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Banking Regulation with Risk of Sovereign Default

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Abstract

Banking regulation routinely designates some assets as safe and thus does not require banks to hold any additional capital to protect against losses from these assets. A typical such safe asset is domestic government debt. There are numerous examples of banking regulation treating domestic government bonds as "safe," even when there is clear risk of default on these bonds. We show, in a parsimonious model, that this failure to recognize the riskiness of government debt allows (and induces) domestic banks to "gamble" with depositors' funds by purchasing risky government bonds (and assets closely correlated with them). A sovereign default in this environment then results in a banking crisis. Critically, we show that permitting banks to gamble this way lowers the cost of borrowing for the government. Thus, if the borrower and the regulator are the same entity (the government), that entity has an incentive to ignore the riskiness of the sovereign bonds. We present empirical evidence in support of the key mechanism we are highlighting, drawing on the experience of Russia in the run-up to its 1998 default and on the recent Eurozone debt crisis.

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1 Introduction

Sovereign debt crises are often accompanied by major banking crises in the affected countries, with examples ranging from Russia in 1998 and Argentina in 2001 to the recent crisis in peripheral Eurozone countries. We argue that inadequate prudential regulations, which do not recognize the riskiness of government debt, may be responsible for banks' excessive exposure to government debt and, as a result, for the major banking crises that follow the defaults.[1]

The basic story is simple. Banks fund their investment with deposits and are protected by limited liability. This situation creates incentives for excessive risk-taking on the part of the banks.[2] To prevent excessive risk-taking, governments introduce prudential regulation, which requires banks to hold sufficient amounts of capital (have enough of their own wealth at stake) so that excessive risk-taking is no longer attractive. Certain "safe" securities are exempt from capital adequacy requirement. The classic such safe security (from the point of view of prudential regulation) is government debt. However, government debt is not always as safe as the prudential regulation considers it to be. What happens when "safe" government debt becomes risky? Prudential regulation may fail in that case. The banks are then able to gamble (i.e., take on excessive risks by purchasing government debt) while still satisfying the prudential regulation. If the government does not default *ex-post*, the gamble works out, and everyone is happy; but if the government does default, the whole banking system comes crashing down.

We provide a very simple model that captures the basic story. The model provides an interesting insight into why the prudential regulations were not adjusted to account for the riskiness of government debt. Highly indebted governments may *choose* not to adjust the regulation in order to postpone (or prevent) a looming debt crisis. By not adjusting the regulation, the government lowers its cost of borrowing as banks are willing to pay more than actuarially fair prices for the government bonds. Effectively, by allowing the banks to gamble with depositors' money, the government itself is gambling for redemption. If the government is more interested in avoiding (or even postponing) default than in the well-being of its citizens, it will choose to (let the banks) gamble in this way. In a way, the key message of our paper can be viewed as an example of the problem that Hurwicz (2008) termed (in

[1]Daniele Nouy, the chair of the Supervisory Board of the European Central Bank, and Olivier Guersent, the director general of the European Commission's Directorate-General for Financial Stability, Financial Services and Capital Markets Union, have recently used a very similar argument when calling for an end to the treatment of domestic government bonds as risk-free (see Morris and Jenkins (2018) and Jenkins (2019)).

[2]As Jensen and Meckling (1976) point out in their seminal work, the basic insight appears in Smith (1776).

the words of Juvenal[3]) "Who will guard the guardians?"

We start with the simplest model of banking in which there is a role for prudential regulation, before introducing a government and government debt. Our two-period environment is populated by risk-averse depositors, who need to save for retirement; risk-neutral entrepreneurs, who need to borrow to finance productive investment; risk-neutral investors, who can open banks to intermediate financing between the households and entrepreneurs; and the government, which regulates banks and issues debt. We model both households and entrepreneurs in the most parsimonious way, and focus on incentives and behavior of bankers and the regulator. We assume that households lack the ability to invest directly in productive projects and supply saving (inelastically) into the banking sector. There are two types of entrepreneurs, which can be thought of simply as two types of investment projects — safe productive investments and risky projects with lower expected returns but significant upside. Investors, who may choose to open banks and accept households' deposits, are endowed with some wealth and a unique ability to screen entrepreneurs. Critically, banks are subject to limited liability. The presence of risky projects and limited liability generates moral hazard in banking — unregulated banks have strong incentive to invest in inefficient gambles. Since only investors are capable of distinguishing between the two types of projects, the only way to prevent banks from investing in inefficient risky projects is to force the bankers to have minimal equity (capital) in their banks. If bankers have enough "skin in the game," they choose the efficient safe investment strategy. The government in the model plays two critical roles — it regulates the banking sector and borrows to finance (exogenous) budget deficit. Banking regulation takes the form of risk-weighted capital adequacy requirements. Since government debt is the only investment readily identifiable by the regulator in the model, our prudential regulation has two key parameters — the minimum capital requirement and the risk weight assigned to government bonds.

We characterize equilibrium outcomes in our model for the full range of capital requirements and for three key values of the risk weight on government bonds — zero (i.e., ignoring the risk altogether), one (i.e., treating government bonds the same as any other investment), and prohibitive (i.e., sufficiently high to prevent banks from investing any of their depositors' funds into government bonds). The first result confirms what the model was built to deliver: Prudential regulation that works when government debt is safe fails when government debt is risky. Yet, the result is not as simple as it appears at first glance. In the model, merely recognizing the riskiness of the debt is not enough. The banks must be prevented from channeling any of the depositors' funds into government debt, if the banking regulation is to be effective (i.e., if the probability of depositors' losses is to be kept at 0).

[3]Juvenal (1891), Satire VI.

The key insight from the model (and the main theoretical result of the paper) is that the interest rate the government has to pay on its debt is lower if the banking regulation does not acknowledge the risk of government default. This is hardly surprising, as such regulation permits banks to gamble with their depositors' money, as long as they purchase the government bonds. This finding is not just intuitive but also very robust — the interest rate on government bonds is always lower when the risk of default is ignored by the prudential regulation, regardless of whether that prudential regulation was effective to start with.

This lower cost of borrowing creates a potential moral hazard on behalf of the regulator, if the regulator is also the borrower. Allowing banks to gamble (by purchasing government bonds) may permit a self-interested government to postpone (or gamble to prevent) a default. In other words, the true gambling party in our model is the government, rather than the banks. We formalize this idea with an illustrative extension. While our benchmark model treats the risk of government default as exogenous, we offer a simple extension that allows us to explicitly model the government's choice of default (and banking regulation). We show that lax banking regulation (which permits domestic banks to gamble via purchasing government bonds) can be the only way for a heavily indebted government to avoid an immediate default. Faced with a choice between immediate default on the one hand and risking a larger crisis in the next period on the other, an office-motivated politician is likely to take the gamble of lax regulation. Of course, this gamble comes at a non-trivial cost to society. First and foremost, as our model highlights, this regulatory failure leads to misallocation of risk — the risk of government default is borne by risk-averse domestic households that are ill-equipped to handle such risk, instead of being borne by risk-neutral (possibly foreign) investors. Second, as our empirical analysis illustrates, this leads to a very tight correlation between the risk of government default and the risk of a systemic banking crisis. Such a banking crisis can be devastating for the domestic economy in the aftermath of default (see, for example, Sandleris and Wright (2014) and Gennaioli, Martin, and Rossi (2018)).

By assuming that the supply of deposits is inelastic, we are abstracting from the explicit analysis of the households' incentives to participate in the banking system. Presence of gambling in the banking system should make households reluctant to keep their deposits in banks. An obvious antidote to this is deposit insurance, which was present in the Eurozone, for example.[4] And while we are not explicitly modeling the deposit insurance here either,

[4] Alternatively, we could follow Brusco and Castiglionesi (2007) and assume that our households are Diamond and Dybvig (1983) consumers subject to liquidity shocks, and that the banks provide liquidity insurance to the households. While this may provide a reason for the households to keep their money in the bank as it does in Brusco and Castiglionesi (2007), we feel that the issue of liquidity insurance is orthogonal to our analysis and adopt the simpler formulation.

it is important to note that the key mechanism we are highlighting is intact in an economy where deposits are insured. The cost of the regulator's gamble is borne by future tax-payers in that economy, rather than by bank depositors as in our model, but these tax-payers and depositors are, of course, one and the same. Critically, to the extent that the current politician discounts the future government's liabilities in the event of the crisis (as we assume all along), the moral hazard in banking regulation is still present.[5]

The basic mechanism of our paper has a number of testable implications, and we examine several of them in this paper. One key prediction of the model is that gambling banks with large exposure to domestic government debt will want the rest of their investments to have returns strongly correlated with the government repayment. It is hard to think of anything more correlated with government default than the exchange rate on domestic currency. And as Ippolito (2002) documents, a number of Russian banks took vast positions in "currency forward" contracts in 1998.[6] Using a unique dataset of balance sheets of Russian banks just prior to (and during) the 1998 crisis, we document a strong correlation between the private banks' holdings of government debt and their foreign currency risk exposure (net liabilities) prior to the crisis.[7] Notably, this correlation disappears after the crisis happens, lending further support to our key mechanism.

Additional empirical support comes from the recent Eurozone debt crisis. Specifically, we focus on the period around the major Long-Term Refinancing Operation (LTRO) program announced by the European Central Bank (ECB) in December 2011. This LTRO program made the failure of banking regulation, which is at the core of our paper, even more pronounced. Not only was the riskiness of the sovereign debt not recognized by individual countries' banking regulators, but the ECB was providing long-term financing to the banks of the distressed Eurozone countries against those same risky government bonds as "safe" collateral. In line with Brutti and Sauré (2016), we document the reallocation of (risky) sovereign debt from foreign lenders to domestic banks in the troubled European countries (though we have a different and complementary interpretation of the underlying forces be-

[5]Empirically, the question of how responsive the supply of deposits is to systemic risk in the banking sector (arising from the risk of government default) is a complicated one. Even in the absence of the formal deposit insurance prior to the crisis, Russian households did not flee the banking system in the run-up to the 1998 default (see Figure 1 in Livshits and Schoors (2012)), while Argentine depositors ran on their banks in 2001 despite being supposedly insured. While these considerations are both interesting and important, they are outside the scope of this paper.

[6]Ippolito (2002) further argues that it was this currency risk exposure that led to the banking crisis. Our analysis in no way contradicts that view. We simply argue that the failure of prudential regulation (ignoring the risk of government bonds) incentivized the banks to take these currency gambles (strongly correlated with government debt).

[7]Alessandro (2009) provides a novel motivation for the domestic banks' holdings of potentially risky government bonds, but his mechanism does not imply a correlation of individual banks' bond holdings with foreign currency exposure.

hind this debt repatriation). We perform an event analysis around the announcement date of the LTRO and show that there was a reduction in sovereign yield of the distressed countries, which was not accompanied by a similar decline in default risk, as measured by credit default swap (CDS) spreads. This is consistent with the evidence presented in Krishnamurthy, Nagel, and Vissing-Jorgensen (2017).

As another manifestation of the concentration of sovereign risk in the domestic banks, we document a stark increase in the correlation of the risk of bank failure and the risk of sovereign default (as measured by the CDS spreads on both bank securities and government bonds).[8] Our model shows that this risk-shifting effect arises via direct holdings of sovereign debt or by domestic banks investing in gambles that are correlated with that risk.

The rest of the paper is organized as follows: The following subsection frames our contributions in the context of the existing literature. Section 2 presents our model, which aims to be the simplest environment in which there is a role for prudential regulation of banks. Section 3 defines the equilibrium in that environment. Section 4 characterizes the equilibria under various forms of regulation and presents our main results. Section 5 discusses empirical evidence on the relation between the sovereign default risk and the domestic banks' holdings of government debt (and correlated assets). Section 6 concludes.

1.1 Literature Review

Our paper is related to the burgeoning literature that explores the link between sovereign debt and the domestic financial sector. A number of recent papers explicitly link the exposure of the domestic financial sector to the risk of a government default (e.g., Alessandro (2009), Boz, D'Erasmo, and Durdu (2014), Gennaioli, Martin, and Rossi (2014), Perez (2015), Sosa-Padilla (2018)). These papers highlight that the exposure of domestic banks to government debt changes repayment incentives of a (benevolent) government, lowering the risk of default and, hence, the interest rates on government bonds.[9] In contrast, we treat the risk of default itself as largely exogenous (as in Bocola (2016), for example) and focus instead on how macroprudential regulation affects the incentives of the banking sector to hold domestic sovereign debt. One key insight from our analysis is that the failure of banking regulation to recognize the riskiness of government bonds *further* lowers the cost of borrowing (domestically) for the government, above and beyond the possible effects on the probability of repayment. While we choose to think of government as self-interested, rather than benevolent, it should be

[8]This is consistent with the evidence offered in Abad (2018).

[9]The idea that the cost of sovereign default is endogenous and affected by domestic agents is also present in Broner, Martin, and Ventura (2010) and Broner et al. (2014), who study selective defaults and their link to domestic exposure to sovereign debt.

pointed out that the failure to adjust prudential regulation (and the ensuing excessive risk-taking by the banks) may not be inconsistent with a benevolent government maximizing the welfare of its citizens. Think of the government of a severely borrowing-constrained country that wants to attract foreign lenders. The amount of debt such a government is able to raise (credibly promise to repay) is directly linked to how costly a default would be for such a country. If default is followed by a banking crisis, as it is in our model, then the cost of the default is greater ex-post, and the government would be able to borrow more ex-ante.[10]

Our paper is also related to the literature that studies what is referred to as the "doom loop" (as in Farhi and Tirole (2017), Cooper and Nikolov (2018), and Abad (2018)). The doom loop is formed between the government and the banks, as the government may need to (or choose to) bail out insolvent banks, thus raising the probability of government default, while the banks have an added incentive to hold government bonds. While Farhi and Tirole (2017) examine the effects of fundamental shocks in creating the feedback effect, Cooper and Nikolov (2018) present a model where banks' incentives not to issue equity against sovereign exposures is the main reason for the existence of the loop. We offer a complementary mechanism of how the sovereign and the banking sector intertwine. Ineffective capital regulation induces the banking sector to gamble with government debt.[11] Abad (2018) also studies the interaction between capital regulation and the doom loop. One key distinction between the mechanism we are highlighting and the existing work is that the government debt is *mispriced* in our model.

Our analysis highlights that "financial repression" (as in Becker and Ivashina (2017), Krishnamurthy, Nagel, and Vissing-Jorgensen (2017), and Chari, Dovis, and Kehoe (2018)) may not be necessary to achieve the aims attributed to it in these papers. The banks can be induced to hold government debt without the use of "repression," by simply adopting lax financial regulation. Our paper does not in any way contradict the idea that banks were often forced to hold the risky bonds (e.g., Díaz-Cassou, Erce-Domínguez, and Vázquez-Zamora (2008)).[12] Our story is complementary to the idea of forcing the banks to hold risky government bonds. Presumably, there is a limit to governments' ability to force the banks to hold the bonds. Notably, the data from Russian banks show that the gambling on foreign currency was much more prevalent among the private banks, over which the government

[10]Several recent papers present empirical evidence in support of this endogenous cost of default mechanism (e.g., Garcia-Posada and Marchetti (2016), Carpinelli and Crosignani (2017), Crosignani, Faria-e-Castro, and Fonseca (2017), Acharya et al. (2018), Gennaioli, Martin, and Rossi (2018)). Notably, that evidence is also consistent with the alternative mechanism that we are highlighting in this paper.

[11]It should be noted, of course, that we model only one side of the doom loop, as we are not explicitly considering ex-post bailouts of the failing banks nor a deposit insurance.

[12]Financial repression need not be restricted to just banks, of course. In 2001, it applied in equal measure to the pension funds in Argentina, and Alessandro (2009) points to several other examples.

presumably had much less sway.[13]

One paper closely related to ours in spirit is Brusco and Castiglionesi (2007), which studies the failure of prudential regulation due to cross-country insurance arrangements among banks. The paper shows that prudential regulation, which is sufficient under autarky, may fail once international financial arrangements are possible. In a similar line, Uhlig (2014) presents a model where regulators in distressed countries have an incentive to allow their banks to hold risky domestic bonds that can be used in repo transactions with a common central bank. As in our model, this allows the government to borrow at a lower rate and to shift the risk of default (to domestic banks' depositors in our model and to the common central bank in Uhlig (2014)). We offer a model with an explicit role for prudential regulation and further highlight that the moral hazard on the part of the regulator arises even in the absence of a supra-national central bank.

In line with the predictions of our model, several papers (see, for example, Acharya and Steffen (2015)) document that a large fraction of LTRO loans have been used by GIPSI (Greek, Irish, Portuguese, Spanish, and Italian) banks to purchase sovereign bonds. Our analysis suggests that this may be evidence of the failure of prudential regulation in these countries. Notably, the current design of the European LTRO programs rather facilitates such regulatory failure by leaving vetting the collateral up to national central banks. Our model also has clear implications regarding the correlation between the risk of bank failure and that of sovereign default. Ineffective banking regulation induces banks to gamble using a portfolio of assets that is strongly correlated with a sovereign risk. This prediction is in line with the findings of Acharya, Drechsler, and Schnabl (2014), who study balance sheet linkages between banks and sovereigns and documents that sovereign and bank CDS spreads exhibit a positive correlation during the crisis but not before. Using the announcement of the largest LTRO program in December 2011, we offer additional evidence consistent with this theoretical insight.

2 Environment

We start with the simplest two-period environment in which there is a role for prudential regulation of banks. Into that environment we introduce a government that has two key roles — it regulates banks, and it borrows to finance an exogenous deficit. We then incorporate the risk of the government defaulting on its debt in the second period and analyze the impact of this risk of default on banking and, most importantly, banking regulation.

[13] Alessandro (2009) presents related evidence for a set of Latin American countries.

Consider a two-period economy populated by risk-averse depositors (households); competitive risk-neutral investors, who may choose to operate banks; risk-neutral entrepreneurs, who own productive technologies; and a government, which regulates the banks and may need to borrow to finance a random stream of expenditures. We model households in a rather simplistic way, which results in perfectly inelastic supply of deposits to the banking system. Mechanically, it is equivalent to assuming that the total stock of deposits D is given exogenously. We also take the amount B that the government needs to borrow as exogenous and focus on the pricing of that debt. Besides the government debt, the economy has two types of investment projects — safe productive investments with gross rate of return r (which is endogenous), and risky projects with lower expected returns but significant upside. These risky projects (and the limited liability on the side of bankers) are the source of moral hazard in banking.

2.1 Households

In order to generate the inelastic supply of deposits, we assume that economy has a measure 1 of identical households. Households have an (after-tax) endowment of e in the first period and 0 in the second.[14] Their period utility function is $u(c) = \ln c$, and their time discount factor is δ. This implies that the aggregate supply of household savings is $D = \frac{\delta e}{1+\delta}$ (regardless of the level of interest rates in the economy). The only outlet for household savings in the model is a competitive banking sector. We will denote the (equilibrium) interest rate on deposits by i^d.

2.2 Productive Technologies

There is a continuum of entrepreneurs who own productive technologies, which turn period-1 investments into period-2 consumption goods. Measure 1 of these entrepreneurs possess risk-free production projects with decreasing returns-to-scale. Their production function is $y = Ak^\theta$ with $\theta < 1$, where A is aggregate productivity and k is the amount invested in the project. There is also measure 1 of entrepreneurs who possess risky technology with constant returns-to-scale. These risky projects deliver Rk with probability p and 0 otherwise, where k is the amount invested in the project. We will make an assumption (which is made explicit and formal in Section 3.1) that the safe technology yields higher expected marginal product of capital than the risky one, even if all productive investment in the economy is channeled into safe projects. This implies that any investment into risky technology is socially inefficient.

[14] In order to deal with the possibility of unbounded utility in the second period, we will set the second period endowment to $\epsilon > 0$ and then take a limit as ϵ approaches 0.

All entrepreneurs are risk-neutral and only value consumption in period 2. They have no endowment in period 1, besides their productive project. Thus, entrepreneurs have to rely on external financing.

2.3 Investors and Banking Sector

Investors are risk-neutral. They maximize expected profits, subject to limited liability. They are endowed with heterogeneous wealth, which can serve as the banking capital. We denote by ω_i the wealth owned by investor i. Total wealth is $\Omega = \int \omega_i di$. Investors can operate as a bank by accepting deposits from households. In order to do so, they have to comply with banking regulation (imposed by the government). Deposits promise to pay net interest rate i^d. The balance sheet identity implies that bank i total assets will equal $d_i + \omega_i$ (i.e., total assets equal deposits plus equity).

Investors have a unique ability to screen entrepreneurs. That is, unlike households (and the government), investors can observe the entrepreneurs' type (their technology). Thus, investors have access to two types of productive investments: risky and risk-free. Investors fund entrepreneurs' projects by offering financing in competitive loan markets, segmented by the project type. The market for deposits is also assumed to be competitive. Investors/banks can also invest in (defaultable) government bonds. The return on the government bonds, $(1 + i^g)$, is determined endogenously and is one of the key equilibrium elements.

Investors have limited liability. That is, if the returns from investments fall short of the amount promised to depositors, investors are not responsible for the balance. In addition, individual depositors cannot effectively monitor capital adequacy of banks. These features of the model create a moral hazard problem and motivate prudential regulation of banks.

2.4 Government

The government has two roles in the model. First, it is the regulator of banks. Second, the government issues debt, which is used to finance budget deficits.

The government faces a random (exogenous) stream of budget balances (net of taxes). The deficits are financed by issuing debt. The debt takes the form of (defaultable) non-contingent one-period bonds. Denote by B the amount the government needs to borrow. The rate of returns on the government bonds is determined in equilibrium. Denote the (promised) interest rate on the government debt by i^g (this will be the key equilibrium object we are concerned with). The probability of government repayment p^g is assumed to be exogenous (in Section 4.5, we offer a simple extension that endogenizes the default probability). In the event of government default, bondholders do not get any repayment.

Specifically, we will consider two cases — $p^g = 1$, i.e., deterministic repayment, and $p^g = p$, which makes the government debt closely resemble a risky project (and allows banks to construct portfolios of risky assets perfectly correlated with the government bonds).

By adjusting the capital regulation, the government changes the incentives to hold government debt and the resulting interest rate faced by the government.[15] This creates a potential conflict of interest between the two roles of the government — the borrower and the banking regulator. Our analysis highlights what happens if the regulatory power is allocated entirely to the "borrower side" of the government. We assume that the government's sole objective is staying in power and that a default on the government debt leads to an immediate fall of the government. Thus, the government honors the debt whenever it is possible.

The key simplifying assumption that the probability of the government repaying, p^g, is exogenous (and does not depend on the interest rate faced by the government in the first period) is worth some discussion. Of course, this probability of repayment should be declining in the interest rate, further incentivizing the government to do what it can to lower the interest rate it has to pay. But to highlight the key mechanism of the model, it will be convenient to hold the probability of default (repayment) fixed. This can be justified by explicitly thinking of there being two aggregate states in the second period — one where the government is sufficiently solvent to repay even the highest possible equilibrium interest rate, and one where the government is completely insolvent. More specifically, we will consider two possible values of p^g — we will either set it to 1, making the government debt completely safe, or set it to p, making government bonds closely resemble a "risky project" investment.

2.5 Banking Regulation

The government also sets prudential regulation that the banks must abide by. The prudential regulation takes the form of a capital adequacy requirement. Banks face a minimum capital requirement constraint given by

$$\frac{\omega_i}{(\omega_i + d_i)[\alpha^B q_i + \alpha^I (1 - q_i)]} \geq \beta, \tag{1}$$

where q_i represents the fraction of assets invested in government bonds with risk weight equal to α^B, $(1 - q^i)$ the fraction allocated to investments (safe or risky) with risk weight α^I, and β the minimum capital ratio required. In our baseline, and to resemble the observed

[15] We are interested in a situation where the government cannot *force* the banks to buy all of its debt. That is, the situation that goes beyond the coercion described in Díaz-Cassou, Erce-Domínguez, and Vázquez-Zamora (2008).

regulation in countries like Russia in 1998 as well as most countries following Basel II (the regulation that was in place in most countries around that time), we will consider $\alpha^B = 0$ and $\alpha^I = 1$. We will also consider alternative regulations with $\alpha^B > 0$. Note that, for exposition purposes, we assume that the bonds are the only verifiable ("safe") asset. Without loss of generality, we normalize the risk weight on investments α^I to 1. Since the type of investment is not observable, the risk weight cannot depend on the nature of the project.

We define an *effective regulation* as one that eliminates the possibility of bank failure (gambling) in equilibrium. In turn, "bank failure" is defined as a situation where the total ex-post returns on a bank's portfolio come short of the outstanding deposits in that bank (with interest). Effective regulation necessarily requires a sufficiently high capital adequacy ratio β. When government debt is risky, an effective regulation will further require a sufficiently high α^B. We will be specific about the values of such β and α^B in Section 4 below.

We will focus our analysis on the setting (parameter values) where the total wealth of the investors is sufficiently large to both purchase all the government bonds and support safe banking that intermediates all of the households' deposits. Formally, this requires

$$\Omega \geq B + \frac{\beta^* D}{1 - \beta^*}, \qquad (2)$$

where β^* is specified in the statement of the Proposition 1 as a function of r^*, and r^* is defined by equation (4).

3 Equilibrium

In this section, we define the equilibrium in our model environment. In order to do so, we first describe the problem(s) faced by the investors under different regulatory regimes.

3.1 Returns on Productive Investments

In any competitive equilibrium, the returns to investors from loans to entrepreneurs have to be equal to the marginal product of capital in their respective productive projects. This means that the investors' return on the risk-free productive projects per unit of investment is

$$r = \theta A K^{\theta - 1}, \qquad (3)$$

where K is the total amount invested in safe projects (which in equilibrium is evenly distributed across all safe entrepreneurs). Similar argument implies that risky projects, if financed, deliver R with probability p and 0 otherwise.

It is useful to define a benchmark rate of return r^* — the risk-free rate of return that arises when all assets (deposits plus investor's wealth) are invested only in government bonds and safe assets (i.e., there is no investment in the risky technology):

$$r^* = \theta A(\Omega + D - B)^{\theta-1}. \tag{4}$$

Assumption 1. *Throughout the paper, we will assume that*

$$pR < r^* < R. \tag{5}$$

The first inequality of this assumption implies that investing in risky projects is always inefficient. On the other hand, the second inequality guarantees that unregulated banks are subject to a non-trivial moral hazard — they are tempted to channel their depositors' funds to these inefficient risky projects. If such an investment does take place, we will call it "excessive risk-taking."

3.2 Investor/Bank's Problem

Investors decide whether to take deposits (i.e., become a bank) or not, and then the optimal allocation of their (bank's) assets. We can characterize the value of an investor (under any banking regulation) by looking at the three alternatives that we will denote by "not a bank" N, "safe bank" S, and "gambling bank" G. We will denote the corresponding decision rules by $\chi \in \{N, S, G\}$.

The value function of an investor that decides not to take deposits (chooses N, not to become a bank) is given by

$$V^N(\omega) = \omega \max\{r, pR, p^g(1 + i^g)\}. \tag{6}$$

An investor that does not become a bank will invest all its wealth in the asset with the highest expected return. In all equilibria of our model (under any regulation), that return is equal to that of the safe asset (since investing in risky projects is inefficient). Hence, $V^N(\omega) = \omega r$.

An investor can instead decide to become a bank. In that case, we have to distinguish between the problem of a "safe bank," $\chi = S$, and a "gambling bank," $\chi = G$. A safe bank invests a fraction $(1 - q)$ of its assets in the safe project (a "safe" bank S) and a fraction q in government bonds. Provided it becomes a bank, the investor faces the minimum capital requirement constraint when choosing the portfolio allocation. The value of being a safe bank is thus

$$V^S(\omega) = \max_{d,q\geq 0} \left[(d+\omega)\left(p^g q(1+i^g) + (1-q)r\right) - d(1+i^d)\right] \quad \text{subject to (1).} \tag{7}$$

Note that a safe bank (by definition) pays out its depositors in all states of the world and that limited liability is not binding in this case.

In contrast, a gambling bank does take advantage of limited liability with positive probability. In defining the value of a gambling bank below, we embed the fact that such a bank would always align its portfolio risks to be perfectly correlated and will not find it worthwhile to invest in safe productive projects. The gambling bank then chooses a fraction q of funds it invests in the risky asset (paying R with probability p) and a fraction $(1-q)$ in government bonds. The value for a gambling bank (G) is

$$V^G(\omega) = \max_{d,q\geq 0} p\left[(d+\omega)[q(1+i^g) + (1-q)R] - d(1+i^d)\right] \quad \text{subject to (1).} \tag{8}$$

Note that one important characteristic of a gambling bank is that, if the government debt is risky, the bank chooses risky projects that are (perfectly) correlated with government bonds. The gambling banks then survive only when the government repays (that coincides with the states in which the risky projects succeed).

The value for an investor is

$$V(\omega) = \max\left\{V^N(\omega), V^S(\omega), V^G(\omega)\right\}. \tag{9}$$

It is worth highlighting that, in a policy environment where $\alpha^B = 0$, investors are able to operate "banks" that invest only in government bonds without any equity (i.e., financed entirely with deposits). We will call these zero equity banks. A zero equity bank is essentially a particular case of a gambling bank with no equity. The value of creating this type of bank is

$$V^0 = \max_{d\geq 0} p^g\left[d(1+i^g) - d(1+i^d)\right]. \tag{10}$$

Of course, any equilibrium under $\alpha^B = 0$ must have $V^0 \leq 0$.

Last but not least, we should highlight that the deposit interest rate in problems (6), (7), (8), and (10) is the same i^d, as the depositors cannot distinguish these banks from each other.

3.3 Definition of Equilibrium

Two key aggregate variables that are important in characterizing equilibrium outcomes are the fraction of deposits in gambling banks (i.e., banks that fail with probability $(1 - p)$), which we denote by λ, and the fraction of total assets allocated to risky investments, which we denote by μ.

Definition 1. *Given policy parameters (α^B, β), a competitive equilibrium is an allocation $((\chi_i, q_i, d_i), \lambda, \mu)$ and a set of interest rates (r, i^g, i^d) such that*

1. *Given the interest rates, (χ_i, q_i, d_i) is a solution of investor i's problem.*
2. *The risk-free rate is $r = \theta A((1 - \mu)(\Omega + D) - B)^{\theta-1}$.*
3. *The market for government bonds clears. That is, i^g is such that $B = \int q_i(\omega_i + d_i)di$.*
4. *The deposit market clears. That is, i^d is such that $D = \int \mathbf{1}_{\chi_i \in \{S,G\}} d_i di$.*

4 Equilibrium Characterization

We begin by establishing the benchmark of effective regulation when government debt is safe and then proceed to the analysis of our model outcomes when the government debt is risky. In the latter setting, we characterize equilibrium outcomes in our model for the full range of capital requirements and for three key values of the risk weight on government bonds — zero (i.e., ignoring the risk altogether), one (i.e., treating government bonds the same as any other investment), and prohibitive (i.e., sufficiently high to prevent banks from investing any of their depositors' funds into government bonds).

4.1 Effectiveness of Regulation When Government Debt Is Safe

In order to establish a clear benchmark for the rest of the section, we begin by characterizing the effective banking regulation when there is no risk of government default.

Proposition 1. *When government debt is safe ($p^g = 1$), banking regulation is effective if and only if $\beta \geq \beta^* = \frac{p(R-r^*)}{r^*(1-p)}$.*

Proof. Safe government debt is largely equivalent to the safe productive asset in this environment. While it may have regulatory advantages, both assets have the same marginal buyer — the risk-neutral investor who has to be indifferent between holding one and the other. Hence, the rates of return are equalized between the two: $(1 + i^g) = r$. And since in any equilibrium under effective regulation there is no investment in risky assets, $(1 + i^g) = r^*$. Furthermore, banking competition (for deposits) guarantees that the interest rate on deposits is at the same level: $(1 + i^d) = r^*$.

In order to establish the result of the proposition, we simply need to compare the profitability of a "gambling" strategy on behalf of a bank against the profitability of investment in the safe asset. The former is $V^G(\omega) = p\left[\frac{\omega}{\beta}(R - (1-\beta)r^*)\right]$, while the latter is simply $V^S(\omega) = \omega r^*$. Simply rearranging these expressions yields the result that $V^S(\omega) \geq V^G(\omega)$ if and only if $\beta \geq \beta^*$. □

4.2 Effectiveness of Regulation When Government Debt Is Risky

In the rest of the section, we focus on the case when government debt is risky. For clarity of exposition, we set $p^g = p$, so that government debt is essentially the same as a risky project, except, of course, for the different regulatory treatment. Unlike the risky project however, the rate of return on government debt is endogenous in our model. That makes the risk of government default harder to regulate against. This important point is delivered in a very dramatic fashion by the following proposition:

Proposition 2. *When government debt is risky ($p^g = p < 1$), regulation cannot be effective as long as it permits bankers to channel household deposits into government bonds (i.e., if $\alpha^B\beta < 1$).*

Proof. Suppose not. In other words, suppose that $\alpha^B\beta < 1$ and there is an equilibrium where no deposit-taking banks have positive probability of failure. That immediately implies that the government bonds are held (at least in part) and priced by risk-neutral investors. That implies $(1 + i^g) = \frac{r^*}{p} > r^*$. Since banks do not fail in this candidate equilibrium, the deposit rate cannot exceed the return on the safe asset: $(1 + i^d) \leq r^*$. But the last two inequalities imply that, as long as $\alpha^B\beta < 1$, an investor can make (infinite) profits by opening a zero equity bank (see problem (10)). □

While Proposition 1 establishes that the model does indeed generate the role for banking regulation, Proposition 2 delivers the first basic result of the paper: Prudential regulation that works when government debt is safe fails when government debt is risky. This proposition notably delivers more than just a confirmation that the model delivers what it was built for. Merely recognizing the riskiness of the government debt and treating it just like any other risky investment (which seems identical in the nature of its payoffs) is not enough to preclude banks from "gambling" (and failing in the event of a government default). In order to be effective when government debt is risky, the banking regulation has to outright prevent the banks from channeling any of the depositors' funds into government debt. This somewhat surprising result arises from the endogenous pricing of government debt. While the payoffs on government debt look very similar to those of a risky project, the expected return is not fixed exogenously but instead responds to the regulation. If the regulation is effective, then government debt is priced actuarially fairly. That is, the expected rate of return on government debt is the same as that of the productive risk-free investment. That makes government debt such an attractive lottery that there is simply no way to discourage a limited-liability bank from investing depositors' funds in nothing but the debt (short of ruling it out by decree or by requiring 100% banking equity on that portion of the portfolio).

4.3 Results and Key Insights

In what follows, we characterize the equilibrium outcomes under various regulatory regimes. One key insight from the analysis presented in this section is that the interest rate the government has to pay on its debt is lower if the banking regulation does not acknowledge the risk of government default. This finding is very robust in that it holds regardless of the minimum capital requirement β. Another important result, which we derive in the simple extension in Section 4.5, is that the lax banking regulation can be the only way for a heavily indebted government to avoid an immediate default.

For a given value of α^B (risk weight on government debt), we identify three regions of β (minimum capital ratio), based on whether banks choose to invest in risky projects R and on what fraction of household deposits end up in gambling banks.[16] We call the "high β" region one where banks do not invest in risky projects and failure risk arises only from government bonds, the "intermediate β" region where banks invest in risky projects and government bonds but not all banks are exposed to default risk, and the "low β" region where the capital requirement is low enough that (even in the case with $\alpha^B = 1$) all banks are exposed to default risk via government debt and risky investments. Within each region, we will show how recognizing the riskiness of government debt affects the interest rate on sovereign debt and also whether regulation can be effective or not (i.e., prevent bank failure).

Note that, in any equilibrium, the capital requirement will bind if the bank is gambling (i.e., the bank fails with probability $(1 - p)$). That implies that

$$\frac{\omega}{(\omega + d)(\alpha^B q + (1 - q))} = \beta. \tag{11}$$

For future reference, we note that when the capital requirement constraint is binding total

[16] Recall that we focus on the case where $\alpha^I = 1$.

assets can be expressed as $(d+\omega) = \frac{\omega}{(\alpha^B q+(1-q))\beta}$, deposits as $d = \frac{\omega(1-\beta(\alpha^B q+(1-q))}{(\alpha^B q+(1-q))\beta}$, and wealth as $\omega = d\frac{(\alpha^B q+(1-q))\beta}{(1-\beta(\alpha^B q+(1-q))}$.

4.3.1 High Capital Requirements

We describe here the equilibrium that arises when β is high enough in the sense that it prevents banks from investing in risky assets. Whether the regulator recognizes the riskiness of government debt or not has important implications for the price of government debt and the fraction of deposits allocated to gambling banks (i.e., those investing in government debt).

When β is high enough and government bonds are risky but the banking regulation does not recognize this risk ($\alpha^B = 0$), the only equilibrium features a fraction $\lambda = B/D$ of deposits being invested in government bonds and the rest in risk-free assets (i.e, there is no investment in the risky project). Competition for deposits drives down the interest rate on government bonds. More specifically,

Proposition 3. *If $\beta \geq \beta^* = \frac{p(R-r^*)}{r^*(1-p)}$ and $\alpha^B = 0$, the equilibrium is characterized by the following:*

1. *The banking sector is composed of zero equity banks, which invest only in government bonds, and safe banks, which invest only in the risk-free asset.*

2. *There is no bank investing in the risky project: $\lambda = B/D$ and $\mu = 0$.*

3. *Investors that do not take deposits invest only in the safe asset.*

4. $(1 + i^g) = (1 + i^d) = r^*$.

Proof. We proceed by characterizing the equilibrium without the excessive risk-taking and verifying that the banks do not have an incentive to take on excessive risk (invest in risky projects).

In this equilibrium, provided banks are allowed to operate with zero equity, there will always be banks that take deposits to invest only in government bonds, so competition and free entry implies that $(1 + i^g) = (1 + i^d)$ and $V^0 = 0$. Zero equity banks take deposits until they exhaust all government bonds. What are the conditions necessary to induce safe banks not to invest in government bonds (i.e., $q^S = 0$)? If $q^S = 0$, then the value of a safe bank is

$$V^S_{q^S=0}(\omega) = \max_d \left[(d + \omega)r - d(1 + i^d)\right] = \max_d \left[\omega r + d(r - (1 + i^d))\right]. \qquad (12)$$

Competition implies that following this strategy and staying as a non-bank investor should provide the same value, so $V^S_{q^S=0}(\omega) = V^N(\omega) = \omega r$ should hold. Then $(1 + i^d) = r$ since this equality implies that $V^S_{q^S=0}(\omega)=\omega r$. We also need to show that, at these prices, setting $q^S=0$ is optimal (i.e., there is no profitable deviation involving $q^S>0$). It is straightforward to show that $V^S_{q^S=0}(\omega)>V^S_{q^S>0}(\omega)$ since

$$V^S_{q^S=0}(\omega)=\omega r>((d+\omega)pr-dr)=\omega r+(p-1)dr=V^S_{q^S>0}(\omega). \tag{13}$$

Finally, in order to show that this is an equilibrium, we need to check that the value of a bank that invests in the risky technology is lower than the value of a safe bank. In particular, the value of bank that invests in the risky technology (for any value of q) is

$$\begin{aligned} V^G_q(\omega) &= p\left[\frac{\omega}{(1-q)\beta}\left(qr+(1-q)R-(1-\beta(1-q))r\right)\right] \\ &= p\left[\frac{\omega}{(1-q)\beta}(1-q)(R-(1-\beta)r)\right] \\ &= p\left[\frac{\omega}{\beta}(R-(1-\beta)r)\right]. \end{aligned}$$

Then, the value of a bank that invests in the risky technology is independent of q. In order for an equilibrium with no such banks to exist, we need $V^G_q(\omega)<\omega r=V^S_q(\omega)$. This is true whenever

$$\omega r>p\left[\frac{\omega}{\beta}(R-(1-\beta)r)\right] \qquad \Leftrightarrow \qquad \beta>\frac{p(R-r)}{r(1-p)}.$$

Since all wealth is invested in the safe asset (either via safe banks or non-bank investors), we obtain that $r=r^*$, and from here it follows that we need $\beta>\beta^*$. Since zero equity banks are the only ones investing in government bonds, we conclude that $\lambda=\frac{B}{D}$ and $\mu=0$. □

In this equilibrium, all of the government debt is held by the zero equity banks. In other words, the entire risk of default is borne by the risk-averse depositors, who are least suited to handle it. This is the dramatic cost of the regulation failure. On the other hand, the cost of borrowing for the government is dramatically lower than it should be — the government pays absolutely no risk premium on its debt.

If the riskiness of government debt is recognized by the regulator ($\alpha^B=1$), it is no longer possible to finance government debt using only deposits (since zero equity banks cannot satisfy the regulation anymore). In this case, the government needs to compensate investors (bankers) for taking on some of the risk associated with government debt. Specifically,

Proposition 4. *If $\beta\geq\beta^*=\frac{p(R-r^*)}{r^*(1-p)}$ and $\alpha^B=1$, the equilibrium is characterized by the following:*

1. *The banking sector is composed of banks that invest only in government bonds and banks that invest only in the risk-free asset.*

2. *There is no bank investing in the risky project:* $\lambda = \frac{B(1-\beta)}{D}$ *and* $\mu = 0$.

3. *Investors that do not take deposits invest only in the safe asset.*

4. $(1 + i^d) = r^*$.

5. $(1 + i^g) = r^*(\beta/p + (1 - \beta))$.

Proof. As before, we proceed by characterizing the equilibrium without the excessive risk-taking and verifying that the banks do not have an incentive to take on excessive risk (invest in risky projects). We start by finding the price of deposits that makes it optimal for safe banks not to invest in government bonds (i.e., $q^S = 0$). If $q^S = 0$, then the value of a safe bank is

$$V^S_{q^S=0}(\omega) = \max_d \left[(d + \omega)r - d(1 + i^d)\right] = \max_d \left[\omega r + d(r - (1 + i^d))\right]. \tag{14}$$

Competition equalizes the value of a safe bank and the value of staying a non-bank investor, so $V^S_{q^S=0}(\omega) = V^N(\omega) = \omega r$. This equation pins down $(1 + i^d)$ since $(1 + i^d) = r$ implies $V^S_{q^S=0}(\omega) = \omega r$.

Setting $q^S = 0$ is optimal (i.e., $V^S_{q^S=0}(\omega) > V^S_{q^S>0}(\omega)$) as long as

$$\begin{aligned} \omega r \;\; > \;\; & (d + \omega)p(1 + i^g) - dr = \omega p(1 + i^g) + d(p(1 + i^g) - r) \\ & \Leftrightarrow \omega r > \omega p(1 + i^g) + d(p(1 + i^g) - r) \\ & \Leftrightarrow (r - p(1 + i^g))(\omega + d) > 0. \end{aligned}$$

Since $(\omega + d) > 0$, this equilibrium requires $(r - p(1 + i^g)) > 0$ or $\frac{r}{p} > (1 + i^g)$.

We now need to find the value of β such that gambling banks invest only in government bonds. Note that all wealth is invested in the safe asset or government bonds, so $r = r^*$. In this equilibrium, an investor will never choose to operate a bank and invest in the risky technology, as long as

$$\omega r^* > p\left(\frac{\omega}{\beta}(R - (1 - \beta)r^*)\right) \qquad \Leftrightarrow \qquad \beta > \frac{p(R - r^*)}{r^*(1 - p)}.$$

In order to compensate gambling banks for holding government bonds, the value of i^g needs to satisfy

$$\omega r^* = p\left(\frac{\omega}{\beta}((1+i^g) - (1-\beta)r^*)\right) \qquad \Leftrightarrow \qquad 1+i^g = \frac{r^*}{p}(\beta + (1-\beta)p).$$

Note that $R < (1+i^g) < \frac{r^*}{p}$, where the last inequality holds as long as $\beta < 1$. The last inequality also implies that a safe bank will choose not to hold government bonds.

In this case, $\lambda = \frac{B(1-\beta)}{D}$ since banks investing in government bonds are against the capital requirement constraint and do not take risky investments. Moreover, $\mu = 0$. □

The takeaway from this section is that when β is sufficiently high (i.e., capital requirements are high enough to induce zero investment in risky projects), not recognizing the riskiness of government debt reduces the cost of borrowing for the government ($i^g(\alpha^B = 0) < i^g(\alpha^B = 1)$) but results in a considerably larger fraction of deposits in gambling banks. That is, the trade-off the government faces is whether to shift the risk of default to the household sector in order to reduce its cost of borrowing.

One important point (established in Proposition 1) regarding the high capital requirement regime ($\beta > \frac{p(R-r)}{r(1-p)}$) is that, if there is no risk of government default, the capital regulation is *effective* (independent of α^B). The equilibrium properties are similar to those we described in Proposition 4, but since there are no banks investing in the risky technology and the government default probability is zero, there is no bank failure in equilibrium.

What about implementing an *effective* regulation when there is risk of government default? Proposition 2 shows that an effective regulation would require moving all government bonds out of banks' balance sheets (i.e., removing completely the indirect exposure of households to government debt). This can be attained if both β and α^B are high enough.

Corollary 1. ***Effective Regulation.*** *If $\beta \geq \beta^* = \frac{p(R-r^*)}{r^*(1-p)}$ and $\alpha^B \geq 1/\beta$, the equilibrium is characterized by the following:*

1. *The banking sector is composed only of safe banks (i.e., banks that invest only in the risk-free asset).*

2. *There is no bank investing in the risky project: $\lambda = 0$ and $\mu = 0$.*

3. *Investors that do not take deposits invest in government bonds.*

4. *$(1+i^d) = r^*$.*

5. *$(1+i^g) = r^*/p$.*

In this equilibrium, government bonds pay the actuarially fair interest rate; i.e., the borrowing cost is significantly higher for the government. However, all the risk of default is shifted away from the risk-averse households. Intuitively, holding government bonds requires enough capital that banks prefer to stay away from them and only investors (who are compensated accordingly) hold all the government bonds.

4.3.2 Intermediate Capital Requirements

In this section, we study a policy regime where β is in an intermediate range, where capital regulation does not prevent banks from investing in risky projects. What makes the case we study in this subsection "intermediate" is that, while there are some banks that invest in risky assets, there are still some banks in equilibrium that invest in safe assets and do survive an event of government default. The lower bound on β that assures that such safe banks operate depends on the regulatory treatment of government debt and is given by equations (15)-(16) and (18)-(19), for $\alpha^B = 0$ and $\alpha^B = 1$, respectively. We shall denote these bounds $\hat{\beta}_0$ and $\hat{\beta}_1$, respectively. As in the previous subsection, whether the regulator recognizes the riskiness of government debt or not has important implications for the price of government debt and the fraction of deposits allocated to gambling banks.

We start by describing our baseline scenario where the regulator sets $\alpha^B = 0$ (i.e., the risk of government debt is not recognized). In this case, the minimum capital requirement is not enough to induce banks not to invest in risky investments, but there is still a premium for investing in R since banks are not required to hold capital against government debt. More specifically,

Proposition 5. *If $\beta \in [\hat{\beta}_0, \beta^*]$ and $\alpha^B = 0$, the equilibrium is characterized by the following:*

1. *The banking sector is composed of zero equity banks that invest only in government bonds, safe banks that invest only in the risk-free asset, and gambling banks that take the risky investment.*

2. $\lambda = \frac{(\Omega+D-K(r))(1-\beta)+\beta B}{D}$ *where $K(r)$ is the level of assets invested in the risk-free asset and* $\mu = \frac{\Omega+D-B-K(r)}{\Omega+D}$.

3. *Investors that do not take deposits invest only in the safe asset.*

4. $(1+i^g) = (1+i^d) = r$.

5. $r = \frac{pR}{\beta(1-p)+p}$.

Proof. As in the previous case, since banks with no equity are in operation, $(1+i^d) = (1+i^g)$. Using the arguments we used before, we can show that, in an equilibrium where safe banks do not invest in government bonds (i.e., $q^S = 0$), $(1 + i^d) = r$. The value of a safe bank equals ωr. At these prices, coexistence of banks investing in the risky technology with safe banks requires

$$\omega r = p\left(\frac{\omega}{\beta}(R-(1-\beta)r)\right) \quad \Leftrightarrow \quad \beta = \frac{p(R-r)}{r(1-p)} \quad \Leftrightarrow \quad r = \frac{pR}{\beta(1-p)+p}.$$

The wealth invested in the safe asset $(K(r))$ can be pinned down from the production technology equation, $r = \theta A\left(K(r)\right)^{\theta-1}$.

This will be an equilibrium as long as some fraction of deposits is channeled through safe banks (i.e., banks investing in R do not take all deposits left outside the zero equity banks). That means we need the amount of deposits in banks investing in the risky technology to be lower than $D - B$. If the deposits in banks investing in R equal $D - B$, the wealth invested in risky banks equals $(D-B)\frac{\beta}{(1-\beta)}$, so resources left to be invested in the safe asset equal $\Omega - (D-B)\frac{\beta}{1-\beta}$. Using these conditions we can derive the minimum value of β and the implied interest rate in the safe asset such that this is an equilibrium. Let $\hat{\beta}_0$ be the minimum value of β such that this equilibrium exists. We can find the value of $\hat{\beta}_0$ (and the associated value of r) from the following two equations:

$$\hat{r}_0 = \theta A\left(\Omega - (D-B)\frac{\hat{\beta}_0}{1-\hat{\beta}_0}\right)^{\theta-1} \tag{15}$$

$$\hat{\beta}_0 = \frac{p(R-\hat{r}_0)}{\hat{r}_0(1-p)}. \tag{16}$$

It is simple to show that equation (15) is increasing in β and equation (16) is decreasing in β, so a solution exists. Any value of $\beta \in [\hat{\beta}_0, \beta^*]$ will generate the equilibrium described here.

In this equilibrium, $\lambda = \frac{(\Omega+D-K(r))(1-\beta)+\beta B}{D}$, where $K(r)$ denotes the value of assets invested in the risk-free asset consistent with $\hat{r}_0$ (equation (15)). The fraction of assets allocated to gambling banks is $\mu = \frac{\Omega+D-B-K(r)}{\Omega+D}$. □

If the regulation recognizes the riskiness of government debt, the nature of this equilibrium does not change dramatically, but the regulator needs to compensate banks for holding government debt. In particular,

Proposition 6. *If $\beta \in [\hat{\beta}_1, \beta^*]$ and $\alpha^B = 1$, the equilibrium is characterized by the following:*

1. *The banking sector is composed of safe banks that invest only in the risk-free asset and gambling banks that invest in the risky assets and government bonds.*

2. $\lambda = \frac{(\Omega+D-K(r))(1-\beta)}{D}$, *where* $K(r))$ *is the level of assets invested in the risk-free asset, and* $\mu = \frac{\Omega+D-B-K(r)}{\Omega+D}$.

3. *Investors that do not take deposits invest only in the safe asset.*

4. $(1+i^d) = r$.

5. $(1+i^g) = R$.

6. $r = \frac{pR}{\beta(1-p)+p}$.

Proof. Competition equalizes the value of a safe bank and the value of staying as a non-bank investor, so $V^S_{q^S=0}(\omega) = V^N(\omega) = \omega r$. This equation pins down the interest rate on deposits $(1+i^d) = r$.

In order for gambling banks to be indifferent between investing in government bonds and the risky investment, it has to be true that $(1+i^g) = R$. Competition also equalizes the value of a gambling bank with that of an investor that invests in a safe asset:

$$\omega r = p\left(\frac{\omega}{\beta}[R-(1-\beta)r]\right) \qquad \Leftrightarrow \qquad r = \frac{pR}{\beta(1-p)+p}. \tag{17}$$

This will be an equilibrium as long as some fraction of deposits is channeled through safe banks (i.e., gambling banks do not take all deposits). If the deposits of gambling banks equal D, the wealth in these banks equals $D\beta/(1-\beta)$. Let $\hat{\beta}_1$ be the minimum value of β such that this equilibrium can exist. We can find the value of $\hat{\beta}_1$ (and the associated value of r) from the following two equations:

$$\hat{r}_1 = \theta A\left(\Omega - D\frac{\hat{\beta}_1}{1-\hat{\beta}_1}\right)^{\theta-1} \tag{18}$$

$$\hat{\beta}_1 = \frac{p(R-\hat{r}_1)}{\hat{r}_1(1-p)}. \tag{19}$$

It is easy to show that equation (18) is increasing in β and equation (19) is decreasing in β, so a solution exists. □

In the intermediate region of β the government debt still pays a lower interest rate and the fraction of deposits in gambling banks is higher when $\alpha^B = 0$ than when $\alpha^B = 1$. Importantly, note that $\hat{\beta}_1 < \hat{\beta}_0$, so in this region of parameters there is room for misallocation of resources (since more assets are allocated to inefficient risky investments when $\alpha^B = 0$ than when $\alpha^B = 1$).

It is straightforward to show that there is no effective regulation in this region. Setting $\alpha^B > 1$ does not make regulation effective because, while it would shift all government bonds to investors, banks still find it profitable to invest in risky investments (R), so a positive fraction of deposits end up in gambling banks.

4.3.3 Low Capital Requirements

In this region, capital requirements are sufficiently low that all deposits end up in gambling banks (banks that invest in R and government bonds). The following two propositions characterize the equilibrium conditional on the value of α^B.

Proposition 7. *If $\beta < \hat{\beta}_0$ and $\alpha^B = 0$, the equilibrium is characterized by the following:*

1. *The banking sector is composed of zero equity banks that invest only in government bonds and gambling banks that undertake the risky investment.*

2. $\lambda = 1$ *and* $\mu = \frac{D-B}{(1-\beta)(\Omega+D)}$.

3. *Investors that do not take deposits invest only in the safe asset.*

4. $(1 + i^g) = (1 + i^d)$.

5. $(1 + i^d) = \frac{R - r\beta/p}{(1-\beta)}$.

6. $r = \theta A \left(\Omega - (D - B)\frac{\beta}{1-\beta}\right)^{\theta-1}$.

Proof. As before, since banks with no equity are in operation, $(1 + i^d) = (1 + i^g)$. In this equilibrium there are no safe banks. Competition implies that operating a risky bank and investing in safe assets (without taking any deposit) should provide the same value. Then,

$$\omega r = p\left[\frac{\omega}{\beta}(R - (1 - \beta)(1 + i^d))\right].$$

This equation pins down the value of i^d as a function of r. The value of wealth invested in the safe asset is $\Omega - (D - B)\frac{\beta}{1-\beta}$, so $r = \theta A \left(\Omega - (D - B)\frac{\beta}{1-\beta}\right)^{\theta-1}$. Note that $\frac{\beta}{1-\beta}$ is increasing in β. So, as β decreases, wealth channeled to the safe asset increases and the return on the safe asset declines.

We are left to show that no safe bank will exist. For this to happen, we need $(1+i^d) > r$. Intuitively, an investor would not be willing to take a unit of deposit if the cost of doing so exceeds the return on the safe asset. Simple algebra shows that

$$1 + i^d = \frac{1}{1-\beta}(R - r(\beta/p)),$$

so $(1+i^d) > r \Leftrightarrow \frac{1}{1-\beta}(R - r(\beta/p)) > r$, which implies that $\beta < \frac{p(R-r)}{r(1-p)}$. In this case, $\lambda = 1$. □

Proposition 8. *If $\beta < \hat{\beta}_1$ and $\alpha^B = 1$, there is an equilibrium where*

1. *the banking sector is composed of gambling banks that invest in the risky assets and government bonds;*
2. *$\lambda = 1$ and $\mu = \frac{D/(1-\beta) - B}{\Omega + D}$;*
3. *investors that do not take deposits invest only in the safe asset;*
4. *$(1 + i^d) = \frac{R - r\beta/p}{(1-\beta)}$;*
5. *$(1 + i^g) = R$; and*
6. *$r = \theta A \left(\Omega - D\frac{\beta}{1-\beta}\right)^{\theta-1}$.*

Proof. If $\beta < \hat{\beta}_1$, it is straightforward to show (using the results from the previous subsection) that all deposits are allocated to banks taking the risky investment (since deviating resources to the safe asset is not profitable). Competition drives the value of a gambling bank to the value of the outside investor

$$\omega r = p\left[\frac{\omega}{\beta}(R - (1-\beta)(1+i^d))\right];$$

then, $(1+i^d) = \frac{R - r\beta/p}{(1-\beta)}$. Since all deposits are invested in gambling banks, wealth allocated in gambling banks is $D\frac{\beta}{1-\beta}$ and assets allocated to the risk-free technology equal $\Omega - D\frac{\beta}{1-\beta}$, so $r = \theta A \left(\Omega - D\frac{\beta}{1-\beta}\right)^{\theta-1}$. In addition, in order for banks to be indifferent between investing in the risky technology and government bonds, it has to be the case that $(1 + i^g) = R$.

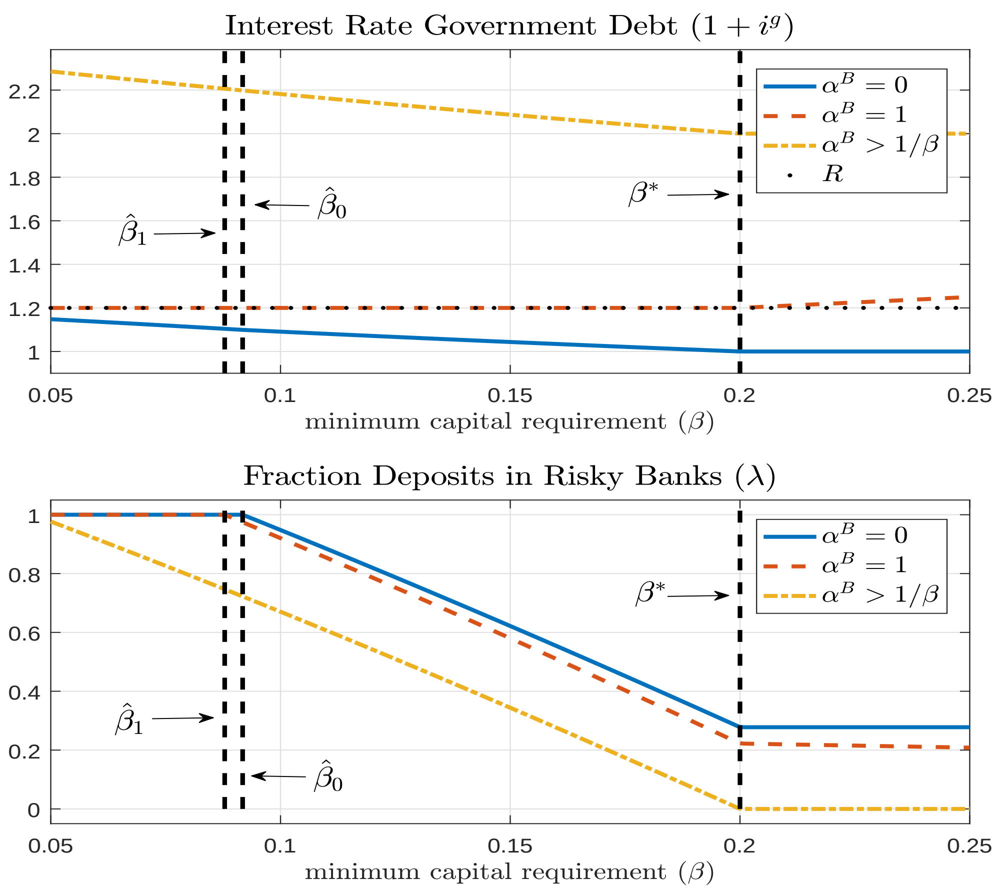
Since all deposits are in gambling banks, we have $\lambda = 1$ and $\mu = \frac{D/(1-\beta) - B}{\Omega + D}$. □

As in the previous region of the parameter space, it is the case that the cost of government debt is lower when $\alpha^B = 0$ than when $\alpha^B = 1$. Interestingly, the fraction of deposits in gambling banks equals 1 in both scenarios. Only a regulation that will make it very costly to hold government bonds ($\alpha^B > 1$) will reduce the exposure of the household sector to a government default. The value of β that leads to this equilibrium is a function of α^B.

4.4 Summary

Figure 1 illustrates the differences in the cost of borrowing for the government $(1 + i^g)$ and the fraction of deposits allocated to gambling banks for different values of α^B and β.[17]

Figure 1: Equilibrium Conditions Under Different Capital Regimes



Differences in $(1 + i^g)$ (top panel) and λ are evident from Figure 1. This figure presents the trade-off that a regulator faces when setting risk weights in government debt.

4.5 Banking Regulation and Endogenous Default

Consider the following explicit micro-foundation of the government default risk in our model. There are two aggregate states of nature in the second period, which differ in the amount of

[17] In order to construct this figure, we parameterize the model as follows: $R = 1.2$, $p = 0.5$, $\theta = 0.8$, $\Omega = 2.5$, $B = 0.5$, $D = 1.8$.

primary surplus available to the government. With probability p, the government surplus is S_H, while with the complementary probability, it is $S_L < pS_H$. This future ability to repay endogenously determines the government's ability to borrow in the first period. Critically, these borrowing limits in the first period depend on the banking regulation adopted in that period.

Proposition 9.

1. *If* $B \leq \frac{S_L}{r^*}$, *then government debt is safe (i.e.,* $p^g = 1$*).*
2. *If* $\frac{S_L}{r^*} < B \leq \frac{pS_H}{r^*}$, *then there is positive probability of government default in the second period (specifically,* $p^g = p < 1$*), but the default in the first period is avoided, irrespective of the banking regulation.*
3. *If* $p\frac{S_H}{r^*} < B \leq \frac{S_H}{r^*}$, *then the only way to avoid an immediate default in the first period is by allowing systemic risk in the banking sector. In other words, any government strategy that avoids immediate default involves the probability* $(1 - p^g) = (1 - p)$ *of government default in the second period and an ineffective banking regulation,* $\alpha^B < \frac{1}{\beta}$.
4. *If* $B > \frac{S_H}{r^*}$, *then immediate default is unavoidable.*

The last proposition (in particular, item 3 in the statement) highlights an important insight into the decision-making of a heavily indebted government. The decision such a government faces may simply come down to a binary choice between an immediate default (with no banking crisis) on the one hand and an ineffective banking regulation that may result in a major banking crisis next period on the other. This comes as a consequence of our other main insight — that lax banking regulation lowers the cost of borrowing and thus permits the government to raise more funds in the current period. Considering an office-motivated government official, who cares much more about avoiding a crisis (today) than about the magnitude of the crisis should it take place (tomorrow), it is easy to see the source of the moral hazard in deciding on the treatment of sovereign debt by banking regulation.

5 Empirical Support

This section offers empirical support for the key mechanism of our model. We draw on the experiences of the Russian banking sector in the run-up to the 1998 default and on the recent Eurozone debt crisis.

5.1 Evidence from the Russian 1998 Crisis

We begin with some empirical evidence from Russia using banks' balance sheet data from 1998.[18] The Russian banking regulation prior to the default did consider government debt safe for the purposes of calculating capital adequacy ratios. Ironically, the regulation was changed *after* the default.

In our theoretical analysis, we have established that only when the minimum capital ratio and the risk weight on sovereign debt are high enough the regulation is effective (i.e., prevents bank failure even during a sovereign default). If prudential regulation considers risky government bonds safe, some banks gamble by constructing portfolios composed only of government bonds (if β is relatively high) or composed of a mix of government bonds and risky assets strongly correlated with the bonds. In this section, we examine data concerning the behavior of banks operating in Russia around the 1998 financial crisis, which hit in August of that year. This crisis led the Russian government to effectively default on GKO (domestic government bond) obligations. This was followed by a substantial devaluation of the ruble, which lost roughly two-thirds of its value in a matter of a month. These two occurrences provide an ideal situation whereby to test the implications of the model developed above.

Striking anecdotal evidence in support of our main mechanism can be found in Ippolito (2002).[19] Having realized that the government default on its debt would be accompanied by a dramatic devaluation of the ruble, some banks took remarkably large positions in the currency futures market. Table 1 provides a snapshot of some Russian banks' positions in that market a month before the default. Notably, these banks did not hold just currency futures but rather *derivatives* on these futures, which meant that the banks had to pay out only in the event of a devaluation. The data cited in Johnson (2000) provide further support for our key mechanism.

We perform a more systematic analysis of the behavior of banks in Russia around the time of the crisis, using a unique dataset that contains balance sheet data from over 1,000 banks.[20] Unfortunately, currency risk data are available only for 1998, thus our analysis is restricted to this year. Luckily, there is important variation in the relevant aspects of

[18] We use quarterly data for all banks active in Russia around the time of the default. The data we use are described in detail in Karas, Pyle, and Schoors (2010).

[19] Ironically, Ippolito (2002) argues that it was not the government default that led to the collapse of the Russian banking system in 1998 but rather the exposure of the Russian banks to the exchange rate risk.

[20] Our reader may be concerned about the degree of enforcement (and thus relevance) of the banking regulation in Russia in 1998. While such concerns are not entirely unfounded, Claeys and Schoors (2007) suggest that the capital rules were perhaps the most consistently enforced banking standards of the whole battery of banking standards in place in Russia at the time (although the Central Bank of Russia was found to have some biases in its enforcement behavior in favor of systemically important banks).

Table 1: Estimates of Forward Liabilities to Non-residents

Bank	$mln	% of Capital	Bank	$mln	% of Capital
Inkombank	1884	719%	Sberbank	379	23%
Onexim	1442	203%	NRB	224	50%
Vneshtorgbank	1062	136%	Menatep	91	37%
MDM	634	713%	MFK	80	46%
Avtobank	602	299%	Mezhkombank	67	67%
Total				6500	

Source: Table 1.2 in Ippolito (2002), based on Troika Dialog data as of 01.07.98

the banking system within that year. The crisis took place right in the middle of the third quarter of 1998. We will think of the first two quarters of 1998 as "pre-crisis," when the government debt had become risky, but the banking regulation failed to recognize it as such. Thus, we expect the banks to gamble by combining GKOs (government bonds) with currency forwards in the first two but not the last two quarters of 1998.

Stark support for our key mechanism comes from simply looking at the cross-sectional correlation between banks' GKO holdings and their on-balance-sheet exposure to currency risk.[21] These correlations, reported in Table 2, are positive and quite large in the run-up to the crisis, and are very close to zero after the crisis, when there are no more incentives for the banks to gamble. It is worth noting that the pre-crisis correlations are larger for private banks than for state-owned banks. This observation lends support to the idea that allowing private banks to gamble was a complementary mechanism used by the government in addition to coercion it may have exercised over the state-owned banks.

Table 2: Correlation of GKO Holdings and Currency Risk Exposure

Period	All Banks	State	Private	Foreign	Domestic
1998.Q1	0.2173	0.0966	0.2228	0.7431	0.1421
1998.Q2	0.1798	0.1675	0.1820	0.5173	0.1206
1998.Q3	0.0206	-0.1576	0.0280	0.2910	0.0116
1998.Q4	-0.0004	-0.2649	0.0076	0.3717	-0.0177

Note: Correlations based on quarterly bank balance sheet statements. Source: Authors' calculations

[21] Currency risk exposure is measured as net foreign currency liabilities as a share of total assets.

5.2 Evidence from the Eurozone Debt Crisis

The Eurozone sovereign debt crisis that started in Greece and spread to other countries triggered the implementation of several unconventional policies by the European Central Bank (ECB). Of particular interest is the program that was announced on December 8, 2011.[22] The basic characteristic of this LTRO program was that the ECB opened the possibility of making 3-year loans to banks against a variety of collateral, subject to a collateral-specific haircut schedule. The operations were an extension of the ECB's main lending facility to banks to 3-year loans (previously, the loan had much shorter maturity). While the stated main objective of the LTRO was to increase lending to the private sector, there is evidence that most of the funding was directed toward peripheral countries' government debt. Capital regulations, which did not account for the risk of default on these government bonds, made this strategy (of buying risky Eurozone government bonds, financed by borrowing from the ECB, and using these very bonds as "safe" collateral) a profitable endeavor (Acharya and Steffen (2015) describe this as the "greatest carry-trade ever"). The introduction of this lending facility by the ECB is useful to analyze the disconnect between measures of government default and the price of government debt as well as the risk-shifting from the government to the financial sector. Both of these effects are central in our model.

The main objective of the ECB policy was to "support bank lending and liquidity in the euro area..."; however, the evidence points to small changes in credit to the private sector and significant increases in domestic banks' bond holdings of domestic sovereign debt. The ECB extended €489 billion in loans to more than 500 banks on December 21, 2011, and further €530 billion more on March 1, 2012. As in Krishnamurthy, Nagel, and Vissing-Jorgensen (2017), we use the Bruegel database of sovereign bond holdings to show how exposure to domestic sovereign debt changed during this period. Table 3 presents the evolution of domestic sovereign debt holdings by domestic banks.

[22] See Krishnamurthy, Nagel, and Vissing-Jorgensen (2017) for a detailed description of this program and other ECB programs around the crisis such as the Securities Market Program and the Outright Monetary Transactions.

Table 3: Changes in Domestic Bank Holdings of Domestic Sovereign Debt (Billions EU$)

	2010.Q1	2011.Q1	2012.Q1	2013.Q1	Δ 2012.Q1 - 2011.Q1
Ireland					
Residents	12.33	15.22	18.76	51.60	3.53
Domestic Banks	8.42	12.65	17.16	19.13	**4.51**
Non - Residents	68.53	74.58	60.89	68.48	-13.69
Total	80.86	89.81	79.65	120.08	-10.16
Italy					
Residents	759.49	832.84	1,022.63	1,077.46	189.79
Domestic Banks	224.20	234.55	327.98	390.07	**93.43**
Non - Residents	749.05	740.21	613.84	622.82	-126.37
Total	1,508.55	1,573.06	1,636.47	1,700.28	63.41
Portugal					
Residents	25.14	48.67	60.97	61.31	12.30
Domestic Banks	11.90	20.87	29.68	30.74	**8.81**
Non - Residents	101.05	99.82	76.77	71.41	-23.05
Total	126.18	148.49	137.74	132.722	-10.75
Spain					
Residents	306.61	372.96	492.91	555.52	119.95
Domestic Banks	143.01	162.30	243.43	269.05	**81.13**
Non - Residents	260.35	257.31	215.26	250.79	-42.05
Total	566.96	630.27	708.17	806.31	77.90

Source: Bruegel database of sovereign bond holdings developed in Merler and Pisani-Ferry (2012)

This table shows that the change between pre- and post-LTRO program holdings of domestic sovereign debt by domestic banks is significant. Spain and Italy are the countries where the domestic financial sector exposure to the sovereign increased considerably.[23] It is important to note that, as a fraction of total debt, purchases of domestic sovereign debt are much more significant in Spain than in other countries (reaching close to 10% of the total stock). While we cannot directly attribute all the changes in domestic bond holdings to this program, the available evidence is clearly consistent with the main mechanism we are highlighting. The availability of cheap wholesale funding in combination with the regulatory regime in place exacerbated the incentives of the banks to load up on domestic sovereign bonds. Acharya and Steffen (2015) point to the carry trade incentives and conclude that "GIIPS banks (and Italian and Spanish banks, in particular) substantially increased their peripheral sovereign bond holdings during the first half of 2012, which is consistent with both the moral hazard and the moral suasion hypotheses." Capital regulation and domestic sovereign debt capital risk weights, in particular, allowed banks to load up on government

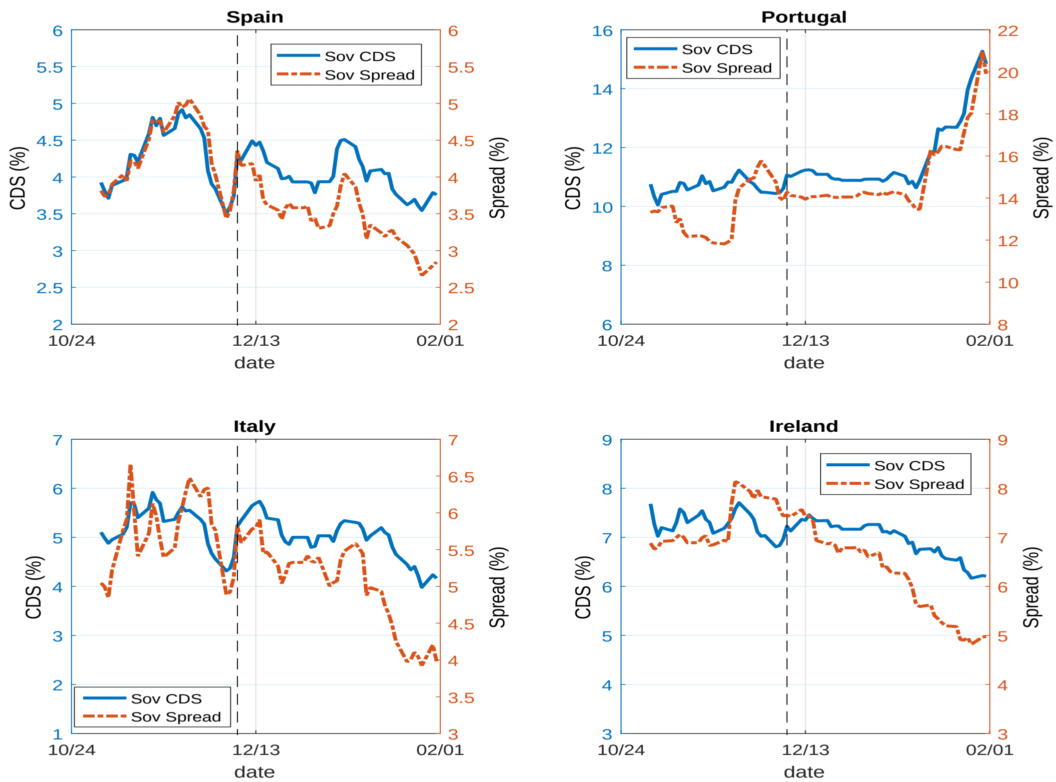
[23]The day after the first LTRO allotment, the Italian government approved a Decree Law allowing banks to obtain, for a fee, a government guarantee on part of their balance sheet. This gave Italian banks a technology to "create" collateral, since government-guaranteed assets were eligible collateral at the ECB (Carpinelli and Crosignani (2017)).

debt and generated the incentives to shift the risk of sovereign default from other investors to the domestic financial sector. This is line with evidence presented in Becker and Ivashina (2017) and Ongena, Popov, and van Horen (2018), who point to different forms of financial repression or "moral suasion" as an attempt by government to circumvent an increased cost of government debt.

In addition to the information presented here, we can point to the studies that have looked at changes in private credit for these countries around the same episode. Carpinelli and Crosignani (2017) for Italy, Crosignani, Faria-e-Castro, and Fonseca (2017) for Portugal, and Garcia-Posada and Marchetti (2016) for Spain present evidence that the effect of the LTRO program on bank lending was modest at most. Bank lending to firms in Italy increased by 2% and credit growth in Spain increased only about 1 percentage point. Since a large fraction of the funds from this LTRO program was used to purchase sovereign bonds, several subsequent LTRO programs (so-called targeted LTROs) tied bank borrowing from the ECB to bank lending to the private sector.

Another important piece of evidence that sheds light on the link between capital regulation and the value of government debt at the center of our model is the disconnect that appeared between sovereign spreads and the market measure of sovereign default risk (measured using CDS) around the LTRO implementation. Figure 2 presents the evolution of 5-year bonds spreads (relative to German bonds) and the corresponding CDS for Spain, Italy, Portugal, and Ireland for the period between November 1, 2011 and January 31, 2012. The dotted line corresponds to December 8, 2011, the day the ECB announced this LTRO program.

Figure 2: Sovereign Default Risk and Bond Prices Divergence



Note: Series presented correspond to 5-year CDS spreads and the spread between the yield of a 5-year government bond for each corresponding country and that of the same maturity for Germany. Vertical dashed line refers to the announcement of the LTRO program (12/8/2011). Source: Bloomberg

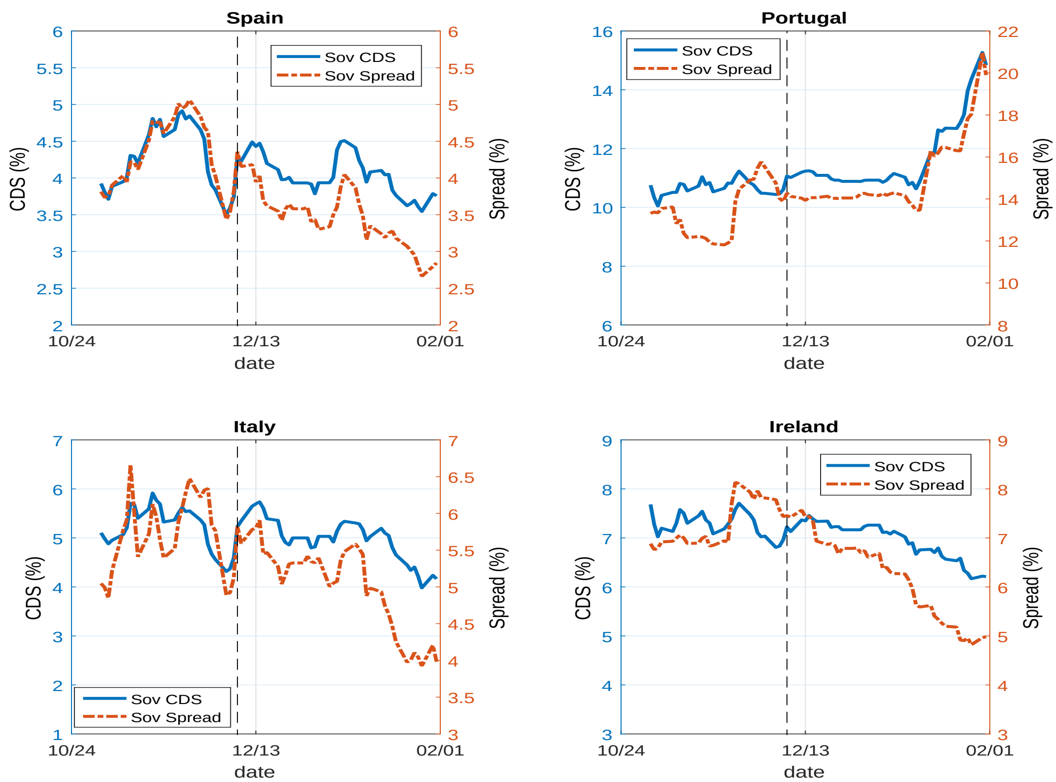
As this figure shows, sovereign yield spreads decline around the announcement of the LTRO program and the decline is not completely driven by changes in default risk (as measured by the sovereign CDS). There appears to be a disconnect between the sovereign default risk and the price of sovereign debt. The domestic banking sector driven demand of government bonds is reducing the cost of borrowing for the government. This event analysis is consistent with the evidence presented in a recent paper by Krishnamurthy, Nagel, and Vissing-Jorgensen (2017) that estimates that changes in default risk explain only between 25% and 35% of the decline in sovereign spreads.[24] In the case of Spain, a country in which repatriation of sovereign debt around the announcement was the strongest (as a ratio of total

[24]Factors such as the expectations hypothesis and the euro-rate term premium appear to play a minimal role in the decline of spreads. Falagiarda and Reitz (2015) also find evidence that unconventional monetary policy in the Euro area reduced long-term government bond yields.

debt outstanding), changes in default risk have almost no effect on the changes of sovereign spreads.

The dynamics of holdings of domestic government debt that we just described imply that the risk of default became more concentrated in the financial sector. That is, the risk-shifting effect that is present in our model plays a role also around this episode. Figure 3 presents the evolution of the perceived risk of default (as measured by 5-year CDS) by the government and the largest banks in each country.

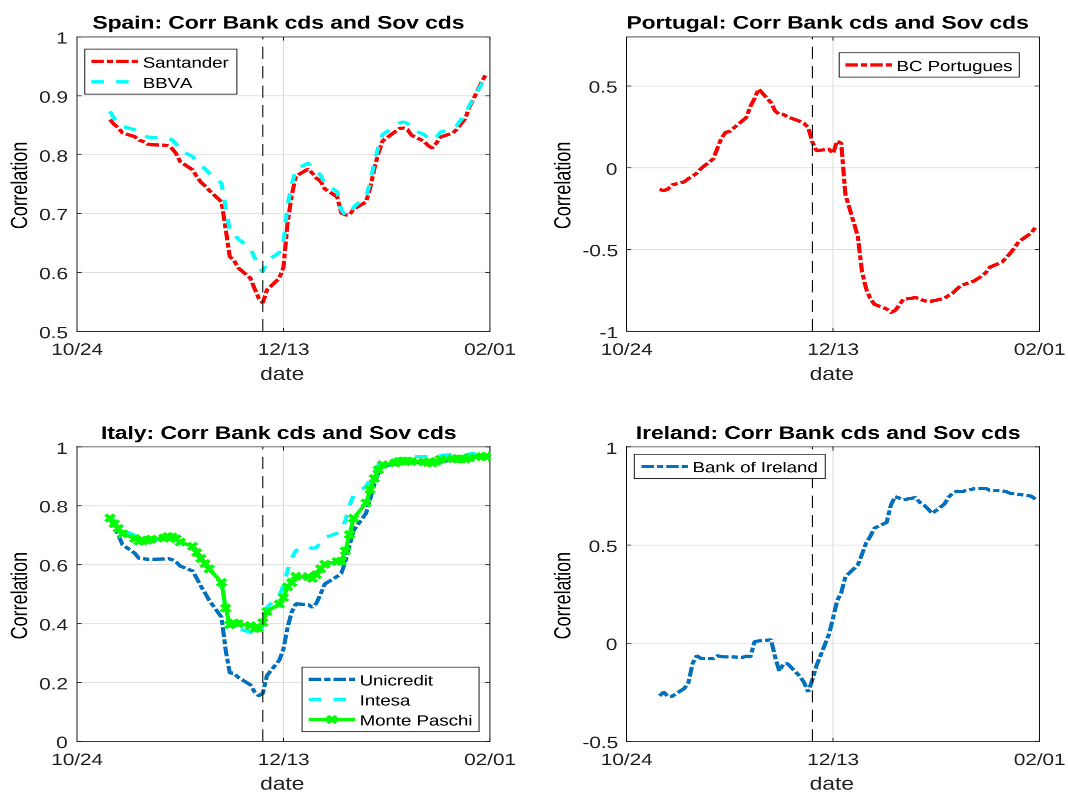
Figure 3: Sovereign and Bank Default Risk



Note: Series presented correspond to 5-year CDS spreads. Vertical dashed line refers to the announcement of the LTRO program (12/8/2011). Source: Bloomberg

This figure shows that the risk of failure of the largest banks in each country co-moved closely with the risk of default of the sovereign even prior to the implementation of this policy. This is not surprising since, even before the LTRO program, domestic banks held between 14% and 26% of the total stock of debt outstanding in these countries. However, the increase in holdings of sovereign debt results in an increase in the correlation of failure and default for banks and sovereigns. Figure 4 presents the correlation between the CDS for each bank and that of the sovereign. Correlations are computed as two-month rolling windows centered in the corresponding date (i.e., one month prior and one month after the date).

Figure 4: Correlation Between Sovereign and Bank Default Risk



Note: Series presented correspond to correlations of 5-year CDS spreads. Correlations are computed as two-month rolling windows centered in the corresponding date (i.e., one month prior and one month after the date). Vertical dashed line refers to the announcement of the LTRO program (12/8/2011). Source: Bloomberg

It is clear how after the implementation of the LTRO program the correlation between the perceived sovereign default risk and the bank failure risk increases considerably. It is notable how this correlation changes for Italy and Spain, the two countries with the largest repatriation of sovereign debt (see Table 3).

6 Conclusion

We have argued that failure of banking regulation to recognize the riskiness of government bonds can lead to excessive risk-taking by banks and system-wide banking crisis during the government's default. We have used a simple model to show that this failure of prudential regulation may serve the purposes of a self-interested government as it lowers the cost of financing the debt and may postpone (and give a chance to avoid) the default. Available evidence regarding the behavior of Russian banks around the time of the 1998 crisis and regarding the effects of LTROs during the Eurozone debt crisis lends support to the key mechanism we emphasize.

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