown in [Gelpern \(2004\)](#). In practice this is done in several ways; for instance, in the case of Argentina's default in 2001 the government issued new (non-defaultable) debt to financial institutions and allowed banks to book government debt at face value. Although we do not model explicitly how the regulated price is

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<sup>7</sup>[Popov and van Horen \(2013\)](#) point out that the large holdings of government debt securities on the balance sheets of European banks represent a possible source of the link between private credit spreads and sovereign spreads. Additionally, [Gennaioli et al. \(2014\)](#) show that private credit declines because banks' balance sheets are weakened during the crisis due to large holdings of sovereign bonds.

set, this assumption captures the fact that, if a sovereign defaults, banks that hold sovereign bonds on their balance sheet experience a deterioration of their capital, and, therefore, their ability to finance firms becomes more limited. Consequently, given this setting, during default the banks solve a similar problem as in normal times, but the value of government bonds is the regulated price,  $\tilde{q}$ . Hence, in time of default the private loan interest rate,  $\tilde{r}^d$ , becomes:

$$\tilde{r}^d = \psi \frac{\eta \left( \frac{\varepsilon(1-\alpha)k^\alpha}{1+\eta r^d} \right)^{\frac{1+\zeta}{\zeta+\alpha}} - \phi A}{(\phi \tilde{q})^2} - \psi \frac{\bar{\Delta}}{\phi \tilde{q}}.$$

When the regulated price  $\tilde{q}$  is low, the private loan interest rate in default is higher than in non-default times.

As emphasized earlier, the banking sector is given in a stylized form. Our setup is consistent with the one in which the bank keeps its net worth constant distributing its profits, whether positive or negative, to international shareholders. The focus of this paper is to understand the effects of bailout policies, but we introduce banking sector to incorporate an additional channel through which default costs could be amplified; default reduces the amount of loans that banks can provide, which results in a higher private credit interest rate.

## 2.4 International Lenders

Following [Yue \(2010\)](#) and [Arellano \(2008\)](#), we assume that risk-neutral international investors trade one-period government bonds and have access to a risk-free asset with net return  $r > 0$ . When pricing sovereign bonds, they take into account that the government can default on its debt with probability  $\delta_t$ . Given the risk-neutrality assumption, they price sovereign bonds such that they break even in expected terms. Investors demand small open economy bonds  $b_{t+1}$  in order to maximize profits,  $\Phi$ , given by:

$$\Phi = q_t b_{t+1} - \frac{1 - \delta_t}{1 + r} b_{t+1}.$$

Hence, equilibrium bond price will be:

$$q_t = \frac{1 - \delta_t}{1 + r}.$$

The default probability is endogenous and depends on the government's incentives to repay its debt obligation.

## 2.5 Government

The government is benevolent and issues bonds to maximize the utility of households under no-commitment. Given that our economy is standard, we present the centralized problem in recursive form. In each period the government chooses the level of one-period asset holdings,  $b'$ , and has three

options: (i) default on its debt obligations; (ii) repay the debt and issue new debt in international markets; (iii) repay its debt obligation while entering/exiting the bailout program.

Let us first describe the bailout choice. We denote the participation in the bailout program with the state variable  $s = \{0, 1\}$ , where  $s = 0$  denotes that the domestic economy is not in the bailout program and  $s = 1$  denotes otherwise; the endogenous decision of entry and exit from the program determines the evolution of the state variable  $s$ .

**Entry decision** When the government asks for a bailout, in that period the domestic economy receives a loan of size  $G$  from the IFI and it enters in the bailout program. The size of the loan is exogenous and constant. This loan is non-defaultable.

**While in the program** While in the program, the IFI imposes a borrowing constraint on the government such that  $b' \geq b$ , i.e. our conditionality is imposed on the level of external market debt. Notice that the government can still optimally choose to reduce the amount of external debt and deleverage. Furthermore, once in the program, the domestic economy cannot request additional interventions and in each period it has to pay interest on the loan at a given rate  $r^b$ .

**Exit decision** When the government decides to repay the principle of the bailout loan  $G$ , in full, the country exits the program and the restrictive borrowing regime ends.

In summary, in our setting the bailout program assumes the form of a long-term contract between the IFI and the domestic economy. The contract specifies that in the period in which it enters the bailout program the domestic economy obtains the non-defaultable loan upfront; in addition to being financially constrained, the economy has to repay an interest in each period of the program duration. This is the key difference with respect to the setting in [Fink and Scholl \(2016\)](#), where in each period the government can choose an optimal level of one-period IFI loans; instead, in our setting the bailout is extended only once and, therefore, acts as a long-term loan as the interest repayment lasts for several periods if the government chooses to stay in the bailout for longer. Importantly, the length of the program, i.e. the duration of the contract, is chosen endogenously and, as we will show later, will vary with the bailout loan size  $G$ . This effect creates non-trivial tradeoffs.

**Default decision** The consequences of the default decision are in part as conventionally assumed in the literature. In particular, if the government defaults, the country is excluded from financial markets for a random number of periods, experiencing productivity losses which capture the disrupting effects of default in the domestic economy. Because of the presence of the financial

intermediation channel in our framework, while in default, the country also experiences endogenous efficiency losses, equal to  $\tilde{r}^d \eta w h$ , stemming from a high interest rate faced by the private sector. Hence, consumption in default equals:

$$c^{def} = \tilde{y} - \tilde{r}^d \eta w h - sr^b G, \quad (3)$$

where  $\tilde{y} = \varepsilon^{def} F(k, h)$  and  $\varepsilon^{def} = \Gamma(\varepsilon)$ . We assume that  $\Gamma(\cdot)$  is a penalty function as in [Arellano \(2008\)](#).<sup>8</sup> We can, however, afford to have a more slack penalty function than usually assumed in the literature because of the endogenous efficiency losses experienced by the private sector, which we will discuss in more detail later in the calibration section. The last term in the expression above conveys that if the government defaults while in the bailout program ( $s = 1$ ) it still needs to repay the interests on the bailout loan in each period. Alternatively, if the government defaults and is not in the bailout program ( $s = 0$ ), the last term disappears. Regardless of the value of  $s$ , government reenters the international credit markets where the entire past external debt is forgiven with an exogenous probability  $\theta$ . However, it is important to emphasize that when the country does reenter the international credit markets while  $s = 1$ , although external debt is forgiven the bailout debt is not and the borrowing constraint is still in place; hence, the country cannot start borrowing on the international markets again until the bailout loan is fully repaid.

**Options and Belman equations** Here we formally write the options that the government faces.

The optimal value of the government that is *not in a bailout program*, ( $s = 0$ ), is given by:

$$v^o(b, \varepsilon, 0) = \max \{v^c(b, \varepsilon, 0), v^p(b, \varepsilon, 0), v^d(\varepsilon, 0)\},$$

where  $v^c(b, \varepsilon, 0)$  is the government's value function of repaying the external debt without asking for a bailout,  $v^p(b, \varepsilon, 0)$  is the value of repaying its external debt while entering the bailout program, and  $v^d(\varepsilon, 0)$  is the value function of defaulting on the entire amount of external debt.<sup>9</sup>

Instead, the optimal value of the government that *is already in a bailout program*, ( $s = 1$ ), is given by:

$$v^o(b, \varepsilon, 1) = \max \{v^c(b, \varepsilon, 1), v^e(b, \varepsilon, 1), v^d(\varepsilon, 1)\},$$

where  $v^c(b, \varepsilon, 1)$  is the value of repaying the external debt while remaining in the bailout program,  $v^e(b, \varepsilon, 1)$  is the value of repaying the external debt and at the same time repaying the bailout loan, and thus immediately exiting the bailout program, and  $v^d(\varepsilon, 1)$  is the value of defaulting on the entire external debt when being in the bailout program.

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<sup>8</sup>In particular,  $\Gamma(\varepsilon) = \begin{cases} \hat{\varepsilon}, & \text{if } \varepsilon > \hat{\varepsilon} \\ \varepsilon, & \text{if } \varepsilon \leq \hat{\varepsilon} \end{cases}$ , where  $\hat{\varepsilon} = \gamma E(\varepsilon)$ .

<sup>9</sup>Notice that when in default the asset level is zero, as the country has defaulted on its entire debt.

The value function of repaying the debt while not asking for a bailout is:

$$\begin{aligned} v^c(b, \varepsilon, 0) &= \max_{b'} u(c(b, \varepsilon, 0), h) + \beta \mathbb{E}[v^o(b', \varepsilon', 0)], \\ \text{s.t. } c(b, \varepsilon, 0) &= y - r^d \eta w h + b - q(b', \varepsilon, 0) b', \\ s' &= 0. \end{aligned}$$

With this notation, we emphasize that the amount of consumption in the economy is a function of the state variables  $b$ ,  $\varepsilon$ , and  $s$ .<sup>10</sup> The second term on the right hand side of the budget constraint represents the resource cost to the economy resulting from the working capital constraint that firms face.

The value function of repaying the debt while asking for a bailout is:

$$\begin{aligned} v^p(b, \varepsilon, 0) &= \max_{b' \geq b} u(c^p(b, \varepsilon, 0), h) + \beta \mathbb{E}[v^o(b', \varepsilon', 1)], \\ \text{s.t. } c^p(b, \varepsilon, 0) &= y - r^d \eta w h + b - q(b', \varepsilon, 1) b' + G, \\ s' &= 1. \end{aligned}$$

The value of repaying the debt while staying in a bailout program is as follows

$$\begin{aligned} v^c(b, \varepsilon, 1) &= \max_{b' \geq b} u(c(b, \varepsilon, 1), h) + \beta \mathbb{E}[v^o(b', \varepsilon', 1)], \\ \text{s.t. } c(b, \varepsilon, 1) &= y - r^d \eta w h + b - q(b', \varepsilon, 1) b' - r^b G, \\ s' &= 1. \end{aligned}$$

Notice that asking for a bailout relaxes the government budget constraint, as it receives a transfer of resources equal to  $G$ . Also, when staying in the bailout program, no new transfers of resources occur, but for the entire duration of the bailout the economy must reduce its stock of debt, since the optimal asset level  $b'$  must satisfy  $b' \geq b$ , and it must repay the interest rate  $r^b$  on the loan received.

The value of exiting the program is:

$$\begin{aligned} v^e(b, \varepsilon, 1) &= \max_{b'} u(c^e(b, \varepsilon, 1), h) + \beta \mathbb{E}[v^o(b', \varepsilon', 0)], \\ \text{s.t. } c^e(b, \varepsilon, 1) &= y - r^d \eta w h + b - q(b', \varepsilon, 0) b' - (1 + r^b)G, \\ s' &= 0. \end{aligned}$$

Notice that when exiting the program, the country needs to repay the principle  $G$ , in addition to the interest.

Finally, the default values are given by

$$\begin{aligned} v^d(\varepsilon, 0) &= u(c^{def}(0, \varepsilon, 0), h) + \beta \mathbb{E}[\theta v^o(0, \varepsilon', 0) + (1 - \theta)v^d(\varepsilon', 0)], \text{ with } s' = 0, \\ v^d(\varepsilon, 1) &= u(c^{def}(0, \varepsilon, 1), h) + \beta \mathbb{E}[\theta v^o(0, \varepsilon', 1) + (1 - \theta)v^d(\varepsilon', 1)], \text{ with } s' = 1, \end{aligned}$$

where  $\theta$  is the exogenous probability of leaving financial autarky. The two default value functions

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<sup>10</sup>Obviously, also the other endogenous variables, such as hours worked,  $h$ , wages,  $w$ , private credit rate,  $r^d$ , and savings,  $b'$ , are all functions of the three state variables. We omit this link in the notation for simplicity.

differ because the government that defaults on its international debt while in the bailout program ( $s = 1$ ) will still pay the interest on the loan, as displayed in equation (3) and will still be borrowing constrained when it exogenously reenters the financial markets until it pays the third-party loan. This is because the government can default on its international debt but not on its third-party bailout loan.

### 3 Empirical Strategy

This section presents the calibration and assesses the ability of the model presented in Section 2 to match various aspects of the data. Our strategy is to initially calibrate the model without the bailout option by imposing  $G = 0$ , and, then, to introduce bailouts in order to evaluate their welfare effects. This approach is motivated by the fact that we base our calibration on historical data that correspond to periods in which the bailout option was arguably unexpected.<sup>11</sup> We now describe the calibration of the full model without the bailout option and document that our model can successfully replicate the data. It will then be used as a laboratory to study the welfare properties of bailouts.

#### 3.1 Output, Interest Rates, and Default Statistics in GIIPS economies

Before we explain in detail the values of calibrated parameters, we document some statistics pertaining to output, sovereign and private interest rates, and to historical default episodes in GIIPS economies (Greece, Ireland, Italy, Portugal, and Spain) that will prove useful for our calibration exercise.

We first calculate the standard deviation and first-order autocorrelation of cubically detrended quarterly per capita real output in the five GIIPS economies during the 1960:Q1 - 2008:Q4 period. We follow Garcia-Cicco et al. (2010) when removing a cubic trend, but the moments are similar when a linear or quadratic trend is removed instead.<sup>12</sup> As displayed in Table 1, in all five economies output is highly persistent with similar levels of volatility. The average standard deviation and autocorrelation of the cyclical component of GIIPS GDP are 5% and 0.94, respectively.

To capture movements in the financial markets before and during the crisis period, we consider the time period 2003:Q1 - 2007:Q4 as the pre-crisis period, and 2008:Q1 - 2012:Q4 as the crisis period and we compute sovereign spreads and private credit rate in the two subperiods.<sup>13</sup> The

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<sup>11</sup>In addition, it can be argued that even the loans extended by EFSF/ESM in recent sovereign debt crisis, which motivates our work, were not at all anticipated, because of the explicit no-bailout clause in the EU laws at the time when the two institutions were established.

<sup>12</sup>Moments are also similar even if we include the crisis period.

<sup>13</sup>We choose the beginning of 2008 as a cutoff point because this is clearly when the spreads on sovereign bonds



Table 1: Output moments

	Greece	Ireland	Italy	Portugal	Spain	Average
$\rho(y)$	0.85	0.97	0.93	0.98	0.97	0.94
$\sigma(y)$	0.05	0.06	0.02	0.06	0.04	0.05

Note:  $\rho(y)$  denotes the first order autocorrelation and  $\sigma(y)$  denotes the standard deviation of the log of the cyclical component of output; the cyclical component is obtained by removing the cubic trend. We use quarterly real output per capita of Greece, Ireland, Italy, Portugal, and Spain during the 1960:Q1 - 2008:Q4 period.

spreads on sovereign bonds are calculated as the difference between the interest rate on 10-year bonds of GIIPS economies and 10-year German bonds. The German bonds are considered to be safe as they remained stable during the entire period, with the average of quarterly real interest rate of 0.69% over the 2003 - 2012 period. While before the crisis period the spreads on GIIPS bonds were quite low (averaging 0.07%, annualized), they started to increase rapidly during the crisis period (averaging 3.17%, annualized). In the same period, private credit rates rose from 1.65% to 2.03%. We will calibrate the parameters of the financial sector in the model such that the model will be able to capture this observed dynamics.

We also calculate some key statistics regarding the default episodes in Europe using the historical data of the last 200 years. In particular, we use the evidence provided in [Reinhart and Rogoff \(2009\)](#).<sup>14</sup> Table 2 displays the number of default episodes, the quarterly probability of a default episode, the share of periods that the economy spent in default relative to the total quarters in our sample, and the average length of a default episode. Based on this data we calculate the average probability of default per quarter across the five economies to be 0.64 percent, and the average length of default to be 30 quarters.<sup>15</sup>

## 3.2 Calibration

We set the model to a quarterly frequency and base our calibration largely on data for Greece, Ireland, Italy, Portugal, and Spain. Table 3 displays the calibrated parameter values.

A subset of parameters is calibrated by following the existing literature. Specifically, the relative

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started to rise.

<sup>14</sup>In their framework, a default episode is defined as follows: “A sovereign default is defined as the failure of a government to meet a principal or interest payment on the due date (or within the specified grace period). These episodes include instances in which rescheduled debt is ultimately extinguished in terms less favorable than the original obligation.”

<sup>15</sup>Most of the quantitative studies on sovereign default focus on using data from Argentina, which defaulted two times in last 40 years. However, none of the countries in our sample defaulted during this period, which is why we need to rely on the historical data. However, one might be worried that default episodes are being restructured much faster now than 50 years ago, and that a long exclusion period of 30 quarters makes the default very painful and, consequently, bailouts very attractive. To address this concern we have conducted the main exercise of the paper using an exclusion of 15 periods and the results do not substantially change. The reason is that a shorter exclusion also implies higher default incentives, which makes bailouts still beneficial because they reduce default risk, as we illustrate in the next section.

Table 2: Default statistics

	Greece	Ireland	Italy	Portugal	Spain	Average
Default episodes	5	0	1	6	13	
Frequency default per quarter (%)	0.70	0	0.17	0.71	1.64	0.64
Average length of default	72	N.A.	20	14	14.36	30

Note: Greece (1832-2009), Ireland (1919-2009), Italy (1861-2009), Portugal (1800-2009) and Spain (1812-2009). Statistics are in quarters. Default statistics are taken from [Reinhart and Rogoff \(2009\)](#).

risk aversion parameter  $\sigma$  is set to 2, which is standard in quantitative business cycle and sovereign default studies. The utility parameter associated with labor supply,  $\zeta$ , is set to 2.66, which implies a value of Frisch labor supply elasticity in line with the micro evidence documented by many authors (see, for example, [Altonji \(1986\)](#), [Chetty et al. \(2011\)](#) and [Peterman \(2016\)](#)), and also consistent with macro models as in [Martinez-Garcia et al. \(2012\)](#) and [Rotemberg and Woodford \(1999\)](#). The capital share in the Cobb-Douglas production function is set to 0.32, a value standard in the literature. The endogenous labor supply that is affected by the presence of the financial friction implies some endogenous default cost. This cost, however, is not sufficient to reproduce the observed drop in output during default episodes, which is why we assume an additional exogenous default penalty. However, this penalty is quite slack, captured by the parameter  $\gamma$  set to 1. We refer to this value as being slack, because it is usually set to a lower value in the quantitative studies of sovereign defaults. For example, in [Arellano \(2008\)](#) this value is 0.96.

The rest of the parameters are chosen to match a set of moment conditions from the data. The autocorrelation and the standard deviation of productivity shocks,  $\rho_\varepsilon$  and  $\sigma_\varepsilon$ , are calibrated to match the average GIIPS GDP statistics reported in Table 1 above. The discount factor,  $\beta$ , and the probability of re-entering the asset markets,  $\theta$ , are calibrated to match the observed default statistics across GIIPS economies reported in Table 2. In particular, the former is chosen to match the average default frequency, and the later is chosen to match the average length of default. Although the value of  $\beta$  that is needed to match the observed default frequency is low, it is similar to the values used in the literature, for example 0.8 in [Aguiar and Gopinath \(2006\)](#) and 0.88 in [Mendoza and Yue \(2012\)](#). As pointed out by Mendoza and Yue, one can justify these lower values of  $\beta$  by arguing that government experiences higher rates of time preference because of political economy incentives. The risk-free interest rate  $r$  is set to match the quarterly real interest rate on 10-year German bonds considered above, which is 0.69%.

The parameter  $\eta$  which determines the size of firm loans is calibrated to 0.3. This value ensures that the model generates an average debt service burden of the private firms as a percentage of their operating surplus around 60 percent, a target in line with the data counterpart for EU countries

during our sample.<sup>16</sup> This value is on the lower side of the values assumed in the literature, therefore assuring that our welfare analysis of bailouts is not biased by assuming too strong financial frictions. For instance, the benchmark specification of [Neumeyer and Perri \(2005\)](#) requires that the entire wage bill must be paid before final output is available, implying  $\eta = 1$ , while [Mendoza and Yue \(2012\)](#) set their share of import goods that has to be paid using working capital to 0.7.

Table 3: Baseline calibration

<i>Calibrated Parameters</i>		<i>Value</i>	<i>Target statistics</i>
Relative risk aversion coefficient	$\sigma$	2	Standard RBC value
Utility parameter with labor supply	$\zeta$	2.66	Frisch wage elasticity
Capital share	$\alpha$	0.32	Standard capital share in GDP
Default penalty	$\gamma$	1	Slack default penalty
<i>Parameters Chosen To Match Targets</i>		<i>Value</i>	<i>Targets from data</i>
TFP persistence	$\rho_\varepsilon$	0.95	GIIPS GDP autocorrelation
Std. deviation of the TFP shock	$\sigma_\varepsilon$	0.045	GIIPS GDP std. deviation
Intertemporal discount factor	$\beta$	0.887	Default frequency
Prob. of re-entering asset markets	$\theta$	0.033	Average length of default
Risk-free interest rate	$r$	0.0069	Real interest rate on 10-year German bonds
Working capital constraint coef.	$\eta$	0.3	Debt service burden of non-financial corporations as a percentage of the surplus
Regulated price in default	$\tilde{q}$	0.78	Private credit rate in default
Adjustment cost parameter, slope	$\psi$	40.08	{ crisis and pre-crisis average private credit spreads crisis and pre-crisis average sovereign spreads correlation bw private and sovereign spreads pre-crisis private credit spread std dev
Adjustment cost parameter	$\bar{\Delta}$	0.0025	
Bank endowment	$A$	0.0012	
Loan Production Technology	$\phi$	20	

The financial sector parameters, namely  $\psi$ ,  $A$ ,  $\phi$ , and  $\bar{\Delta}$ , are calibrated by taking into account the statistics regarding private and sovereign interest rates reported above. In particular, the four parameters are calibrated jointly to obtain reasonable ranges for: average private credit and sovereign spreads in the pre-crisis and crisis periods, their correlation, and the private credit spread standard deviation in non-crisis period.<sup>17</sup> Finally, the regulated bond price in time of default,  $\tilde{q}$ , is set to 0.78. This value guarantees that the private credit rate in times of default is not extremely

<sup>16</sup>Data Source: ECB, and *ECB Monthly Bulletin, February 2012*. The series used is the debt service burden of non-financial corporations as a percentage of the gross operating surplus. The model counterpart of the debt burden is the working capital constraint paid by the firms. The ratio of this debt burden and the operating surplus of the firms is then given by  $\eta w_t h_t / (y_t - w_t h_t)$ .

<sup>17</sup>To compute moments, we discretize the exogenous process for total factor productivity using 41 nodes, following the procedure proposed by [Tauchen \(1986\)](#). In the same spirit as [Arellano \(2008\)](#), we discretize the asset space using 300 nodes and we simulate the economy over one million periods. Given the simulated data, we identify the default episodes and compute the average duration of default, the default frequency, and the share of quarters in default. We use all the subsamples of at least 275 quarters that do not contain default episodes to compute all the relevant moments. As already discussed, for the data moments, the “pre-crisis” period refers to the period between 2003:Q1 to

large, around 9 percent annualized. This seems a reasonable bound since the private credit rate was around 7.5 percent in Greece when, despite a very high sovereign spread (35 percent), it was not in default.

Table 4 reports empirical and theoretical moments. Our model-generated default episodes on average match well the ones observed in GIIPS countries. The model also replicates the relevant asset prices in the model. Although the pre-crisis average private credit spread is larger than in the data, it is important that the model can capture the increase in that spread during the crisis period, reflecting the tightening conditions on the domestic lending markets. At the same time, the model can replicate quite well the correlation between the sovereign and private credit spreads. Finally, the last row of the table reports the impact of financial frictions in the economy, by computing the amount of resources that are lost due to the presence of the working capital constraint, i.e.  $r_t^d \eta w_t h_t$  as a percentage of output.

Table 4: Data and Model Moments

Moments	Data	Model
<i>Output</i>		
$\rho(y)$	0.94	0.95
$\sigma(y)$	0.05	0.05
<i>Default</i>		
Average duration of default (quarters)	30	30
Default frequency (% , quarterly)	0.64	0.67
<i>Asset Prices</i>		
Average sovereign spread (% , annualized)		
- pre-crisis	0.12	0.07
- crisis	4.11	3.12
Average private-credit spread (% , annualized)		
- pre-crisis	0.55	1.65
- crisis	2.05	2.03
Pre-crisis private-credit spread st. dev. (%)	0.40	0.30
Private-credit and sovereign spread correlation	0.7	0.5
<i>Loans and Output Loss</i>		
Ratio of private debt service burden to surplus	0.60	0.64
Average output loss from financial friction(% of output)	-	0.27

Note: All moments except average sovereign spread, in both periods, are targeted.

## 4 The Effects of the Bailout Program

Having a model that is able to capture the empirical evidence regarding default, sovereign and private interest rates reasonably well, we now introduce the additional option of requesting a

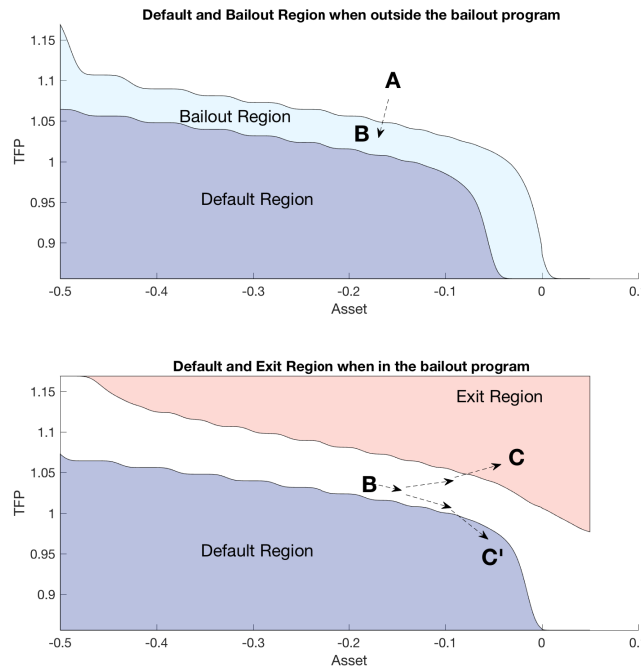
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2007:Q4, while the “crisis” period refers to the post-2008 period (from 2008:Q1 to 2012:Q4). For the model moments, the “pre-crisis” period refers to the subsample for which the spreads are below the average maximum spread level registered before 2008, equal to 0.28 percent. All the interest rates and spreads are annualized both in the model and in the data.

bailout. Two parameters characterize the bailout policy intervention: the size of the loan,  $G$ , and the interest rate on this loan,  $r^b$ . We assume that the latter is equal to the risk-free interest rate; hence a bailout is technically a loan from a third party that is surely not more expensive than the market debt. Regarding the bailout size  $G$ , our approach is to consider a range of different values in order to understand bailout costs and benefits as a function of the size. We will show that the overall net gain from bailouts is a non-trivial function of the size; hence, the goal of this section is to clearly explain the tradeoffs. At the end of this section, we will show that the ranges of bailout size that we consider are indeed in line with the financial assistance that troubled economies requested from EFSF/ESM.

## 4.1 Bailout, Exit, and Default Regions

Figure 1: Repayment, default and intervention sets

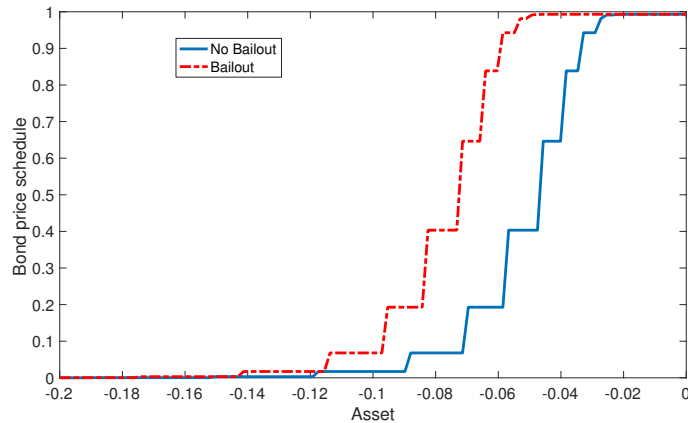


Note: The top panel represents the combinations of assets and TFP that determine the optimal default and intervention sets in an economy that is not in the bailout program ( $s = 0$ ), but has an option of asking for it. The dark blue area represents the default region, the light blue area represents the bailout region, and the white area represents the continuation region in which the economy decides to repay its debt. The bottom panel represents the optimal regions when the economy is already in the bailout program ( $s = 1$ ). The dark blue area represents the default region, the white area represents the continuation region in which the economy remains in the program, and the red area represents the region in which the economy chooses to exit the bailout program. The arrows connecting A, B, C and C', illustrate possible directions in which the economy moves.

In Figure 1 we first illustrate the optimal choices when the bailout option is introduced in the model as a function of the three state variables. The top panel shows, in the space  $(b, \varepsilon)$ , the default (dark blue) and bailout (light blue) regions conditional on not being in the bailout program

( $s = 0$ ). As the figure suggests, the economy honors its debt without asking for a bailout during good times, characterized by low debt and relatively high TFP levels. The economy asks for a bailout when debt levels become relatively high and/or when TFP becomes relatively low; this is illustrated, as an example, by the transition from point A to point B. Finally, the economy defaults when the economy performs badly along both dimensions. Importantly, the existence of bailouts, which leads to the creation of a bailout region, contributes to the shrinking of the default region with respect to a model without bailout. This is because investors understand that the availability of bailouts decreases default risk, if the borrower has the option to request them, and therefore, they are willing to offer loans to the government at better conditions when it is outside the bailout program. To demonstrate this point, in Figure 2 we plot the bond price schedule in a model without (solid blue line) and with (dashed red line) bailouts, conditional on a given realization of TFP and on being outside the bailout program ( $s = 0$ ). The fact that the bond price schedule in a model with bailouts is above the one in a model without bailouts reflects the fact that the default region in the former scenario is smaller.

Figure 2: Bond price schedule



Note: The dashed red line plots the bond price schedule in a model with a bailout option; the solid blue line plots the bond price schedule in a model without this option. Both schedules are conditional on being outside the bailout state ( $s = 0$ ) and on a TFP realization equal to  $\varepsilon = 0.975$ .

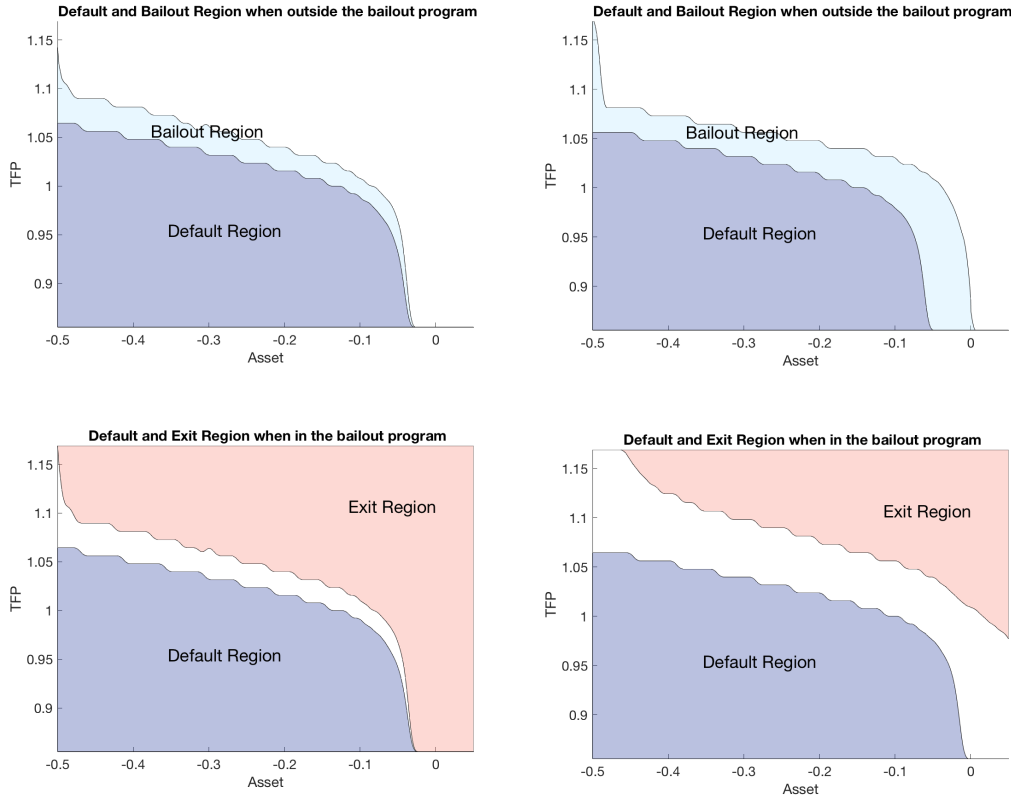
The bottom panel of Figure 1 shows the optimal option sets conditional on already being in the bailout program ( $s = 1$ ). Since additional bailouts are not feasible when a country is already in the bailout program, the bailout set is empty by construction. Nevertheless, in addition to choosing to remain in the bailout program (white region), the government can still choose to default (dark blue region) or to exit from the bailout program (red region). When already in the program, the country is forced to deleverage and whether it exits the program or not depends on the realization of TFP - it exits the program only when economic conditions improve, as illustrated by the transition from point B to point C. Because the economy cannot request additional bailouts when already in the

program, the deleveraging force puts even more strain on the economy if the TFP does not improve; this is reflected in the larger default region when in the program (bottom panel) than when outside the program (top panel). If TFP worsens substantially, the economy will default even when in bailout state, as illustrated by the transition from point B to C'.

Figure 3: Repayment, default and intervention sets

(a) Small bailout

(b) Large bailout



Note: The top panel represents the combinations of assets and TFP that determine the optimal default and intervention sets in an economy that is not in the bailout program ( $s = 0$ ), but has an option of asking for it. The dark blue area represents the default region, the light blue area represents the bailout region, and the white area represents the continuation region in which the economy decides to repay its debt. The bottom panel represents the optimal regions when the economy is already in the bailout program ( $s = 1$ ). The dark blue area represents the default region, the white area represents the continuation region in which the economy remains in the program, and the red area represents the region in which the economy chooses to exit the bailout program. The left panel displays the regions associated with a small  $G$ , equal to 0.005; the right panel displays the regions associated with a large  $G$ , equal to 0.02.

As we mention, the goal of this section is to clearly illustrate how the tradeoffs faced by the government change as a function of the bailout size,  $G$ . Therefore, in Figure 3 we display how the default, intervention, and exit regions get affected when moving from a small  $G$ , left panel, to a large  $G$ , right panel. When bailouts are generous, the default region conditional on being outside the program shrinks (comparing the dark regions in the right top panel to the one in the left top panel), as asking for a bailout becomes preferable to defaulting; consequently, the bailout region

expands.

One might think that more generous transfers and smaller default regions must imply that larger bailouts are always more beneficial. However, one should also consider the costs associated with larger bailouts. First, as these loans are non-defaultable, the government will have to repay a larger loan to exit the bailout state, which, recall, has financial constraints attached to it. Second, the government has to pay an interest, which we assume is equal to the risk-free rate, in each period while the bailout intervention lasts. The overall cost of a bailout, therefore, depends on the duration of the bailout state. As it is harder to repay big loans, a larger  $G$  is associated with a much smaller exit region (comparing the lighter regions in the right bottom panel to the left bottom panel); intuitively, a government can afford to repay a larger loan only when exogenous economic conditions are particularly good. This implies that the region in which the government remains in the bailout (the central white region in the bottom panels) is bigger with more generous bailouts. In this region the government faces both the monetary cost of bailout (the interest that it has to pay to the third party) and the cost of being financially constrained. Therefore, when income declines further, which is exactly when the country would like to increase its borrowing, being tied to the bailout region is not desirable.

## 4.2 Equilibrium dynamics: an example

The analysis of bailout, exit, and default regions, conditional on the bailout size, is informative to illustrate the tradeoffs generated by different bailout sizes, but to properly assess the magnitudes of the bailout costs and benefits one should analyze which part of the state space the economy transits into more frequently; this dynamics obviously varies with the bailout size. Therefore, to further investigate the implications of different bailout sizes, in Figure 4 we fix the evolution of the exogenous TFP component to a specific path and we illustrate the different equilibrium behavior of a model without a bailout option (solid blue line), with a small bailout option (dashed red line, left panels), and with a large bailout option (dashed red line, right panels). To illustrate the main tradeoffs we assume that the exogenous TFP process is such that it generates a recession and then a recovery of output (first row) and we then compute the evolution of bond prices (second row), debt levels (third row) and consumption (forth row) for that trajectory of output.<sup>18</sup> The shaded yellow area represents the intervention period in the model with a bailout option.

There are four main results worth noticing; first we will list them and then we will explain them.

(i) When outside the bailout region, debt is higher in a model with a bailout option, but the

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<sup>18</sup>The first row reports the evolution of output, although the exogenous process that drives the economy, and whose realizations we fix for the exercise, is the one for TFP. As TFP is the main determinant of output, the two dynamics are substantially similar and therefore we do not report its evolution.



bond price is very similar; as a consequence, the country can enjoy higher consumption. This effect increases with the bailout size.

- (ii) When output declines further, in period 4, the bond price declines, making the borrowing from the international market more expensive. Therefore, in that period, the government asks for a bailout and it receives a loan. Total debt (dotted green line in the third panel) increases above market debt from international investors (dashed red line) because the government is now also indebted to the IFI. Receiving the loan in period 4 allows the country to consume more than in a model without bailout, as the loan relaxes the government's budget constraint. Also this effect increases with the bailout size.
- (iii) While in the bailout the economy is financially constrained as it cannot increase its debt, limiting the ability of the government to further increase its consumption using international debt market. Larger total than international market debt reflects the fact that the government has yet to repay the IFI loan.
- (iv) The duration of the bailout state depends on the size of the bailout. When the recession reaches its trough and it stabilizes (period 7), if the loan is small (left panel), the country repays it. Repaying the loan cuts resources for consumption in that period, but it also ends the financial restrictions: the economy continues to borrow from the market at better conditions which, in turn, fuels consumption. In contrast, if the loan is large (right panel) output has to increase further to incentivize the government to repay the larger loan. This means that the country is financially constrained for a longer period, and its consumption is lower than in a model without bailout. It is only after output finally becomes large enough (period 11) that the country repays the large loan and starts borrowing large amounts to fuel its consumption.

We now provide intuition for these equilibrium outcomes. First, when outside the bailout state, the existence of a bailout option allows the economy to borrow more from the market, as illustrated in point (i); this feature reflects the fact that, conditional on being outside the program, default regions are smaller when bailouts are larger. Consequently, as already presented in Figure 2, investors offer better price schedule to the government, which can then decide to borrow more (with respect to a model without bailouts) at a similar price. Hence, when outside the program, the mere existence of a bailout option increases the ability of the government to borrow from the market and enjoy higher consumption.

Second, when the government asks for a bailout it receives a loan of size  $G$ . The loan allows the government to keep a higher consumption profile in period 4 than it would have absent the

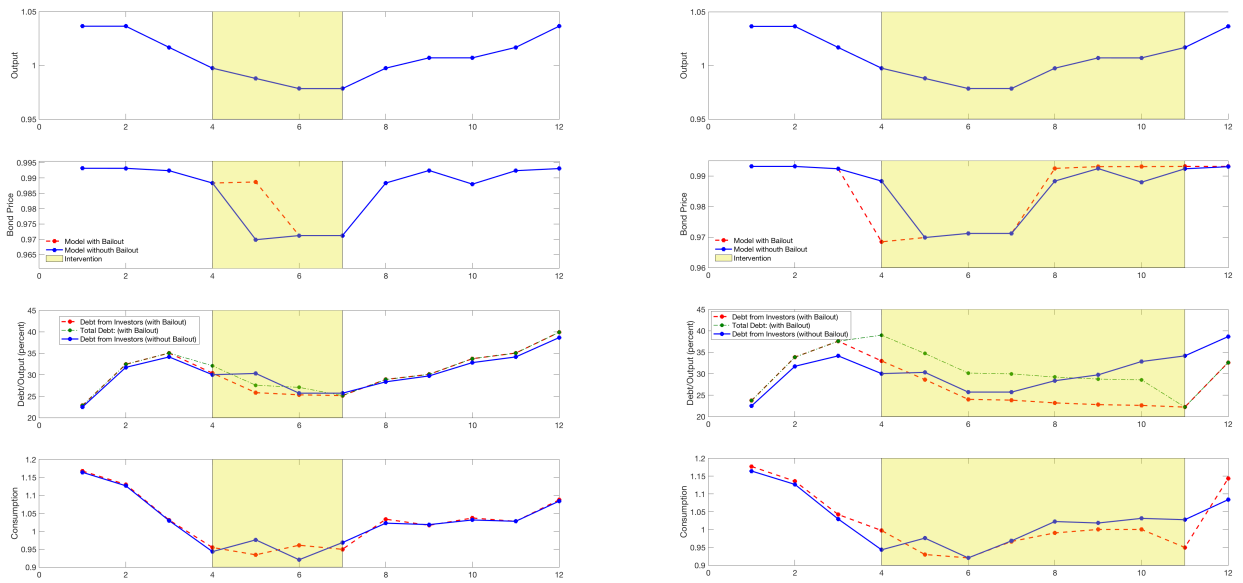
bailout option.<sup>19</sup> This is because the bailout loan, when received, relaxes the government budget constraint. Notice that, in equilibrium, bailouts are asked in crisis periods, when output is low. Hence, point (ii) illustrates the insurance properties inherent in the bailout loan: the country receives new resources in times of declining output, and repays them in times of increasing output.

Third, the bailout option, however, comes with a conditionality clause attached to it: debt cannot increase. This property forces the government to deleverage at a higher rate than in a model without bailout, as explained in point (iii).

Figure 4: Equilibrium dynamics with small and large bailouts

(a) Small  $G$

(b) Large  $G$



Note: The figure shows the evolution of bond prices, debt levels, and consumption in two economies - an economy with a bailout option (red dashed line) and an economy without a bailout option (blue solid line). The left panel represents a scenario when the bailout size  $G$  is small, while the right panel represents a scenario when the bailout size  $G$  is large. The shaded yellow areas represent periods when the economy with a bailout option is in the bailout program ( $s = 1$ ). Finally, the green dotted line in the third row represents total debt of the economy, which corresponds to the sum of the market debt from investor plus the outstanding debt with the IFI. The difference is, therefore,  $G$ .

Forth, the duration of the bailout program depends on how costly it is to repay the loan. To repay larger loans, the economy requires better exogenous economic conditions, which lengthens the duration of the bailout state, as explained in (iv). Longer bailouts financially constrain the economy at a larger extent, making it less able to finance its consumption with new debt issuance than in the model without bailouts. This feature is directly linked to the exit regions that are decreasing with bailout size, as demonstrated in Figure 3.

<sup>19</sup>The resources from the bailout are not all consumed in period 4, as the government transfers part of them to future periods by decreasing its stock of debt.

In summary, bailouts generate nontrivial tradeoffs that are driven by different forces implied by bailout loan size on the one side, and the sacrifices needed to repay that loan on the other side. In particular, a smaller bailout loan implies smaller amount of resources available in times of need, but, because they are easier to repay, also shorter-lasting financial constraints. Vice-versa, a larger loan secures larger resources in times of need, but also imposes longer-lasting financial constraints; these longer constraints paired with larger interest payments accrued make repayments of larger loans much more challenging. The welfare analysis of the model with bailout is, therefore, a non-trivial function of the bailout size as we illustrate in the next section.

### 4.3 Quantitative Implications and Welfare

We first compute the welfare gains brought about by the existence of bailouts, as a function of the bailout size  $G$ . We measure welfare in terms of consumption equivalent net of disutility of labor.<sup>20</sup> For several values of  $G$ , we compute the value of  $\lambda(G)$ , which corresponds to percentage increase in consumption, net of disutility of labor, in any state and time, that an agent in a model without a bailout option,  $NB$ , should be given to achieve the same utility as an agent in a model with bailouts of that given size,  $B(G)$ , keeping labor at the equilibrium levels of the two models:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U(c_t^{B(G)}, h_t^{B(G)}) = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t U^{NB}(c_t^{NB}, h_t^{NB}, \lambda(G)). \quad (4)$$

where,  $U^{NB}(c_t^{NB}, h_t^{NB}, \lambda(G)) = (1 + \lambda(G)) \left( c_t^{NB} - \frac{(h_t^{NB})^{1+\zeta}}{1+\zeta} \right)$ .

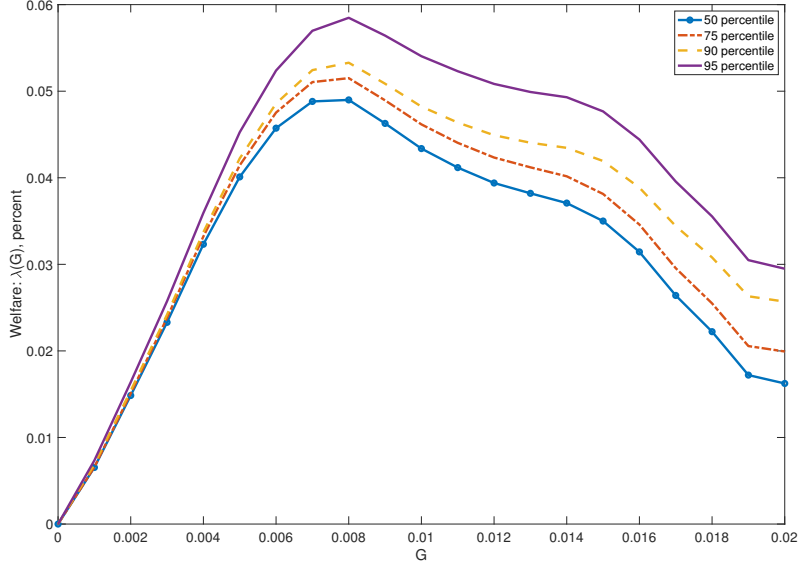
Figure 5 plots the function  $\lambda(G)$ , in percent.<sup>21</sup> Each line display the welfare gain for a different starting value of the initial debt, assumed to be at the 50th, 75th, 90th, and 95th percentile of the equilibrium distribution of debt simulated from a model without bailouts.

There are three main observations worth pointing out. First, regarding the magnitude, welfare gains of bailouts are quite small. As it will be clear in the rest of the section, bailouts do not change consumption (and labor) levels, but only affect their second moments; hence, in our setting welfare calculations have the same drawbacks as pointed out in Lucas (1987). Second, welfare gains are increasing with larger initial debt; this is intuitive, because, in that case, the government is more likely to request a bailout and the economy gains from having the additional option to the standard model without bailouts. Third, and most importantly, the welfare gain of bailouts is a non-monotonic function of  $G$ . Gains are increasing for small bailout sizes, and then, after reaching a peak, they monotonically decrease with size. In what follows we provide a rationale behind this result.

<sup>20</sup>See Durdu et al. (2013) and Fink and Scholl (2016).

<sup>21</sup>In order to compute welfare expectations we run the simulations in each model 5000 times, for 1000 periods.

Figure 5: Welfare Gains of bailouts

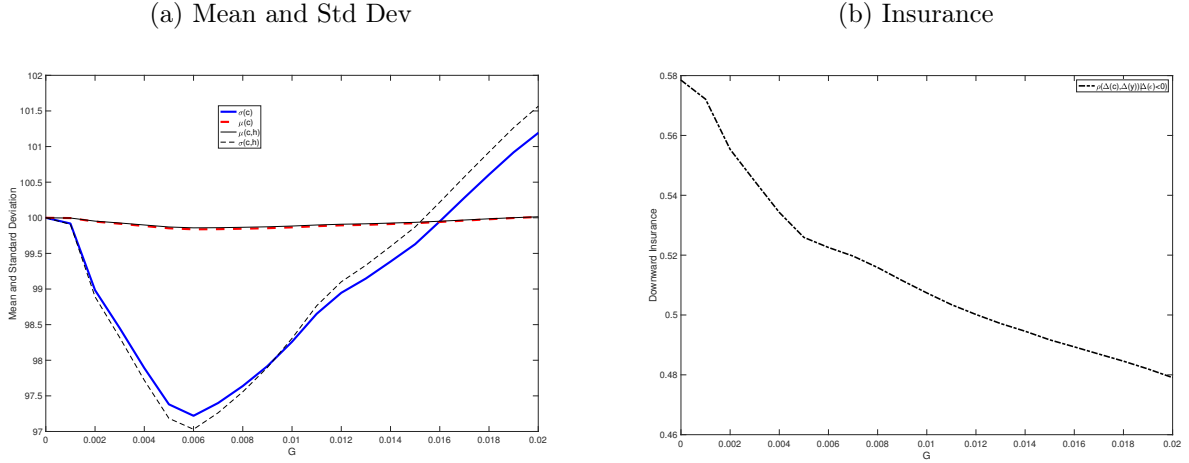


Note: The figure plots the welfare gains of bailouts, as a function of the bailout size  $G$ . Welfare is measured in terms of consumption equivalent net of disutility of labor (in percent). The different lines are related to different initial debt levels assumed to be at the 50th, 75th, 90th, and 95th percentile of the equilibrium distribution of debt simulated from a model without bailouts.

#### 4.4 Consumption mean, standard deviation, and insurance

The function  $\lambda(G)$  is driven by the properties of the equilibrium consumption path that vary with the size of  $G$ . Intuitively, there are three features of consumption that affect welfare: *(i)* consumption levels, summarized by its mean; *(ii)* consumption volatility, as risk averse agents prefer smooth paths of consumption; and *(iii)* the ability of the government to buffer negative income shocks so that, when large negative income shocks occur, it does not need to abruptly adjust consumption. Notice that while *(ii)* and *(iii)* are related they are not equivalent. In fact, while the standard deviation of consumption captures the unconditional symmetric consumption volatility, an agent with concave utility function cares much more about downward insurance (that is keeping consumption relatively high when hit by negative income shocks), than about upward insurance. We will show that it is the interaction between consumption volatility and insurance that leads to hump-shaped welfare gains. In the rest of the section we present moments computed by simulating models one million periods.

Figure 6: First and second moment of consumption



Note: The left panel plots average consumption (dashed red line), average consumption net of disutility of labor, i.e.  $\left(c_t^{NB} - \frac{(l_t^{NB})^{1+\zeta}}{1+\zeta}\right)$  (solid thin black line), standard deviation of consumption (solid blue line), and standard deviation of consumption net of disutility of labor (thin dashed black line), relative to the model without bailout ( $G = 0$ ), normalized to 100. The right panel plots downward insurance, measured as the correlation between consumption growth and income growth, conditional on observing an exogenous TFP decline.

In the left panel of Figure 6 the dashed red line plots average consumption for different bailout sizes, relative to the average consumption in a model without bailouts, normalized to 100; the solid thin black line plots the average argument of the utility function,  $\left(c_t - \frac{h_t^{1+\zeta}}{1+\zeta}\right)$ , denoted by  $\mu(c, h)$  with a slight abuse of notation. The average consumption barely changes with the bailout size, which implies that this channel cannot be the driver of hump-shaped welfare gains.<sup>22</sup> The fact that also the argument of the utility function is essentially constant across different  $G$ 's indicates that labor levels, like consumption levels, are not the main drivers of the welfare effects. The solid blue line displays the standard deviation of consumption: it initially declines with  $G$  before it starts to increase, reaching the levels above the ones implied by the model without bailouts. The explanation is the following: on the one hand, when loans are small, the government will request them only when hit by large negative shocks, and because these loans are easily repaid, they do not substantially constrain the ability of the government to use financial markets. Therefore, small bailouts represent a good instrument to smooth consumption. On the other hand, large bailouts are attractive, when outside the bailout state, as they represent a large inflow of resources. However, as they are hard to repay, they are associated with long periods of borrowing constraints, as already displayed in

<sup>22</sup>Notice that our results are not in contrast, but rather in line with Hatchondo et al. (2017). In fact, they compute the welfare change of an *unexpected* introduction of non-defaultable debt (which plays a similar role of a bailout in our setting). They find that consumption increases in the *short-run*, that is right after the unexpected introduction of the policy, but this increase vanishes in the *long-run*. Our measure of welfare is close to the long-run horizon in Hatchondo et al. (2017), because we do not introduce abruptly the policy, but we compare a model in which the bailout option is always present (and therefore not introduced unexpectedly) to a model in which the bailout option is not present at all.

Figure 4. Since the economy will stay in the bailout for a longer time, the government is less able to smooth consumption which, in turn, generates quite high fluctuations in consumption. Finally, the standard deviation of the argument of the utility function, denoted by  $\sigma(c, h)$  and displayed with the black thin dashed line, substantially overlaps with the consumption standard deviation, which, once again, assures us that the consumption dynamics are the main drivers of welfare. Finally, these patterns rationalize the low welfare gains of bailouts: consumption (and utility) levels remain unchanged, while bailouts are able to cut about 3 percent of the consumption standard deviation; as risk aversion is rather small, these changes do not lead to large welfare gains, consistent with Lucas (1987). Nevertheless, we believe it is relevant to understand and explain why these welfare gains are a hump-shaped function of the bailout size.

One might wonder why, if larger bailouts are associated with a similar consumption mean and a larger consumption standard deviation than in a model without a bailout option, they still imply a positive welfare gain. As we mentioned above, bailouts play the role of an imperfect state-contingent asset, as the government requests them in times of negative income shocks and repays them only when output is high. In the right panel of Figure 6 we report a measure of downward insurance, measured as the correlation of consumption growth,  $\Delta \log(c_t)$ , and income growth,  $\Delta(\log(y_t))$ , conditional on observing an exogenous TFP decrease,  $\Delta \log(\epsilon_t) < 0$ , where  $\Delta$  is the lag operator. The larger the bailouts, the higher is the degree of downward insurance, as asking for a bailout provides large resources which can keep consumption at a relatively high level in times of bad exogenous TFP realizations. Therefore, on the one hand, large bailouts are good buffers for negative income shocks; this feature improves welfare; on the other hand, they are associated with large periods of financial constraints and large repayments needed to exit the bailout state, causing consumption to be quite volatile;<sup>23</sup> these features deteriorate welfare, and lead to the hump-shaped function  $\lambda(G)$ .

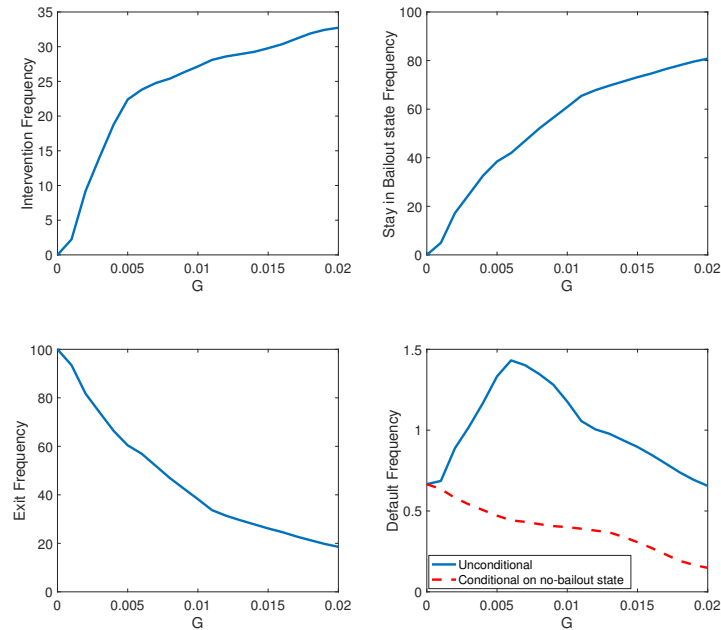
It is clear that to fully understand the welfare gains of bailouts and how they vary with  $G$ , it is important to assess whether the economy stays more frequently outside the bailout option, in which it can enjoy better financial conditions, or in the bailout state, in which it is financially constrained after having received the fresh resources of the IFI loan. To this end, in the top-left panel of Figure 7 we report the intervention frequency, in percent, which measures the probability to enter in the bailout state, conditional on being outside, i.e.  $Pr(s' = 1 | s = 0)$ , as a function of  $G$ . When the bailout is small, there is little incentive to ask for it; this incentive increases with the size. The

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<sup>23</sup>These properties are well illustrated in the right panel of Figure 4, where we show the effects of large bailouts; in period 4, when the economy asks for a bailout consumption does not drop as much as in the model without bailouts. In period 11, the economy repays its loan and consumption drops even when income is increasing. Finally, in period 12 the economy is outside the bailout state and it can freely borrow from the market, which imply a large increase of consumption. As a results, consumption in a model with large bailouts is more volatile then in a model without bailouts, but the former has better downward insurance properties.

bottom-left panel reports the probability of exiting the bailout state, i.e.  $Pr(s' = 0|s = 1)$ , and the top-right panel reports the probability of staying in the bailout state, i.e.  $Pr(s' = 1|s = 1)$ , both conditional on being in the bailout state already. These two measures obviously sum to 100.<sup>24</sup> Intuitively and as already mentioned, larger bailouts are hard to repay which increases the stay-in-the-bailout frequency and decreases the exit frequency. Hence, larger bailouts endogenously imply longer periods of being financially constrained.

Figure 7: Intervention, Stay, Exit, and Default frequencies



Note: The top-left panel displays the intervention frequency, in percent, which measure the probability to enter in the bailout state, conditional on being outside it. The top-right panel displays the probability to stay in the bailout, conditional on being already in the bailout state. The bottom-left panel displays the probability to exit the bailout, conditional on being already in the bailout state. The bottom-right panel displays the unconditional default probability (blue solid line), and the default probability conditional on being outside the bailout state (dashed red line)

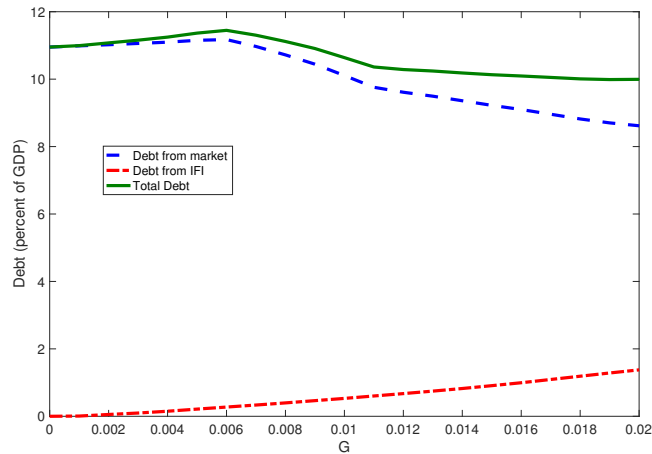
Finally, the bottom-right panel reports the unconditional default frequency (solid blue line) and the default frequency conditional on being outside the bailout state (dashed red line). We find that the unconditional probability is hump-shaped in the bailout size. This finding relates to the one in [Fink and Scholl \(2016\)](#), where they show that the default frequency is hump-shaped in the tightness of the fiscal constraint.

In our case, when  $G$  is positive but still small, the government enjoys better borrowing conditions from the market when it is outside the bailout state. Therefore, the level of market debt available to the government increases. When a crisis occurs the economy asks for this small bailout, but a further

<sup>24</sup>Recall that if a government defaults on the market debt while in the bailout state will still have to repay the third party loan; therefore, it will remain technically in the bailout state.

deterioration of the economy pushes the government to default on the accumulated large levels of debt. When  $G$  increases further bailouts are asked at relatively lower levels of debt, as they are very generous. The economy stays longer in the bailout state, but default is not attractive as debt is not that large. This interpretation is supported by Figure 8, which plots the average debt/output ratio (in percent) borrowed from the market (dashed blue line), the average outstanding debt of the economy with the IFI (dotted red line), and the total indebtedness (solid green line), which is the sum of the two.<sup>25</sup> Notice that the amount of debt from the market supported in the economy is also hump-shaped. When  $G$  first increases from zero, average market debt rises. This is because loans are still quite small, but market borrowing conditions are better than in a setting without bailouts. On the contrary, if bailouts are more generous the intervention will be triggered at lower levels of debt, and, therefore, the economy substitutes market debt with IFI debt.

Figure 8: Market Debt, IFI debt, and Total debt



Note: The dashed blue line plots the average debt from the international market to output ratio (in percent); the red dotted line plots the average outstanding indebtedness with the IFI; the solid green line plot average total debt, which is the sum of other two variables.

We can now understand why the unconditional default frequency is larger for small bailout sizes: in that case, the economy can sustain larger debt levels, because of the presence of the bailout option, and yet bailouts are not so generous to be frequently requested. Larger levels of debt are associated with larger default risk, once the economy is in the bailout program.

As a final point, notice that the peak of the welfare gains as well as the trough of the standard deviation of consumption are related to the larger unconditional default probability. This fact reveals two important features. First, in our model defaults are associated with larger endogenous inefficiency costs. Nevertheless, welfare is higher when defaults are more frequent. The reason

<sup>25</sup>In each period the indebtedness with the IFI is equal to  $G$  if the economy is in the bailout state, and equal to 0 otherwise. Hence, that variable is simply equal to  $G \times Pr(s' = 1)$ .



is that these inefficiency costs turn out to be negligible as illustrated by the fact that average consumption is essentially unaffected by the peak of the default frequency (see Figure 6). By modeling the endogenous cost of default with the interaction between sovereign spreads and private loan rates insures that we are giving the model the best chance to feature disruptive defaults. We interpret our result in the following way: even when accounting for endogenous default cost, if they are calibrated to mimic the observed relationship between private and sovereign rates, these costs do not induce large welfare effects. Second, the existence of small bailouts relaxes the endogenous borrowing limit that characterizes endogenous default models. This result is in line with [Pancrazi and Zavalloni \(2019\)](#) who point out the inefficiency of these borrowing limits. Higher level of borrowing has two implications: the borrower can use financial markets at a larger extent for consumption smoothing purposes, and, second, the borrower is more prone to defaults if the economic outcome is grim. It turns out that, in our setting, the gains of the former effect are larger than the costs of the latter.

## 4.5 The recent European sovereign debt crisis

The primary motivation behind our work is the recent European sovereign debt crisis that most severely affected GIIPS economies that we decide to focus on. In this subsection we conduct a back-of-the-envelope calculation that will relate the magnitudes of the financial assistance received by these economies to the magnitudes,  $G$ , implied by our model. This exercise is remarkably useful because it allows for a direct comparison between the observed bailout levels and those levels that maximize welfare, as displayed in Figure 5.

Let us start with some background information. EFSF and ESM were established during the 2010-2012 period with the aim of providing financial assistance to the Eurozone states in difficulty in order to preserve financial stability of the overall union. At the same time, the assistance imposed some constraints on these economies. Five countries requested financial assistance: Ireland, Portugal, Greece, Spain and Cyprus. We focus only on the GIIPS economies, and within them on the first three episodes, because the financial help offered to Spain was of a quite different nature and scope; it was not subject to any specific program conditionality but rather subject to the implementation of the banking sector reforms. The start and end dates of the three programs are reported in Table 5. Each program lasted for three years.

Although other institutions, such as the European Union and the IMF, were also involved in offering financial assistance to these countries, we focus only on the EFSF/ESM loans because of their specific nature that resembles the bailout programs that we modelled above. First, EFSF/ESM

financing was provided at significantly lower rates and longer maturities than the IMF loans.<sup>26</sup> Second, most of the disbursements were front loaded, making our modelling choice of receiving funds all at once at the beginning of the program quite reasonable. Finally, in all of the programs debt redemption reflected the largest share of troubled economies' gross financing needs.

Let us now provide some numbers behind these financial assistance programs offered to Ireland, Portugal, and Greece, so that we can understand what ranges of  $G$  in our model would be in line with the empirical evidence.

In this analysis we choose to match observed bailout-to-debt ratios, given a well-known fact that these models are not able to reproduce very high debt-to-GDP ratios in the data, especially not as high as the ones faced by these troubled European economies.<sup>27</sup> Therefore, given the debt-to-GDP ratio implied by our model, we can calculate the model-implied bailout-to-GDP ratio that would deliver bailout-to-debt ratio in the model equal to the one observed in the data.<sup>28,29</sup>

**Empirical Bailout-to-Debt Ratios** There is not only one way to calculate bailout-to-debt ratios in the data, because it depends on the time period as well as on financial assistance tranches that one focuses on. Therefore, we consider two reasonable scenarios and report our calculations in Table 5. The first scenario (*scenario 1*) considers total financial assistance offered, while the second scenario (*scenario 2*) considers financial assistance offered within one year of the first tranche. That is, the first scenario reports the average of the entire financial assistance amount per year of the bailout duration, and the second scenario reports the assistance amount offered only during the first year of the program and compare it with the GDP (and debt) in that year.

**Model-implied average debt-to-GDP ratio** Our model delivers the average debt-to-GDP ratio of 13.25 percent. During crisis times it reaches higher levels, amounting to about 30 percent of average GDP. Therefore, in our analysis we consider two levels of debt-to-GDP ratios: average and high.

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<sup>26</sup>EFSF/ESM recently conducted an evaluation of the financial assistance programs where, among other things, they asked participants about their perceptions of the programs that were offered to them. Most of them agreed that although lower interest rates were relevant, it is having larger loans at longer maturities that they valued the most.

<sup>27</sup>A known quantitative issue with similar stylized strategic default models is that they generate low debt-to-GDP levels. In the recent literature it has been shown that long term bonds, as in Sanchez et al. (2014), stochastic volatility, as in Seoane (2019), and renegotiation, as in Yue (2010), bring the model-implied debt levels somewhat closer to the levels observed in the data. However, because these additional features would obscure the channels operating in our model and would not bring debt levels close to the ones observed in GIIPS economies, we believe that it is better to conduct our analysis using a parsimonious model even at this quantitative cost.

<sup>28</sup>In particular,  $(G/GDP)/(debt/GDP) = G/debt$ . Then, given the model-implied debt/GDP we can calculate  $G/GDP$  that would make the model  $G/debt$  match the one observed in the data. Once we recover the value for  $G/GDP$  we can, obviously, back out the value of  $G$ .

<sup>29</sup>We would like to thank an anonymous referee for suggesting this approach.

Table 5: Model-implied bailout size under different scenarios

	Ireland	Portugal	Greece	Average
<b>Assistance Period</b>				
- start	Nov 2010	Apr 2011	Mar 2012	
- end	Dec 2013	May 2014	Jun 2015	
Duration (years)	3	3	3	3
<b>Debt-to-GDP ratio</b>				
- Year of the first tranche	86	111.4	159.6	119
- Entire financial assistance duration (average)	105.6	122.2	171.9	133.3
<i>Scenario 1</i>				
Financial assistance, total amount (bill euros)	17.7	26	141.8	61.8
- % of GDP yearly (entire duration)	3.5	5.1	25.3	11.3
- % of debt yearly (entire duration)	0.033	0.041	0.15	0.07
<b>Model implied <math>G</math></b>				
- average debt	0.001	0.001	0.004	0.002
- high debt	0.002	0.003	0.010	0.007
<i>Scenario 2</i>				
<b>Financial assistance</b>				
within one year of the 1 <sup>st</sup> tranche (bill euros)	9.3	14.8	113	45.7
- % of GDP (year of the first tranche)	5.5	8.4	59.4	24.4
- % of debt (year of the first tranche)	0.064	0.075	0.37	0.17
<b>Model implied <math>G</math></b>				
- average debt	0.002	0.002	0.011	0.005
- high debt	0.004	0.005	0.025	0.011

Note: When calculating values of  $G$ , we consider two levels of debt-to-GDP ratio: average (13.25 percent) and high (30 percent). Given this debt-to-GDP ratio, we then recover the model-implied bailout-to-GDP ratio needed to match the bailout-to-debt ratio observed in the data. Finally, in these calculations, we account for the fact that our model is calibrated to quarterly frequency with the mean average quarterly output ( $\bar{y} = 0.9180$ ).

**Model bailout size,  $G$**  We are now ready to recover the model-implied bailout size,  $G$ , in both scenarios, given the two different levels of debt-to-GDP ratios, average and high. For example, the level of  $G$  that corresponds to the average debt-to-GDP ratio under scenario 1 for Ireland is given by  $\frac{13.25 \cdot 0.033}{400} * \bar{y}$ , while the level of  $G$  that corresponds to the high debt-to-GDP ratio amounts to  $\frac{30 \cdot 0.033}{400} * \bar{y}$ , where the average output  $\bar{y} = 0.9180$ .<sup>30</sup>

The model-implied values of bailout size,  $G$ , range from 0.001 to 0.025, suggesting that the values that we consider in our exercise above are well in line with what we observe in the data. While for Ireland and Portugal the size of the bailout is rather small, in a range close to the peak of the welfare function, bailout size for Greece, if read under the lenses of our exercise, might have been too large, as Greece might be under the conditionality clause for a long time, before being able to clear the received loan.

<sup>30</sup>Notice that we divide by 400 to account for the model being in quarterly frequency. The average quarterly output level implied by the model,  $\bar{y}$  is 0.9180.

## 5 Conclusions

Inspired by the recent European sovereign-debt crisis, in this paper we investigate the welfare effects of offering financial assistance (bailouts) to the economies that face grim economic conditions and are exposed to sovereign default risk.

We model bailouts in the following way. When the government of a small open economy requests financial assistance from an IFI, it receives a one-time loan of an exogenous size,  $G$ . This loan is non-defaultable and limits the ability of the government to borrow on international markets, i.e. the country that enters bailout program must deleverage its external debt. While in the program, the country services interests payments on this loan in each period.

Investors understand that the presence of this bailout option reduces sovereign default and they are then willing to offer credit to an indebted government at better conditions and the government increases its borrowing. If economic conditions do not improve, the government finds itself in the situation where it is optimal to request a bailout. How long it stays in the bailout is a function of the bailout size. We show that the duration is increasing in the bailout size. Moreover, the size of bailout creates non-trivial tradeoffs between receiving larger amount of relatively cheap resources precisely when the government is strained for additional funds on the one hand, and facing longer-lasting financial constraints and accumulated interest payments, on the other hand.

We characterize and quantify these tradeoffs and document that welfare gains of bailouts are hump-shaped in their size. We show that this shape is driven mostly by the effect of bailouts on the second moment of consumption, as the average levels of consumption (and labor) are barely affected by the bailout size. During crisis times, small bailouts allow for a good consumption smoothing profile, while not constraining the economy too much; this feature increases welfare. In contrast, while large bailouts are good buffers for negative income shocks, they are also associated with longer-lasting constraints and larger outstanding loan amounts that are harder to repay, causing consumption to be quite volatile; these features deteriorate welfare.

Our results indicate that it is not always optimal to offer larger financial assistance as it might reduce the overall welfare gains. We offer some back-of-the-envelope calculations and show that while financial assistance offered to Portugal and Ireland by the EFSF/ESM was close to the levels that would have maximized welfare gains implied by our model, financial assistance offered to Greece might have been too large.

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