

Sovereign Risk, Private Credit, and Stabilization Policies*

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February 11, 2014

Abstract

Taking into account the positive interaction between sovereign spreads and private credit conditions observed in the 2008 European crisis, this paper examines the impact of spread stabilization policies, such as recently proposed Outright Monetary Transactions, in small open economies. Recognizing the link between sovereign and private spreads is crucial for policy evaluation: when sovereign spreads comove with private rates, sovereign debt crisis worsens private credit conditions leading to output losses and exacerbates macroeconomic instability. By alleviating sovereign spreads, bailouts reduce the likelihood of government debt defaults and improve private credit conditions. The use of bailouts is able to reduce output losses by 0.06 percent of GDP and increases welfare by up to 1 percent in terms of consumption equivalent. In the case of Italy, as an example, this would imply a gain of \$1.2 billion (U.S.) due to lower financial frictions. Moreover, this beneficial effect emerges even when governments merely have the option of receiving a bailout but do not take advantage of it.

Keywords: Default, Sovereign Debt, Sovereign Risk Premium, Private Credit, Private Spread, Outright Monetary Transactions.

JEL Classification: E44, F32, F34.

*We thank Pablo Ottonello, Franck Portier and the seminar participants at various conferences and seminars for helpful comments and discussion.

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1 Introduction

During the recent European crisis, debt levels and sovereign spreads soared, and private credit conditions deteriorated dramatically. For example, in the period between April 2007 and January 2012, when the sovereign spreads in Spain increased from 0.05 percent to 5.4 percent, the difference between the 10-year private lending rate and the European Central Bank (ECB) repo rate increased from less than 1 percent to 2.85 percent. Recognizing the interrelation between sovereign spreads and private credit markets is important for policy evaluation. Intuitively, sovereign crises pose a great burden on private businesses because of the association between increased sovereign spreads and higher private borrowing costs. This burden is costly because it diverts economic resources that would otherwise be productive pursuits and channels them into the cause of serving higher private lending rates. This inefficiency, in turn, worsens the economic conditions of the country and slows down its recovery. Though the link between sovereign debt levels and private lending rates is widely recognized in the policy circles¹, the connection is not well explored in the macroeconomic literature. This paper fills that gap by evaluating recently proposed bailout policies, such as Outright Monetary Transactions, that are aimed at reducing interest rates on sovereign bonds faced by troubled economies, when taking into account possible effects on private credit.

We characterize the relationship between sovereign and private lending spreads by designing a model in which both spreads arise endogenously: sovereign spreads arise from the government's lack of commitment to repay its debt, which leads to an endogenous default decision, as in [Eaton and Gersovitz \(1981\)](#), and private lending spreads arise from the existence of financial frictions. The interaction between these two modelling features endogenously creates a positive link between the two rates; as a result, higher sovereign spreads have an extra negative effect on the economy because they raise the cost of private borrowing. In this framework, we can study the following questions: to what extent are policy interventions aimed at reducing sovereign risk able to ameliorate private credit conditions, and how important are these effects quantitatively? To answer these questions we augment the government choice set in a standard endogenous default model with the possibility of asking for a bailout. In particular, a government has three options: to default on its debt obligation, to honor its debt by staying in the debt contract, or, alternatively, to ask for a bailout from a third external party, which can be thought of as an international organization or a central bank of a monetary union. While in the bailout program, the country should comply with certain restrictive

¹For 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.

conditions, in line with the “conditionality clause” defining Outright Monetary Transactions in the European Union. We show that third-party bailouts reduce the exposure of the economy to default, reduce sovereign spreads, and have large effects on welfare, also thanks to the additional beneficial effects that bailouts have on private credit rates. Importantly, we observe positive effects of bailout policies even when the policy is not actually requested: in fact, simply knowing that the option of bailouts exists reduces sovereign spreads, and hence private credit spreads, even in periods when the government repays its debt.

In the first part of the paper, we illustrate the relationship between the sovereign spreads and private lending rates by examining five troubled economies: Greece, Ireland, Italy, Portugal, and Spain during the periods before and after 2008. Sovereign spreads in all five economies increased after 2008 - a striking characteristic of the ongoing European sovereign-debt crisis. Interestingly, private lending rates started to increase as well. We show that the correlation between these two rates is negative before 2008, whereas it is large and positive after the crisis. This evidence suggests that the link between the conditions in the two markets strengthened during the crisis, which underscores the importance of recognizing this connection in policy analysis; any policy aimed at stabilizing conditions in the sovereign bond market also would likely affect private credit conditions.

We then construct a model that is able to capture the relationship between sovereign spreads and private spreads in line with the empirical evidence presented above. The model is a stochastic general equilibrium model augmented with strategic sovereign default, in which the dynamics are driven by the interaction between the government, firms, and international lenders. The government borrows from the international credit markets, paying an interest rate which reflects its endogenous default probability. In addition, it faces a convex adjustment cost when changing its debt level. As in [Uribe and Yue \(2006\)](#), this setup can be decentralized through the banking industry. Following [Uribe and Yue \(2006\)](#), [Neumeyer and Perri \(2005\)](#), and [Mendoza and Yue \(2012\)](#) we also assume that firms face working capital constraints that require them to hold non-interest-bearing assets to finance a fraction of their wage bill each period. Therefore, faced by this financial friction, firms must borrow funds from domestic banks. The interaction between working capital constraints and costs of adjusting asset positions creates an endogenous link between private lending and the sovereign debt level which, as observed in the data, depends on macroeconomic conditions and changes over the business cycle. Specifically, during normal times, characterized by a low level of sovereign risk premium, the variability of the private-sector interest rate is mainly driven by changes in the debt position and not by changes in the sovereign risk premium. Hence, the correlation between sovereign risk premium and private-sector spread is rather low. However, as the sovereign debt increases in order to smooth private-sector consumption during a crisis, the sovereign risk premium and adjustment costs are likely to increase as well. In addition, larger sovereign debt also induces

higher adjustment costs, reinforcing the impact of changes in the sovereign risk premium on the private interest rate, and increasing the correlation between the two prices.

We note that our assumption about the presence of increasing and convex adjustment cost related to the level of debt is supported by macroeconomics and banking literature (for example, [Hester and Pierce \(1975\)](#), [Edwards and Vegh \(1997\)](#), [Guerrieri et al. \(2012\)](#), [De Nicolò et al. \(2011\)](#), [Gertler et al. \(2012\)](#), [Dib \(2010\)](#)). Nevertheless, alternative settings as in [Justiniano et al. \(2013\)](#), in which financial-intermediation sector consists of perfectly competitive retail banks and monopolistically competitive investment banks, or as in [Cúrdia and Woodford \(2010\)](#), in which financial intermediation requires real resources which are non-decreasing in the amount of extended loans, generates a similar relationship between sovereign risk premium and private sector spreads.

An important contribution of the paper is to propose a parsimonious framework to evaluate bailout policies. For this purpose, in line with [Pancrazi et al. \(2013\)](#), we augment the choice set of a government with respect to standard endogenous default models. We assume that, in addition to defaulting or repaying its debt, a government also has the option to enter in the bailout program. In this case, it receives a transfer from a third-party fund (for example an international organization or the central bank of a monetary union) but it also agrees to borrowing restrictions as a condition of participation in the bailout program. This assumption reflects the “conditional clause” that characterizes Outright Monetary Transactions as announced in August 2012 by the European Central Bank, aimed to reduce sovereign bond interest rates faced by troubled economies.

The implications of bailout policies are the following. First, they drastically reduce the exposure of an economy to a default, because the default region shrinks, particularly when private-sector inefficiency is considered. Second, they successfully lower sovereign spreads: after a bailout policy is introduced, the government bond interest rate declines by almost 300 basis points. The intuition is simple: international investors are aware that asking for a bailout is now an additional option for the government to avoid default. Since the default probability declines, investors ask for a lower premium when lending to the government. Third, bailout policies have large and remarkable effects on private credit as well. In fact, when considering a model with financial frictions, we show that the reduction of government bond rates is associated with a reduction of the private loan rates. This link, generated by the presence of working capital constraint and financial intermediaries, has important implications for the bailout policies’ impact on output losses and welfare. Specifically, the reduction of private loan rates diminishes the inefficiency generated by financial frictions and is reflected in lower output losses: in our quantitative analysis, better private credit conditions reduce output losses up to 0.06 percent of GDP. To put this number in perspective, a similar reduction of output loss in Italy would be equivalent to \$1.2 billion (U.S.), and in Spain to \$800 million. Hence, when taking into account sovereign risk’s spillover effect on the private sector, bailout policies are

even more desirable.

Finally, we assess welfare gains attributable to bailout policies. In particular, we compute the percentage of consumption level that an agent in an economy without bailout option is willing to forfeit in exchange for an economy with this option. In other words, we compute the level of welfare, in terms of consumption equivalent, associated with having the additional option of asking for a bailout. It is important to stress that our calculation abstracts from the additional resources obtained by the domestic country from the third party when asking for a bailout. The underlying assumption is that the resources obtained will be repaid in the future, thus bringing no additional utility per-se. Nevertheless, the bailout option carries welfare benefit due to the reduction of sovereign risk and the reduction of output losses. On the other hand, the bailout constrains the domestic economy to be subject to the borrowing regulations dictated by the third party for the immediate future, thus leading to potential welfare loss. We show that bailout policies are, indeed, highly desirable especially in an economy characterized by financial frictions: the welfare gains range from 7.6 percent to 9.4 percent, depending on how strong the bailout conditions are. The presence of financial frictions increases welfare benefits of bailouts up to 1 percent in consumption equivalent terms. This result stems from the additional beneficial effect that a bailout generates by stabilizing the private credit and reducing the inefficiency due to financial friction. Importantly, even when the government does not ask for a bailout, the mere existence of this option still has a strong positive effect, leading to the reduction of spreads: in fact, international investors internalize this by taking into account that a government has a bailout alternative, which, in turn, reduces the default risk.

This paper relates to the three distinct strands of the macroeconomic literature. First, it is related to the literature on strategic default that grew out of seminal contributions by [Eaton and Gersovitz \(1981\)](#), such as [Arellano \(2008\)](#), [Aguiar and Gopinath \(2006\)](#), [Cuadra and Saprizza \(2008\)](#), and [Seoane \(2013\)](#). These papers analyze the dynamics of sovereign interest rates and their interaction with macroeconomic conditions under default risk; however, they do not examine the interaction of sovereign risk premium with private-sector interest rates because they do not model private sector debt explicitly. [Mendoza and Yue \(2012\)](#) introduce financial frictions in default models, with the objective of reconciling default and business cycle stylized facts in emerging economies. While our work here relates to [Mendoza and Yue \(2012\)](#), we extend the baseline default model in a different direction. We focus on the interaction between private and sovereign spreads and its impact on the bailout decision by the government. With this objective, we consider a simplified production side of the economy.

Our work also relates to and expands upon a second strand of literature examining how the introduction of third-party bailouts can increase default probability. [Aguiar and Gopinath \(2006\)](#)

model a bailout as an unconditional and automatic transfer of resources from a non-modeled third party to creditors in case of default. Hence, as they acknowledge, it is not surprising that default rates increase because a bailout in that framework is viewed as a subsidy for default. As a result, their model is not suitable for studying policies in spirit of OMTs because it does not offer a country the option of choosing whether to accept a bailout. It is simply treated as a free transfer of resources without any trade off. In our setting, instead, choosing a bailout constrains the domestic economy to be subject to the borrowing regulations.

Finally, our paper also relates to a third line of the literature on financial frictions, with a focus on credit conditions in the private sector and their interaction with interest rates, as in [Neumeyer and Perri \(2005\)](#), [Garcia-Cicco et al. \(2010\)](#), [Fuerst and Carlstrom \(1998\)](#), [Bernanke et al. \(1999\)](#), and [Corsetti et al. \(2013\)](#), among others. Specifically, our work builds upon the sovereign-private sector spread work of [Uribe and Yue \(2006\)](#). In that paper, the foreign interest rate is exogenously determined, and firms need to advance a share of labor costs before production takes place, giving rise to private debt. In that work, the private-sovereign spread appears as a consequence of a working capital constraint. However, our paper takes this conceptual framework further, offering what we believe to be one of the first model of both endogenous sovereign risk premium and private sector spread in a small open economy environment.

The remainder of the paper is as follows. Section 2 presents empirical evidence regarding the relationship between private and sovereign spreads in Greece, Ireland, Italy, Portugal, and Spain. Section 3 describes the baseline model, which generates dynamics for sovereign and private-lending spreads. Section 4 illustrates the calibration and performance of the model. Section 5 introduces bailout programs in the model and describes their implications on sovereign risk, private credit, output losses, and welfare. Section 6 provides concluding remarks.

2 Private lending rates and sovereign spreads

The link between sovereign spreads and private lending rates has recently attracted the attention of applied macroeconomists and policymakers.² In this section we illustrate the importance of the interconnection between government and private borrowing during periods of turmoil in the five countries that were largely exposed to the recent European sovereign debt crisis: Greece, Ireland, Italy, Portugal, and Spain (henceforth, GIIPS).

We compute sovereign spreads as the difference between the return on 10-year sovereign bonds of the five economies and the return on 10-year German sovereign bonds.³ As a measure of the

²See [Zoli \(2013\)](#) and [Albertazzi et al. \(2012\)](#).

³We use Reuters monthly data from January 2003 to December 2011.

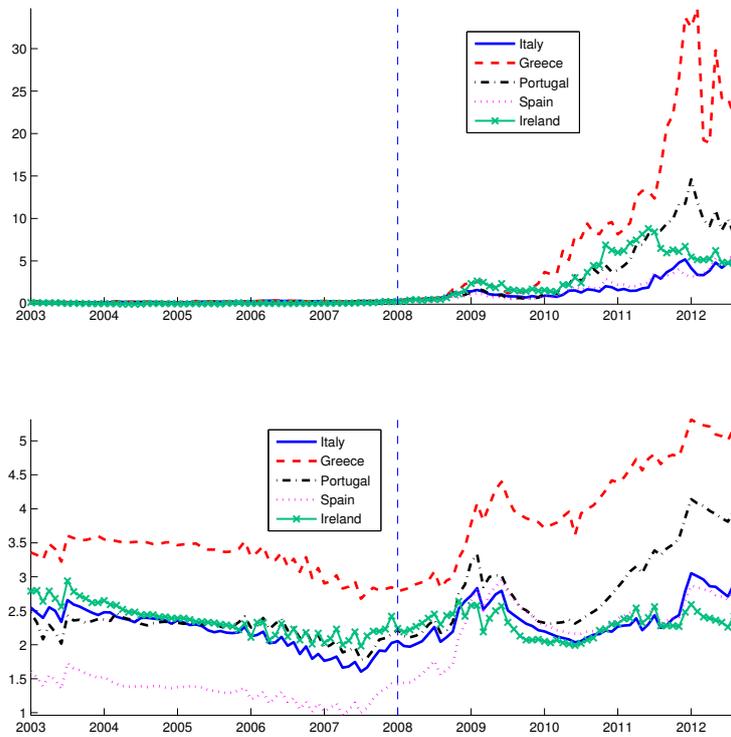


Figure 1: Sovereign Spreads and Private Lending Rates

Note: The top panel displays monthly annualized spreads for Greece, Ireland, Italy, Portugal, and Spain, as measured by the difference between the return of 10-year sovereign bonds of the five economies and the return of 10-year German sovereign bonds. The bottom panel displays private-lending rates for the same economies, as measured by the annualized agreed rate for loans to non-financial corporations from the ECB and the EU marginal lending facility rate. The vertical line depicts the first month of 2008.

private sector cost of borrowing, we consider the annualized agreed rate for loans to non-financial corporations from the ECB. Since this measure is largely affected by the prime interest rate set by the ECB, we compute deviations of the agreed rate from the EU marginal lending facility rate and refer to this variable as “private lending rate”.

The top panel of Figure 1 displays the sovereign spreads and shows the clear increase in government spreads after 2008, a trend that remains a striking characteristic of the ongoing European sovereign debt crisis. The bottom panel shows the private lending rate spreads in the five GIIPS countries. The increase in risk premium affected all five countries, but unequally, with Greece and Portugal experiencing larger impacts. Interestingly, private lending rates also started to increase after 2008, after a period of stability or slight decline. Although the magnitude of a change in private rates is significantly smaller than that of government spreads, these figures provide evidence that the recent sovereign crisis had an impact on private credit conditions as well.

In order to illustrate the strengthened linkage between sovereign spreads and private lending rates that emerged during the crisis, Table 1 reports the mean of these two variables, as well as their correlation, in the pre-crisis period (2003-2008, left panel) and crisis period (2008-2011, right panel). Several interesting regularities merit mention. First, as expected, during the crisis, the average sovereign spread increased by a very large margin in all five countries. Second, private spreads also increased (except for Ireland) by as much as 100 basis points. Third, whereas the correlation between these two rates is negative during the pre-crisis period, it is large and positive during the crisis.

Table 1: Sovereign Spreads and Private Lending Rates

	Pre-Crisis			Crisis		
	Sov. Spread	Priv. Spread	Correlation	Sov. Spread	Priv. Spread	Correlation
Greece	0.2	3.3	-0.66	9.8	4.1	0.82
Ireland	0.1	2.4	-0.08	3.4	2.3	0.26
Italy	0.2	2.2	-0.71	1.9	2.4	0.62
Portugal	0.1	2.2	-0.64	4.1	2.9	0.86
Spain	0.1	1.3	-0.64	1.8	2.3	0.86

Note: Sovereign spreads are measured as the difference between the return of 10-year sovereign bonds of the five economies and the return of 10-year German sovereign bonds. Private spreads are measured as the annualized agreed rate for loans to non-financial corporations from the ECB and the EU marginal lending facility rate. Variables are in annualized percentages. Quarterly variables are computed by averaging monthly rates. “Pre-Crisis” denotes the sub-sample from 2003 until December 2007 and “Post-Crisis” denotes the sub-sample from 2008 until December 2011.

Capturing the different degrees of interaction between private and sovereign spreads during normal and crisis times is important for understanding the effects of policies aimed at stabilizing sovereign risk on aggregate dynamics. Intuitively, through inefficiencies due to financial frictions, higher private credit spreads lead economic conditions to deteriorate, thus putting upward pressure on sovereign spreads; this, in turn, increases private credit spreads further and, thus, the interplay of the two prices is as crucial in the overall economic picture as the individual spreads per se. Therefore, we believe it is imperative to evaluate policies aimed at stabilizing sovereign risk for their implicit effect on reducing financial inefficiency. To this end, we have devised a model that correctly depicts this crucial interaction between private and sovereign rates.

3 The Model

In the previous section we presented empirical evidence that suggests the presence of a tight link between sovereign spreads and private credit markets. It is then natural to investigate how policies primarily aimed at stabilizing sovereign risk affect the domestic private sector as well. We proceed in two steps. First, we present a model in which sovereign risk and private credit conditions are related, by abstracting from any bailout policy; we explicitly explain the mechanism that generates the link, and we calibrate the model to be consistent with the aggregate dynamics of the GIIPS countries. Then, we use our model as a laboratory to study how policy interventions affect macroeconomic aggregates and prices related to both government and private sectors.

The model consists of a small open economy populated by households, firms, banks, and a government. Households own firms and banks, choose consumption, and receive transfers from the government. As standard in default models (i.e. as in [Arellano \(2008\)](#)), the government decides international borrowing and uses it to smooth households' consumption. Firms take production decisions and face financial frictions in a form of a working capital constraint, as they need to finance part of their wage bill before production. We assume that all international borrowing is done through financial institutions, which then lend to domestic agents and face adjustment costs. The rest of the world is populated by foreign, risk-neutral investors. As mentioned above, the baseline model abstracts from policy intervention. A detailed description of the agents follows.

3.1 Households

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

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u(c_t), \quad (1)$$

where c_t represents households' consumption in period t , $\beta \in (0, 1)$ is the discount factor, and $u(\cdot)$ is increasing in consumption and strictly concave. Households supply labor inelastically and receive an hourly wage of w_t . They also own and rent a given amount of capital k at the rate u_t .⁴ Additionally, we assume that households own firms and banks, which will be described later. Finally, households receive government transfers, τ_t , that can be positive or negative. Given these assumptions, the budget constraint of the households at any period t reads:

$$c_t = h_t w_t + k u_t + \tau_t + \pi_t + \pi_t^b, \quad (2)$$

where π_t and π_t^b denote the firms and banks profits, respectively. Given that households supply labor inelastically, take profits, transfers and prices as given and that capital supply are fixed, problem of the household is to maximize (1) subject to (2).

3.2 Firms

There are a large number of identical firms that produce a single good and rent capital and labor services, taking all prices as given. We assume that the economy is subject to financial frictions that affects firms' profit maximization problem. In particular, we assume that firms have to advance a share of the wage bill before production takes place, as in [Uribe and Yue \(2006\)](#) and [Mendoza and Yue \(2012\)](#). Firms production function is given by:

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

where ε_t represents an exogenous productivity shock, y_t denotes output and $F(\cdot)$ satisfies the assumptions of the neoclassical production function. As described above, the production process is subject to a working capital constraint that requires firms to hold non-interest-bearing assets to finance a fraction of their wage bill each period. We denote the interest rate that firms face when financing the working capital constraint by R_t^d . Formally, the working capital constraint is given by:

$$\kappa_t \geq \eta w_t h_t,$$

⁴[Meza and Quintin \(2005\)](#) and [Mendoza \(2010\)](#) find that changes in the capital stock play a small role in output dynamics around financial crises. Additionally, as emphasized by [Mendoza and Yue \(2012\)](#), endogenizing capital makes the recursive contract with default much harder to solve as an additional endogenous variable is introduced.

where $\eta \geq 0$ and κ_t denotes the amount of working capital held by a representative firm in period t . Firms choose labor according to its first order condition:

$$F_h(k, h_t) = w_t \left[1 + \eta \left(\frac{R_t^d - 1}{R_t^d} \right) \right].$$

As noted above, households supply labor inelastically. Hence, this optimality condition determines the hourly wage. Notice that, consistently with the literature on working capital constraint, wages are affected by the degree of financial friction in the private sector, η , and by the private lending rate, R_t^d . The description of firm's asset evolution and derivation of its profits is described in detail in the Appendix A.

3.3 Financial Intermediaries

The economy is populated by financial intermediaries, modelled as in [Uribe and Yue \(2006\)](#). In their setting, intermediaries borrow from foreign investors at a country rate and lend to domestic agents at a higher domestic rate. During the intermediation process, banks face operational costs which are increasing in the volume of intermediation. Therefore, in equilibrium, a domestic rate is equal to the country rate corrected for the marginal adjustment cost, which is exactly equal to the shadow interest rate faced by domestic agents in the centralized problem.

Our problem can be decentralized in a similar manner. Suppose that financial transactions between domestic and foreign agents require financial intermediation by banks. There is a continuum of banks operating in a competitive environment. In each period, bank i borrows funds from foreign investors at price q_t and lends to domestic agents offering an interest rate of R_t^d . When supplying their services, banks face convex and increasing operational costs, $\Psi(b_i)$. That is, banks are subject to frictional costs when re-balancing portfolios. Specifically, we follow the formulation in [Uribe and Yue \(2006\)](#). The problem of the banks is to maximize profits given by,

$$R_t^d [b_{t+1} - \Psi(b_{t+1})] - \frac{b_{t+1}}{q_t}$$

with interest rates and prices given. Solving for the optimal behavior of banks delivers the relationship between domestic private agents rate, R_t^d , and sovereign bond price, q_t , given by

$$R_t^d = \frac{1}{q_t} \frac{1}{1 - \Psi'(b_{t+1})}. \quad (3)$$

This equation shows the interest rate that the private sector faces is an increasing function of the sovereign rate. As will become clear later, the sovereign rates depends on the default probability, which implies that changes in the sovereign risk premium, i.e. changes in the default incentives,

will spread to private interest rates, affecting private firms' businesses. However, since the private rate is also affected by the level of sovereign debt, these changes in the sovereign risk premium will not be reflected one to one in the changes of private interest rates.

Equation (3) provides some insight on the mechanism that links the price of sovereign debt and the private-sector lending rate. Given the convexity of the portfolio adjustment cost, when the economy experiences relatively high levels of debt changes in the sovereign risk will have a large effect on the private rate. On the other hand, when the level of debt is small, changes in the sovereign risk premium have a rather small effect on the private rate. As a result, this simple mechanism is able to capture the higher correlation between private and government spreads during sovereign crisis.

The assumption that banks are subject to frictional costs when re-balancing portfolios has a long tradition in macroeconomics and banking. As described in [Hester and Pierce \(1975\)](#), banks may not converge immediately to the desired level of loans for a variety of reasons. One reason is that they might operate in imperfect markets; additionally, the cost of acquiring and studying information regarding debtors increases with the size of loans. [Edwards and Vegh \(1997\)](#) design a model for a banking sector in which banks produce credit and deposits and, to do so, require resources. In their setup, the resources used by banks are a quadratic function of their lending to the domestic market. In a more recent paper that relies upon setup similar to our own, [Guerrieri et al. \(2012\)](#), suggest that banks face trading and transaction costs during the process of buying and selling assets. [De Nicolò et al. \(2011\)](#) assume quadratic adjustment costs to bank loan policy stem from monitoring costs. [Gertler et al. \(2012\)](#) assume that banks face convex costs when rising external funds because of the a possibility that a fraction of those funds will be diverted. Finally, [Dib \(2010\)](#) assumes quadratic costs due to entry costs in financial markets.

This parsimonious setting is desirable for computational tractability. However, we could obtain a similar expression to equation (3) by decentralizing this problem in a different manner. For instance, [Justiniano et al. \(2013\)](#) assume that the intermediation sector consists of perfectly competitive retail banks and monopolistic competitive investment banks. Retail banks collect deposits from households and the rest of the world and use them to lend funds to the wholesale banks which, in turn, issue securities to the commercial banks or money market mutual funds, charging a lending rate which is increasing in the degree of their market power. As a consequence, the spread between lending and borrowing rates would be derived from the wholesale market power of the investment banks. Alternatively, [Cúrdia and Woodford \(2010\)](#) generate the spread between borrowing and lending rates by assuming that financial intermediation requires real resources which are non-decreasing in the amount of extended loans.

Here, the solution to this decentralized problem is identical to the one in which social planner

faces an adjustment cost when changing the level of debt.

3.4 International lenders

The international financial market is populated by risk-neutral investors who can borrow or lend as much as needed at a constant risk-free interest rate, $r > 0$. Therefore, they price sovereign bonds such that they break even in expected value. Taking prices as given, investors demand small open economy bonds b_{t+1} in order to maximize profits given by,

$$\phi_t = q_t b_{t+1} - \frac{1 - \delta_t}{1 + r} b_{t+1},$$

where ϕ_t denotes investors' profits and δ_t is the probability of default. Hence, bond prices are set as:

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

Note that the risk-neutral nature of investors implies that bond prices satisfy the zero expected profit condition for foreign lenders. Since the probability of default δ_t is endogenous and depends on the government's incentives to repay, when foreign asset holdings are negative, foreign investors account for a positive probability of default. However, when default incentives are zero, the price of bonds equals the inverse of the risk-free rate.

3.5 Government

The government is benevolent and trades one period bonds in international asset markets to help households smooth consumption. However, the government cannot commit to honoring its debt. Specifically, the government issues discount bonds b_{t+1} at price q_t . A purchase of a discount bond with a positive value means that the government has entered the contract where it saves $q_t b_{t+1}$ units of current goods to receive b_{t+1} units of goods in the next period. A purchase of a discount bond with a negative value of b_{t+1} means that the government has entered into a contract where it receives $-q_t b_{t+1}$ units of good in the current period t , and repays b_{t+1} units in $t + 1$, conditional on not defaulting.

In this section we abstract from any policy intervention. Hence, the government has only two choices available: to repay the debt, or to default. If the government chooses to repay its debt, it remains in the contract and chooses the new level of assets, b_{t+1} . As the government is benevolent, its objective is to maximize households' lifetime utility (1) using foreign debt, the default option and the transfers, subject to the following resource constraint of the economy:

$$c_t = \varepsilon F(k, h_t) - \eta w_t h_t \left(\frac{R_t^d - 1}{R_t^d} \right) + b_t - q_t(b_{t+1}, \varepsilon) b_{t+1} - \Psi(b_{t+1}),$$

where $\Psi(b_{t+1})$ is the cost government has to pay when adjusting its foreign assets position, ε is the productivity shock, $F(k, h)$ is the total production of the economy. The second term on the right hand side of the resource constraint represents a resource cost to the economy resulting from firms facing a working capital constraint. It requires them to hold non-interest-bearing assets to finance a fraction of the wage bill, η , each period. The interest rate they pay on these assets is given by a shadow interest rate faced by domestic private agents, R^d .

If the government defaults, the country is excluded from financial markets for a random number of periods. In this case, the country experiences productivity losses that capture the disrupting effects of defaults in the domestic economy.⁵ In this case consumption equals:

$$c_t = \varepsilon^{def} F(k, h_t),$$

where $\varepsilon^{def} = \gamma(\varepsilon)$. We assume that $\gamma(\cdot)$ is a penalty function as in [Arellano \(2008\)](#). With some exogenous probability θ , government reenters the international credit markets where all past debt is forgiven.

The timing of decisions within each period is as follows. The government starts with initial assets b , observes productivity shock ε , and decides whether to repay the debt or to default. If the government decides to repay, then, taking the bond price schedule q as given, it chooses the level of asset holdings b' subject to the resource constraint, the intra-temporal optimality condition, and the relationship between domestic interest rates and bond prices. Then, creditors choose b' taking q as given. Finally, government transfers are realized and consumption takes place. [Appendix B](#) defines the recursive equilibrium.

4 Calibration and Dynamics

4.1 Calibration

This section describes functional forms and the strategy used to select parameter values. First, we choose utility function to take the following form:

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

⁵Given the nature of our problem, the working capital constraint is meaningless when a country is excluded from international financial markets. However, we model the disruption of the domestic financial markets during default by assuming productivity losses.

In line with previous literature, we assume that technology is given by a Cobb-Douglas production function:

$$F(k, h) = k^\alpha h^{1-\alpha},$$

with capital share of output, α . The steady state level of capital is determined by this equation once we take into account steady state levels of labor and output. Regarding the adjustment costs of debt, we assume the following convex function:

$$\Psi(b' - b) = \frac{\psi}{2}(b' - b)^2,$$

where $\psi > 0$ determines the strength of adjustment costs.

The time period in our model is a quarter. We calibrate the technology process to match quarterly real output per-capita of the GIPS countries for the period 1960-2008. As in [Arellano \(2008\)](#), we remove a linear trend from output and compute the first order autocorrelations and standard deviations. As seen in [Table 2](#), output is highly persistent for all economies and the volatility level is of a similar order of magnitude.

Table 2: Output moments

	Greece	Ireland	Italy	Portugal	Spain	Average
$\rho(y)$	0.98	0.99	0.98	0.98	0.98	0.98
$\sigma(y)$	0.11	0.07	0.07	0.15	0.08	0.10

Note: $\rho(y)$ denotes the first order autocorrelation and $\sigma(y)$ denotes the standard deviation of log linearly detrended output.

We use quarterly real output per capita for the period 1960-2008.

[Table 3](#) presents some key features of default episodes in Europe during the last 200 years.⁶ The table presents the number of default episodes, the quarterly default probability of a default episode, the share of periods that the economy was in default relative to the total quarters in our sample, and the average length of a default episode. Within our sample, Spain is the economy with the most default episodes, while Greece is the economy that spent the most time in default. Italy and Ireland, on the other hand, exhibit few or no defaults. Based on this data we calculate the average probability of default episode per quarter to be 0.64 percent, average share of periods in default to be 17.6 percent, and finally average length of default to be 30 quarters. These are the

⁶We use evidence in [Reinhart and Rogoff \(2009\)](#). Here, 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.”

Table 3: 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
Share of Periods in Default (%)	50.6	0.	3.4	10.6	23.7	17.6
Ave. length def.	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 \(2009\)](#).

relevant default statistics that we will use when calibrating some of the parameters of the model, as described below.

Table 4 presents the baseline calibration. The relative risk aversion parameter, σ , is set to 2, which is a standard value in the business-cycle literature (see for example [Arellano \(2008\)](#) and [Garcia-Cicco et al. \(2010\)](#)). Regarding the parameters associated with the firm's problem, we assume that capital share is 0.3, as standard in the real business cycle literature. The level of labor is set to 0.3, as described earlier. The level of capital is fixed to 16.6 in order to normalize the steady state level of output to 1.⁷

Table 4: Baseline calibration

Parameter	Description	Values
ρ^{tfp}	Persistence of TFP shock	0.96
σ^{tfp}	Std. deviation of TFP shock	0.02
α	Capital share	0.3
k	Fixed level of capital	16.6
β	Intertemporal discount factor	0.883
σ	Relative risk aversion coefficient	2
r	Risk free rate	1.0064
ψ	Adjustment costs of debt	0.1
γ	Default penalty	0.948
μ	Prob. re-entering asset markets	0.031

We assume the risk-free rate is set to match the pre-2008 period (normal times) ECB rate of

⁷This is only a normalization and does not affect the dynamic properties of the model.

2.56 percent per year. We set the adjustment cost parameter to be 0.1. This is the key parameter to depart from [Arellano \(2008\)](#) model. A model where the adjustment cost is zero or close to zero, would always imply a one-to-one relationship between the government bond return, R_t^g , and, the private lending rate, R_t^d . The parameter γ , which represents a default penalty, is set to 0.948, in line with existing literature. The probability to re-enter asset markets after default, μ , is set to 0.033 to match the average duration of a default episode.

Finally, the process for productivity shocks is exogenous and follows a Markov process. We discretize it in 15 nodes using the Tauchen procedure, as in [Tauchen \(1986\)](#), with parameter persistence equal to 0.96 and standard deviation equal to 0.02. This parameterization targets the output moment averages in [Table 2](#), following a strategy similar to [Arellano \(2008\)](#). In summary, we calibrate β , ψ , μ , σ^ϵ , ρ^ϵ to match five data moments by simulations as shown in [Table 5](#).

Table 5: Data and model moments

Moments	Data	Model
$\rho(y)$	0.98	0.95
$\sigma(y)$	0.10	0.07
Average duration of default	30	31.6
Default frequency (%)	0.64	0.51
Share of quarters in default (%)	17.6	16.1

Note: $\sigma(x)$ denotes the standard deviation of x and $\rho(x)$ denotes the first order autocorrelation of x .

In the same spirit as in [Arellano \(2008\)](#), to compute the moments in the model we simulate the economy for 100,000 periods. Then we identify the default episodes and compute the average duration of default, the default frequency and the share of quarters in default. We then use subsamples of 275 quarters that do not contain default episodes to compute the autocorrelation and standard error of income. The model is able to match the target moments as well as reproduce several aspects of the economy that are not used as targets for our calibration, as discussed in the following section.

4.2 Dynamics

This section evaluates the performance of the model in terms of private and sovereign financial variables. In particular, we are interested in the ergodic mean of the private loan rate and sovereign spread statistics implied by the model in normal times and during times of crisis. [Table 6](#) presents some of these statistics.

Table 6: Non-Targeted Moments (Private and sovereign rates)

	Data		Model	
	Pre-Crisis	Crisis	Pre-Crisis	Crisis
Sovereign Spread	0.12	3.90	0.039	4.23
Private Spread	2.32	2.81	0.11	5.22
Correlation	-0.54	0.68	0.14	0.50
Output Loss	-	-	0.2	0.6

Note: For the data moments, the “Pre-crisis” period refers to the period between 2003 to 2008 while the “crisis” period refers to the post-2008 data. For the model moments, the “Pre-crisis” period refers to the subsample for which the spread are below 0.28%, which corresponds to the average maximum spread level registered before 2008.

The model is able to capture the increasing correlation between sovereign spreads and private-sector loan rates. As seen in the table, on average, the correlation is negative during normal times and positive and large during times of crisis. On the other hand, the model can generate a large positive correlation during bad times and mild positive correlation during normal times. Also, the model is able to qualitatively match several aspects of the behavior of sovereign spreads and private rates. Specifically, the model captures the increase in the mean of both private and sovereign rates during times of crisis. How relevant is the role of financial friction in our model? We can answer this question by computing the average output loss (as a percentage of GDP) implied by the model during periods of crisis and during normal times. Recall that output loss is generated in our model by the interaction between working capital constraints and the portfolio adjustment cost. As Table 6 displays, output losses are quantitatively important in the model: during the normal crisis they account for 0.2 percent of GDP and they triple during a sovereign crisis. This is a feature that the standard default model without financial frictions cannot capture. Hence, our model is able to incorporate the tightening of the link between sovereign rates and private rates during a sovereign crisis, which, in turn, endogenously generates increasing output losses due to financial inefficiency. One of the novel contributions of this paper is to explore how international policies (such as bailout strategies) are affected by this important, and relatively unexplored, consequence of the crisis.

5 Outright Monetary Transactions

In August 2012, the European Central Bank (ECB) announced the creation of the Outright Monetary Transactions program (OMT), aimed at reducing sovereign bonds’ interest rates faced by troubled economies. If a country entered the program, the ECB would buy its bonds on the

secondary market and would keep them until maturity or until the spread decreased, implying that the policy would ultimately lead to an intertemporal transfer of resources to the domestic economy. However, at the same time, a participating country would be under strict conditions in the form of fiscal austerity measures or structural reforms. Therefore, unlike previous ECB bond-buying program, the Securities Market Program, this program is conditional and comes with particular trade offs. We refer to these restrictions as the “conditionality clause”, described in the official announcement of the program⁸.

We augment the baseline model so as to allow us to evaluate a policy in spirit of the OMT policy. Specifically, with respect to a standard endogenous default model, we add a third government choice. A country can choose to: 1) default on its debt obligations, 2) to repay the debt, or 3) repay its debt obligation while entering in a bailout program. In this case, a third party (for instance a monetary authority or an international organization) transfers funds to the domestic economy and imposes a limit that constrains borrowing during the length of the program. The borrowing limit imposed on a participating country depicts the conditionality clause of the OMT program as described above.

Our setting builds on [Aguiar and Gopinath \(2006\)](#), who treat bailouts simply as unconditional transfers of resources from a non-modeled third party to creditors when defaults occur. Hence, bailouts are equivalent to subsidizing default. However, their setup is not suitable for studying the OMT policy because it cannot capture any strategic choice about whether to enter a bailout program, and it cannot capture the conditionality requirement of the OMT policy. Our setup, instead, introduces an endogenous decision for entering the bailout program induced by weighting the benefit (additional resources) and the cost (borrowing constraints) with respect to the alternative choices (default or repaying the debt without asking for a bailout).

We focus on two important questions. Can OMT policies reduce sovereign risk? And, by exploiting the sovereign spread-private credit link, to what extent can OMT policies ameliorate private credit condition and reduce inefficiency due to financial frictions? Whereas the first question can be answered abstracting from a model with a private financial sector, our framework provides the components necessary to analyze and quantify the feedback effect that bailout policies have on the private credit sector.

5.1 Setup

To model OMT policies, we follow the setup used in [Pancrazi et al. \(2013\)](#), in which the authors examine the optimal bailout setting by taking into account both the welfare gain of bailouts from

⁸Details of the OMT program can be found at http://www.ecb.europa.eu/press/pr/date/2012/html/pr120906_1.en.html

a point of view of the domestic economy, and the welfare cost of bailouts from the point of view of the third party that finances them. However, here, we focus only on the domestic economy in order to explore how OMT policies affect sovereign bond spreads, private rates, and output losses. In particular, we extend government's choice set with respect to the benchmark model presented in the previous sections in order to implement a bailout policy. We assume that the government now has three choices: to repay its debt, default, or enter a bailout program. The first two choices remain as we have previously described. We now describe the option of entering a bailout program.

If the government enters the bailout program, it receives a transfer of resources from a third party. While in the program, a country cannot ask for additional bailout funds or exit the program voluntarily; nevertheless, the government can choose to default on its debt. For simplicity we assume that exiting from the bailout program occurs with an exogenous probability. Implicitly, we assume that the domestic economy does not incur any pecuniary cost from receiving a bailout. However, once in the program, the government is financially constrained on its asset position in that it cannot borrow more than \bar{b} , a limit imposed by the third party. This feature captures the previously described “conditionality clause” of the OMT program.

When a government enters the bailout program, consumption is given by:

$$c = y - \eta wh \left(\frac{R^d - 1}{R^d} \right) + b' - q(b', \varepsilon) b' - \Psi(b') + G(b),$$

where $G(b) \geq 0$ is the size of the bailout injected. We assume that the bailout size is zero if level of assets held by the domestic economy is positive and that the function $G(\cdot)$ is a non-decreasing function of b . This means that $G(0) = 0$ and $\frac{\partial G}{\partial b} \geq 0$. The first assumption captures the notion that bailouts are present only when the domestic country has debt. The second assumption captures the notion that bailouts from the third party are proportional to the degree of the fiscal imbalances of the country. For simplicity, in this paper we assume that $G(b)$ is a constant, G . As in the benchmark model, the government observes the income shock ε and, given initial foreign assets b , chooses whether to repay the debt and remain in the contract; to repay the debt and ask for a bailout; or to default. If the government chooses to repay its debt and remain in the contract, then it chooses the new level of foreign assets b' . However, if it chooses to repay its debt and ask for a bailout, the new level of foreign asset position is bounded above by a limit \bar{b} , reflecting the “conditionality clause”.

The government understands that the price of new borrowing $q(b', \varepsilon)$ depends on the state ε and on its choice of b' . Define $v^o(b, \varepsilon)$ as the value function for the government which starts the current period with assets b and endowment ε , and has the option to default; pay its debt and remain in the contract; or pay its debt and enter the bailout program. Define $v^{op}(b, \varepsilon)$ as the value function for the government which starts the current period with assets b and endowment ε , and

has the option to default but not to ask for a bailout since it is already in the bailout program. The government decides whether to repay its debt, with or without asking for a bailout, or to default in order to maximize the welfare of households. Value $v^o(b, \varepsilon)$ satisfies:

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

where $v^c(b, \varepsilon)$ is the value associated with not defaulting and not asking for a bailout, $v^b(b, \varepsilon)$ is the value associated with not defaulting and asking for a bailout, and $v^d(\varepsilon)$ is the value of defaulting. Once in the bailout program, the government cannot ask for an additional bailout. Therefore, $v^{op}(b, \varepsilon)$ satisfies:

$$v^{op}(b, \varepsilon) = \max \{v^p(b, \varepsilon), v^d(\varepsilon)\},$$

where $v^p(b, \varepsilon)$ is the value associated with remaining in the bailout program, and $v^d(\varepsilon)$ is the value of defaulting.

When the government defaults, the economy is temporarily in financial autarky and income falls and equals consumption. The value of default is then given by:

$$v^d(\varepsilon) = u(\varepsilon^{def}) + \beta \int_{\varepsilon'} [\theta v^o(0, \varepsilon') + (1 - \theta)v^d(\varepsilon')] f(\varepsilon', \varepsilon) d\varepsilon',$$

where θ is the probability that the economy will regain access to the international credit markets.

When the government chooses to remain in the credit relationship while not entering the bailout program, the corresponding value is:

$$v^c(b, \varepsilon) = \max_{b'} \left\{ u(y + b - q(b', \varepsilon)b') + \beta \int_{\varepsilon'} v^o(b', \varepsilon') f(\varepsilon', \varepsilon) d\varepsilon' \right\}.$$

When the government chooses to remain in the credit relationship while entering in the bailout program, the corresponding value is:

$$v^b(b, \varepsilon) = \max_{b' \geq \bar{b}} \left\{ u(y + b - q(b', \varepsilon)b' + G) + \beta \int_{\varepsilon'} [\mu v^{op}(b', \varepsilon') + (1 - \mu)v^o(b', \varepsilon')] f(\varepsilon', \varepsilon) d\varepsilon' \right\},$$

where μ is the probability that the economy will stay in the bailout program in the next period.

Finally, when the government is already in the bailout program because it had chosen in the past to utilize a transfer from the third party, the corresponding value is:

$$v^p(b, \varepsilon) = \max_{b' \geq \bar{b}} \left\{ u(\varepsilon + b - q(b', \varepsilon)b') + \beta \int_{\varepsilon'} [\mu v^{op}(b', \varepsilon') + (1 - \mu)v^o(B', \varepsilon')] f(\varepsilon', \varepsilon) d\varepsilon' \right\}.$$

The government policy can be characterized by repayment sets, bailout sets, and default sets. However, those sets are different conditional on the government being in the bailout program (P)

or not (\bar{P}). Conditional on participation in the bailout program, the repayment set $R(b|P)$, is the set of ε 's for which repayment is optimal when asset are b , that is:

$$R(b|P) = \{\varepsilon \in \epsilon : v^p(b, \varepsilon) \geq v^d(\varepsilon)\}.$$

Conditional on being in the bailout program the default set, $D(b|P)$ is the set of ε 's for which default is optimal when asset are b , that is:

$$D(b|P) = \{\varepsilon \in \epsilon : v^d(\varepsilon) > v^p(b, \varepsilon)\}.$$

Conditional on not being in the bailout program, the government has three choices: repayment without bailout, set $R(B|\bar{P})$, repayment with bailout, set $RP(B|\bar{P})$, and default, set $D(B|\bar{P})$. These sets are formally given by:

$$\begin{aligned} R(b|\bar{P}) &= \{\varepsilon \in \epsilon : v^c(b', \varepsilon) \geq \max\{v^b(b', \varepsilon), v^d(\varepsilon)\}\} \\ RP(b|\bar{P}) &= \{\varepsilon \in \epsilon : v^b(b', \varepsilon) \geq \max\{v^c(b', \varepsilon), v^d(\varepsilon)\}\} \\ D(b|\bar{P}) &= \{\varepsilon \in \epsilon : v^d(\varepsilon) > \max\{v^c(b', \varepsilon), v^b(b', \varepsilon)\}\}. \end{aligned}$$

[Pancrazi et al. \(2013\)](#) explore the properties of the three sets. We refer to that work for additional details.

5.2 Calibration

There are three parameters that characterize our policy intervention: the size of the bailout, G , the probability of exiting the bailout program ($1 - \mu$), and the upper limit on borrowing while in the bailout program, \bar{b} . Obviously, there is not an observable empirical target for these parameters since the OMT has not been implemented yet. Nevertheless we calibrate these to be as realistic as possible.

To calibrate the size of the transfers to the small, open economy, we assume the bailout size to be of similar proportions as the transfers our example nations received during the last three years: In May 2010, Greece obtained a bailout of \$110 billion (US) (36 percent of GDP); in November 2010, Ireland obtained a bailout of \$113 billion (51 percent of GDP); in May 2011, Portugal obtained a bailout of \$116 billion (48 percent of GDP, annually); in June 2012, the Spanish banking sector obtained a bailout of \$125 billion (9 percent of Spanish GDP). In line with these observations, our model considers a bailout representing 15 percent of average GDP. Notice that our calibration is conservative with respect to the average size of bailouts experienced in the recent crisis. Hence, our results could be interpreted as a lower bound.

We can relate the probability of exiting a bailout program to the strictness of international treaties (like the Maastricht treaty for EU).⁹ Given the relatively frequent deviations from the Stability and Growth pact that the EU countries consistently experienced in the last decade, we assume that the bailout regime is not an absorbing state, but that it is possible to reenter in the unconstrained regime after getting a bailout $(1 - \mu)$ with probability equal to 0.2, which implies an expected duration of the constrained regime of 5 quarters: our results are however robust to different calibration of this probability.

Finally, we need to set the borrowing limit that the international authority imposes on a country entering a bailout program. We examine two cases: in the first, the limit is strict, and the country entering the program cannot borrow more than 50 percent of its GDP; in the second, the limit is more permissive, and the upper bound of debt for a participating country is 80 percent of GDP.

5.3 OMT and sovereign risk

Introduction of the bailout option affects default sets. Intuitively, as pointed out in [Pancrazi et al. \(2013\)](#), the presence of a bailout option significantly reduces the default set, since there is a region of the state space for which requesting a bailout intervention is preferred to defaulting. In [Figure 2](#), the blue region represents the default set, while the red region represents the area where asking for a bailout is optimal, when assuming a strict bailout policy. The light shaded area displays the default set in a model with the same calibration but in which bailouts are not available. The top panel shows the sets conditional on being in the credit relationship without being in the bailout program: the default set is significantly smaller than in the economy in which bailouts are not available, and there is a significant portion of the state space where the country will prefer to ask for a bailout. The bottom panel of the figure shows the sets conditional on already being in the bailout program. Since additional bailouts are not feasible when a country is already in the bailout program, the intervention set is empty by construction. Notice that, for our parameterization, the government never defaults while in the bailout program since the asset levels for which default is optimal are beyond the borrowing limit faced by a country when it enters the program. This limit is represented by the vertical dashed line, and asset levels to its left are not feasible. By looking at only at the upper panel, it is evident that a presence of bailout policy, even if never implemented alters the default sets with respect to the economy in which there is no bailout option. In fact, OMTs have never been implemented in an economy, but we show that these policies do not need to be implemented in order to have some positive effects.

The shrinking of default sets impacts the sovereign credit market conditions. In fact, interna-

⁹<http://www.acting-man.com/?p=12519>

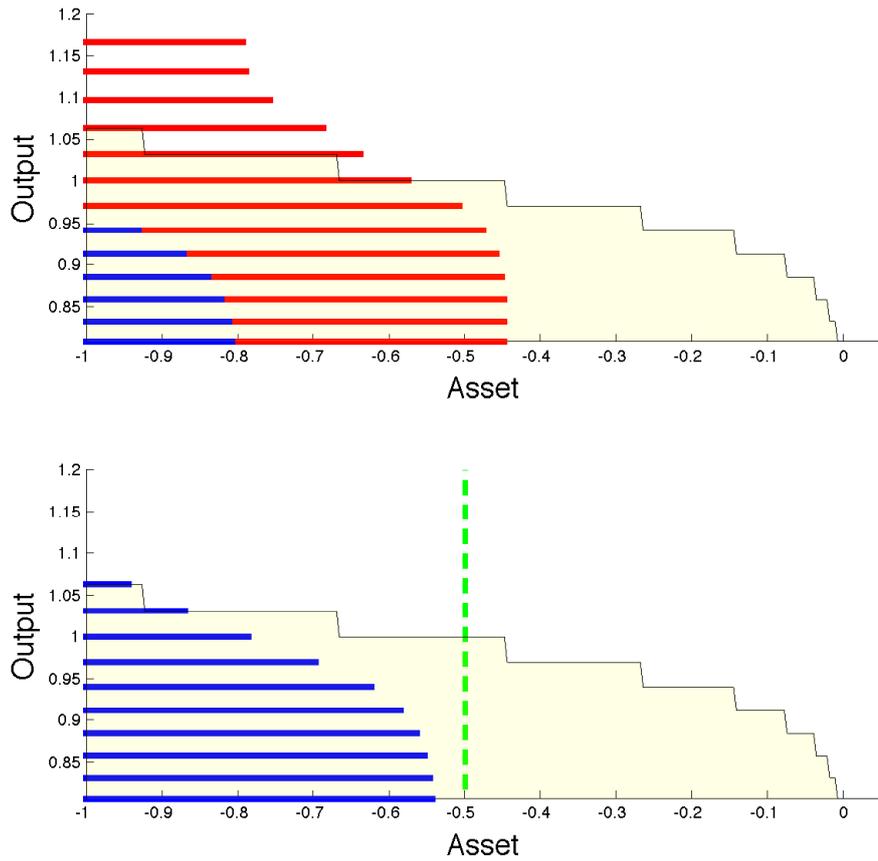


Figure 2: Default and Intervention sets

Note: The top figure represents the default and intervention sets when the economy is in normal times and the bottom panel represents these sets conditional on being already in a bailout program. Blue region denotes the default set; red region denotes the repayment with intervention; shaded region represent the default set when bailout is not available. The vertical line represents the borrowing limit under intervention.

tional investors understand that countries have lower default probability as a result of the bailout option and, consequently, they request a smaller premium when lending to the governments. This feature is clear in Figure 3. Here, we report the price bond schedule, $q(b', \varepsilon)$, in a model with bailout using the thick blue lines, and in a model without bailout using the thin red lines. Each line corresponds to the price of bond as a function of the asset holdings (x-axis), for three different levels of output: low, average and high, from top to bottom respectively. Note that the price bond schedule is always larger in an economy where bailouts are available.

Figure 4 presents sovereign spreads for the economies with and without bailout options in thick blue and thin red lines, respectively. The darker shaded area represents the region where repayment without bailout is optimal, while the white area is the area in which asking for a bailout is optimal.

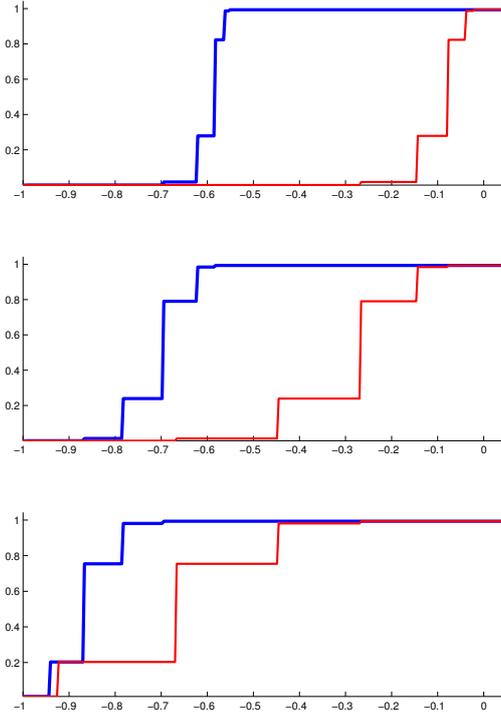


Figure 3: Price bond schedule

Note: Each figure from top to bottom, represents the price bond schedules conditional on low-, average- and high-output levels. The thick blue lines represent the price functions in model with bailout, and the thin red lines represent those of a model without bailout option.

The top panel displays spreads conditional on a low level of output, the middle panel on an average level of output, and the bottom panel on a high level of output. First, consider the model where bailouts are available (thick blue lines): spreads increase only for level of debt near the region where bailouts are optimal (i.e. where the dark shaded area ends); however, when entering the bailout program, spreads drop as the economy receives a transfer from a third party. Another important result that can be inferred from Figure 4 is related to the effectiveness of bailout policies in terms of reducing spreads. In particular, consider the state space where repaying the debt is optimal both in the model with and without a bailout option. That region corresponds to levels of debt where the thin red line is continuous¹⁰. Notice that the existence of the program effectively reduces spread even for levels of debt for which bailout is not requested.

Table 7 presents some quantitative implications of OMT policies for two types of a bailout program (strict and permissive), in a model without financial frictions (left panel) and with financial

¹⁰Spreads are not defined when a country defaults, since by assumption, the country is excluded from international markets. Hence, we can infer default regions in Figure 4 by the level of debt where the spread function disappears

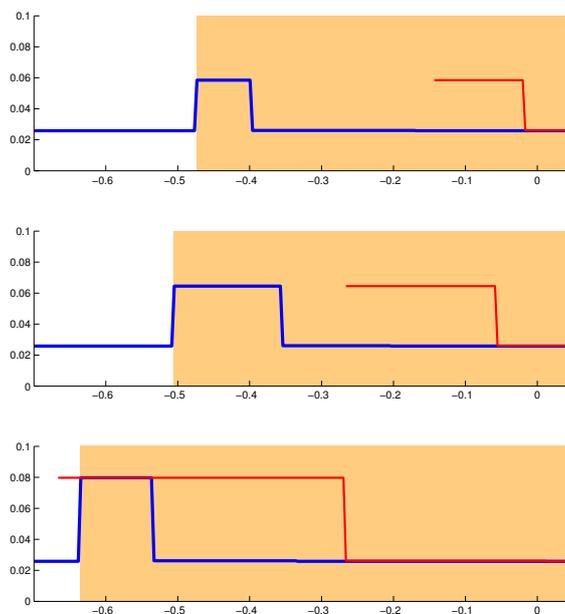


Figure 4: Sovereign spread and intervention sets

Note: Each figure from top to bottom, represents the price bond schedules conditional on low, average and high output levels. The thick blue lines represent the price functions in model with bailout and the thin red lines represent those of a model without bailout option. The dark shaded area represents the region for which repayment of debt without asking for a bailout is optimal (in a model with bailout options). The non-shaded area represents the region for which repayment of debt with asking for a bailout is optimal (in a model with bailout options). The repayment region for the model without bailouts consists of level of debts where the red thin spread function is continuous.

frictions (right panel). Two interesting results are worth noticing.

First, the presence of OMT policy drastically reduces the exposure of an economy to default. In fact, both the model with and without financial frictions imply a large share of quarters in default (19 and 16 percent, respectively) when bailouts are not feasible; however, when we introduce a bailout option, the share of quarters in default drastically diminishes. Notice that the reduction is larger when bailout is permissive and when financial frictions are present. These results suggest that there is a large portion of the state space (which is a pair of debt level and current output level) where asking for a bailout is preferable to defaulting. In that portion of the state space, a government has incentive to ask for a transfer and reduce its debt level rather than to default, pay its cost, and remain completely excluded from the international financial markets. As a result, when OMT is feasible, the default region shrinks and a government makes a large use of this policy, as indicated by the large fraction of share of quarters in the intervention program (around 75 %).

Second, the OMT successfully reduces the sovereign spreads. Arguably, the aim of the ECB

Table 7: Quantitative implications of OMT policies

	No Financial Friction			Financial Friction		
	No OMT	strict	permissive	No OMT	strict	permissive
Sh. of periods in def.	19.1	3.5	1.8	16.1	2.0	1.2
Intervention freq.		75	78		76	77
Mean Sovereign Bond Return	5.7	2.9	2.7	5.1	2.8	2.7
Mean Private Rate	-	-	-	5.8	4.1	3.9
Output loss	0.00	0.00	0.00	0.38	0.35	0.32
Welfare	-	7.6	9.4	-	8.0	10.4

Note: All moments are conditional on non-default. Default and intervention frequencies, $\mu(R^g)$ and $\mu(R^p)$ are in percentages; output loss is in average GDP percentage. The welfare statistics should be interpreted as the percentage of consumption that the representative agent in the domestic economy without bailout is willing to give up to live in an economy with bailout, while keeping the average amount of resources in the economy constant. To do that, we rescale the output endowment in the economy without bailout to have the same mean as the total amount of resources (output level plus resources obtained from the bailout) as in the economy with bailout. Hence, this adjustment isolates the welfare effects of bailouts stemming from the reduction of the cost of debt obligation and of output losses.

when it designed the OMT policy was to bring bond yields down in order to lower borrowing costs. As Table 7 shows, the government bond interest rate falls by almost 300 basis points when OMT is introduced. The intuition is simple: international investors are aware that asking for a bailout is now an additional option for the government to avoid default. Since, as explained above, the default probability falls, investors ask for a lower premium when lending to the government.

5.4 OMT and the role of financial frictions

This section describes in detail the feedback effect that OMT policies have on private credit, through the presence of financial frictions in our economy. In fact, from Table 7, note that OMT policies have large and remarkable effects on the private sector spreads as well. When considering a model with financial frictions, we can observe that the reduction of government bond rates is associated with a reduction of the private loan rates. This link, generated by the presence of working capital constraint and financial intermediaries, has important implications for the OMT policy's impact on output losses and welfare. In fact, the reduction of private loan rates diminishes the inefficiency generated by financial frictions, as displayed by the lower output loss (in percent of GDP) when OMT policy option is present. Hence, when taking into account the spillover effect that sovereign risk transmits to the private sector, bailout policies are even more desirable. To

quantify the gain brought by the bailout policy due to reduction of financial frictions, we find that a permissive bailout policy reduces output losses by 0.06 percent with respect to an economy without a bailout option. Considering the examples of European economies, the gain stemming from reduced inefficiency alone would be equivalent to \$1.2 billion (US) in Italy and \$800 million in Spain.

Finally, we are able to compute a welfare gain attributable to the presence of the OMT policy. In particular, we compute the percentage of consumption level that an agent who lives in an economy where bailouts are not an option, is willing to give up to live in an economy where bailouts are an option. In other words, we compute the level of welfare, in terms of consumption equivalent, associated with the additional option of asking for a bailout. It is important to stress that the welfare computation abstracts the additional resources obtained by the domestic country when applying for a bailout. In fact, to compute welfare we rescale the output endowment in the economy without bailout to have the same mean as the total amount of resources (output level plus resources obtained from the bailout) as in the economy with bailout. Hence, this adjustment isolates the welfare effects of bailouts stemming from the reduction of the cost of debt obligation and of output losses. First, notice that OMT policies are highly desirable even in an economy without financial friction: the welfare gain is 7.6 percent in the case of a strict OMT policy and 9.4 percent in case of a permissive policy. We can interpret the large welfare gain with the aversion of agent to default: defaults are very costly, but, when bailouts are not an option, they still could be optimal. However, when a third option is available (i.e. the OMT), the representative agent is largely better off since she can avoid the cost of defaults. When we consider a model with financial friction, the welfare gain are even larger, up to 1 percent of consumption equivalent in case of a permissive OMT policy. These results stem from the OMT's additional beneficial effect generated by stabilizing the private credit and reducing the inefficiency due to financial friction.

6 Concluding remarks

We study the effects of recently proposed bailout policies, such as Outright Monetary Transactions (OMT). These policies were proposed by the ECB in order to fight very high borrowing costs faced by many European economies. Using the data of five troubled economies (Greece, Italy, Ireland, Portugal and Spain, which we refer to collectively as GIIPS), we show that unfavorable sovereign borrowing conditions prompted unfavorable conditions for private borrowing as well. While the conditions of the two markets are not highly correlated during non-crises times, we show that they are highly correlated during crises times. This means that policies designed to reduce sovereign borrowing rates will have a domino effect on the private borrowing rates, which, in turn,

affect output losses, income levels and volatile spreads of an already troubled economy. Therefore, meaningful evaluating of these policies must consider the connection.

We design a small open economy populated by households, firms and banks that participate in international asset markets. We assume that the government in the domestic economy cannot commit to honoring its debt, and, hence, there exists a default probability which generates an endogenous risk premium. This gives rise to an endogenous link between sovereign and private spreads during times of crisis. In particular, when output is relatively low or debt is relatively high, sovereign spread arises endogenously because of the existence of default probability. Additionally, private spread arises endogenously because of the existence of financial frictions. During times of crisis, when the sovereign spread increases, the private rate also increases and becomes more volatile, as observed in the data stemming from the recent Eurozone crisis. The increase in private spreads, increases the amount of resources used to finance production process, which represents an output loss for the economy. This loss, absent in models that do not take financial frictions into account, is the key to understanding the welfare implications of OMT policies.

To analyze the impact of OMTs, we allow the government of a small open economy three options: to honor the outstanding debt, to default, or to ask for a rescue bailout. In other words, we assume that a country, in addition to defaulting or paying its debt, can also choose to enter the bailout program, which is subject to economic conditionality in the form of borrowing constraints. We document that OMT policies have powerful and positive effects on default incentives. Moreover, the positive impact of OMT policies surfaces even if the government chooses to forgo participation in the program; the mere presence of a bailout option has a positive beneficial effect on sovereign spreads, as investors assign lower probability to the default scenario.

When considering a model with financial frictions, we show that the reduction of government bond rates is associated with a reduction of the private loan rates. In this case, the reduction of private loan rates diminishes the inefficiency generated by financial frictions, and lower output losses. Hence, once we consider the spillover effects that sovereign risk has on private spreads, bailout policies are even more desirable.

Additionally, our work estimates the welfare benefits, measured in terms of the consumption equivalent associated with a government bailout option. Welfare benefits of 7.6 percent to 9.4 percent (depending on the bailout conditions) emerge even in an economy without financial frictions. When we consider a model with financial frictions, the welfare gain are even larger, up to an additional one percent in consumption-equivalent terms. The underlying reason for this finding is the role financial frictions play in exacerbating the impact of sovereign spreads. Moreover, we show that even if the government decides against asking for a bailout, the mere presence of the program still yields positive effects that stem from markets taking into account the reduced likelihood of

defaults as a result of the availability of an extra tool for government during bad times.

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A Firms Problem

The debt position of the firm, d_t , evolves according to the following expression:

$$d_t = R_{t-1}^d d_{t-1} - \varepsilon_t F(k, h_t) + w_t h_t + u_t k + \pi_t - \kappa_{t-1} + \kappa_t,$$

where π_t denotes distributed profits in period t and R_t^d is the relevant interest rate at which domestic firms borrow. Finally, as in [Uribe and Yue \(2006\)](#) we assume that bank profits are distributed to the households in a lump-sum fashion. Define the firm's total liabilities at the end of period t as $a_t = R_t^d d_t - \kappa_t$. Then we can rewrite the evolution of firm liabilities as,

$$\frac{a_t}{R_t^d} = a_{t-1} - \varepsilon_t F(k, h_t) + w_t h_t + u_t k + \pi_t + \left(\frac{R_t^d - 1}{R_t^d} \right) \kappa_t.$$

We limit attention to the case in which the interest rate is positive. This implies that the working capital constraint always binds, since otherwise the firm would incur unnecessary financial costs, which would be suboptimal. Given this, we can use the working capital constraint equation to eliminate κ_t and obtain:

$$\frac{a_t}{R_t^d} = a_{t-1} - \varepsilon_t F(k, h_t) + w_t h_t \left[1 + \eta \left(\frac{R_t^d - 1}{R_t^d} \right) \right] + u_t k + \pi_t. \quad (4)$$

As can be seen in equation (4), the working capital constraint introduces an extra cost to labor bill, $\left[\eta \left(\frac{R_t^d - 1}{R_t^d} \right) \right]$. This cost is increasing in the interest rate experienced by the firm, R_t^d .

The firm objective function is to maximize the present discounted value of the stream of profits distributed to its owners (domestic residents):

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \Gamma^t \pi_t.$$

Here, Γ^t denotes the appropriate discount factor given the households problem. Using (4) to eliminate π_t , the problem is to choose a_t to maximize

$$\max \mathbb{E}_0 \sum_{t=0}^{\infty} \Gamma^t \left\{ \frac{a_t}{R_t^d} - a_{t-1} + \varepsilon_t F(k, h_t) - w_t h_t \left[1 + \eta \left(\frac{R_t^d - 1}{R_t^d} \right) \right] - u_t k \right\}$$

together with the no-Ponzi-game constraint.

We assume that the initial level of assets of firms equals zero. In this case, the optimal plan consists on holding no liabilities at all times, $a_t = 0$ for any t . Profits are given by,

$$\pi_t = \varepsilon_t F(k, h_t) - w_t h_t \left[1 + \eta \left(\frac{R_t^d - 1}{R_t^d} \right) \right] - u_t k.$$

B Recursive Equilibrium in the Benchmark Model

In our model, the state of the economy is determined by two variables: the country's asset position, b , and the productivity level, ε . Given the state, $s = (b, \varepsilon)$, the policy function for the government b' , the price function for bonds, q , the domestic rate R^d , and the policy function for the consumers, c , determine the equilibrium.

Households consume the net output, given by the total production minus the loss from the financial friction arising from the working capital constraint, plus the transfer from the government's foreign credit operations. Foreign creditors are risk neutral and lend the amount of debt demanded by the government as long as the expected gross return on bonds equals $(1 + r)$. Thus, the bond price satisfies

$$q(b', \varepsilon) = \frac{1 - \delta(b', \varepsilon)}{1 + r}.$$

The government observes the productivity level ε , the demand elasticity of the banking sector η , and given the initial asset holding B , chooses to repay its outstanding debt or to default. If the government repays the debt obligations it then chooses a new level of assets B' . We start by assuming that the government understands that the price of new borrowing $q(B', \varepsilon)$ and the private loan rate $R^d(b', \varepsilon)$ depend on the exogenous state, ε , η and on its own choice of B' , i.e. we assume that there is full internalization. Therefore, we can proceed by solving the planner's problem.

Define $v^o(B, \varepsilon)$ as the value function for the government that has the option to default. The government decides whether to default or to repay its debt in order to maximize the welfare of households. Given the option to default, $v^o(b, \varepsilon)$ satisfies

$$v^o(b, \varepsilon) = \max_{\{b', def\}} \{v^c(b', \varepsilon), v^d(\varepsilon)\},$$

where def denotes the default option, $v^c(b, \varepsilon)$ is the value associated with not defaulting and staying in the debt contract and $v^d(\varepsilon)$ is the value of the default option.

When the government defaults, the economy is temporary in financial autarky and experiences productivity losses. In his scenario, private lending stops and therefore the financial friction arising from the working capital constraint. In practice, we capture the disruptive nature of a default with a decline in average productivity. We assume that with some probability, θ , the economy can return to international financial markets. In this case, the debt is reset to zero. The value of default is then given by,

$$v^d(\varepsilon) = u(\varepsilon^{def} F(k, h)) + \beta \int_{\varepsilon'} [\theta v^o(0, \varepsilon') + (1 - \theta) v^d(\varepsilon')] f(\varepsilon', \varepsilon) d\varepsilon',$$

On the other hand, if the government chooses to remain in the contract, the value conditional on not defaulting is given by,

The government decides an optimal policy b' to maximize households utility by allowing consumption smoothing. Notice that the wage is affected by the working capital constraint, and therefore, it depends on the private rate R^d . As stated in the previous section, the private rate is related to the sovereign bond price through the debt adjustment cost.

The government default policy can be characterized by default sets and repayments sets. Let $A(b)$ be the set of (ε) such that:

$$A(b) = \{(\varepsilon) \in (\varepsilon) : v^c(b', \varepsilon) \geq v^d(\varepsilon)\},$$

and let $D(b) = \tilde{A}(b)$ be the set (ε) for which default is optimal,

$$D(b) = \{(\varepsilon) \in (\varepsilon) : v^c(b', \varepsilon) < v^d(\varepsilon)\}.$$

The equilibrium is then defined as follows:

Definition 1. Recursive Equilibrium

Given the state of the economy $s = (b, \varepsilon)$, the recursive equilibrium for this economy is defined as a set of policy functions for consumption, $c(s)$, government's asset holdings $b'(s)$, repayment set $A(b)$ and default set $D(b)$, the price function for bonds $q(B', \varepsilon)$ and a domestic rate $R^d(B', \varepsilon)$, such that

1. Taking as given the government policies and prices, households' consumption is feasible.
2. Taking as given the bond price function $q(b', \varepsilon)$ and the domestic rate $R^d(B', \varepsilon)$ satisfying (3), the government policy functions $B'(s)$ and the repayment set $A(B)$ and default set $D(b)$ satisfy the government optimization problem.
3. Bond prices $q(b', \varepsilon)$ reflect the government's default probability and are consistent with creditors' expected zero profits.

Then, we have a relationship between default probabilities $\delta(b', \varepsilon)$ and default sets $D(b)$, i.e.:

$$\delta(b', \varepsilon) = \int_{D(b')} f(\varepsilon', \varepsilon) d\varepsilon'.$$