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Banking Regulation with Risk of Sovereign Default*

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Abstract

Banking regulation routinely designates domestic government debt as safe, even when this debt is risky. We show, in a parsimonious model, that this failure to recognize the riskiness of government debt induces domestic banks to "gamble" with depositors' funds by purchasing risky government bonds and assets correlated with them. Sovereign defaults then result in banking crises; however, by permitting banks to gamble, the regulator lowers the government's borrowing costs ex-ante. Thus, the government has an incentive to ignore the riskiness of the sovereign bonds. We derive a set of testable implications and present supporting empirical evidence from sovereign debt crises in Russia, Argentina, and the Eurozone.

JEL Classification Numbers: G01, G28, F34

Keywords: Banking; Sovereign default; Prudential regulation; Financial 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 crisis in the Eurozone periphery countries in the 2010s. This link derives, to a large extent, from the large direct exposure of the banking sector to sovereign risk. Figure 1 shows the fraction of sovereign debt in the hands of domestic financial institutions (banks and other financial institutions) before and during the Eurozone debt crisis. Domestic financial institutions held a significant portion of the existing debt both in periphery countries (Greece, Ireland, Italy, Portugal, and Spain) and advanced economies (e.g., Germany) prior to the debt crisis, but that share increased dramatically in the periphery countries when their risk of government default increased (as is illustrated by the sovereign spreads going up). 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]

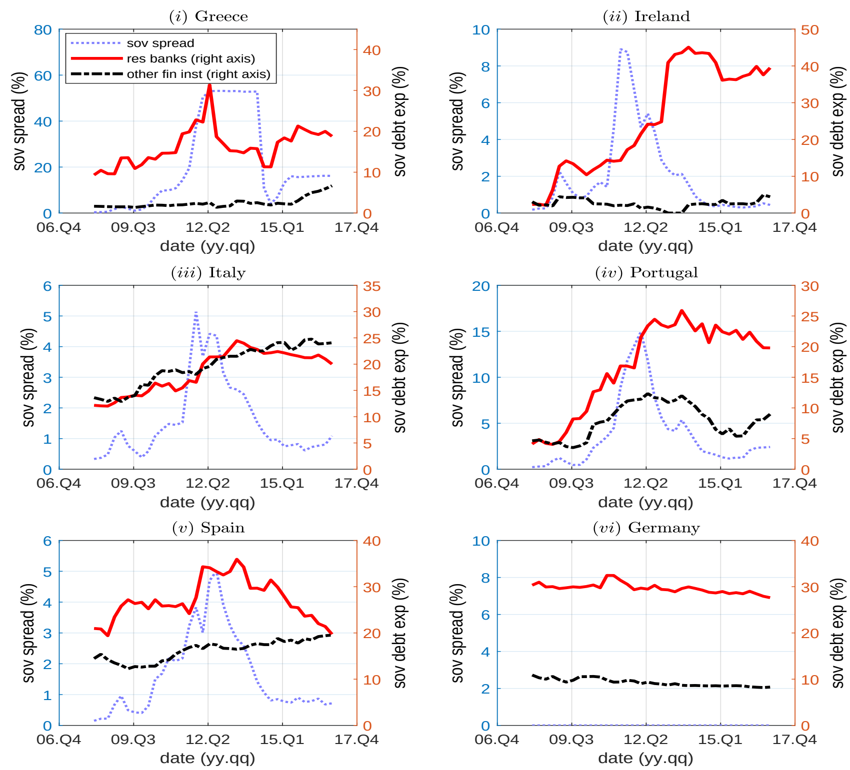
The basic story is simple. Banks fund their investments with deposits and are protected by limited liability. This situation creates incentives for excessive risk-taking on the part of the banks (as Jensen and Meckling (1976) point out, the basic insight appears in Smith (1776)). To prevent excessive 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 the 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. Figure 1 shows evidence consistent with this story as, in many cases, holdings of domestic sovereign debt increase much more in regulated domestic institutions (i.e., resident banks) than in other domestic financial institutions.

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)

[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 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)).

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 the words of Juvenal (1891), Satire VI) “Who will guard the guardians?”

Figure 1: Sovereign Spreads and Exposure in the Domestic Financial Sector



Note: “sov spread” refers to the spread between a 5-year sovereign bond and German bonds of the same maturity. “sov debt exp” refers to sovereign debt exposure as measured by the fraction of sovereign debt in the hands of a particular group of domestic financial institutions. “res banks” refers to resident (domestic) depository institutions (excluding the central bank). “other fin inst” refers to all other financial institutions (excluding the central bank). Source: Bruegel database of sovereign bond holdings developed in Merler and Pisani-Ferry (2012).

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 the 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).

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. Of course, the benefit of the lower borrowing costs does not come for free — permitting the banks to gamble by buying government bonds creates risk of bank failure, thus shifting the risk of government default onto risk-averse depositors (misallocating that risk, which should be borne by risk-neutral investors).[2]

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,

[2]Deposit insurance could, at least partially, protect domestic depositors from the risk of bank failure. While we are not explicitly modeling the deposit insurance here, it is important to note that our key mechanism 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.

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. 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.

The basic mechanism of our paper has a number of testable implications, and we examine all of their empirical validity in this paper. In order to test these theoretical predictions, we use aggregate and bank-level data from the sovereign debt crises in Russia (1998), Argentina (2001), and the Eurozone (2011-2013).

First, our key theoretical insight makes clear that the regulator has incentives not to recognize the riskiness of domestic sovereign debt since not recognizing the risk of sovereign debt leads to lower than actuarially fair sovereign debt interest rates. Since 1988, the Basel Accords have granted the option to apply low capital risk weights for exposures to domestic government debt. In practice, and while developed and developing countries differ in many aspects, most countries take advantage of this benefit, which makes it easier for the government to induce financial institutions into buying domestic sovereign debt. In addition, we observe that, during crisis times, governments adjust banking rules or implement lending programs that make the failure of capital regulation, which is at the core of our paper, even more pronounced. In the case of Argentina, the government relaxed several macroprudential policies in the run-up to the default. In the case of the Eurozone crisis, we focus on the period around the Long-Term Refinancing Operation (LTRO) program (announced in December 2011). The European Central Bank (ECB) provided long-term financing to the banks of the distressed Eurozone countries against those same risky government bonds as "safe" collateral. These policy changes increase the incentives for banks to hold domestic sovereign debt and lower the cost of government borrowing relative to that in the absence of these policy changes. Importantly, we show that, consistent with the predictions of the model, these policy changes lead to a disconnect between the perceived probability of a sovereign default and the price of government debt.

Second, the increase in sovereign spreads during a crisis combined with the regulatory treatment of sovereign debt as safe (passive or active due to policy changes) creates or increases the incentives for regulated banks to gamble by holding domestic sovereign debt. Using bank-level data from Argentina and European countries, we show that there is an increase in the fraction of sovereign debt in the hands of the domestic financial sector during periods of stress. In addition, we document that the increase in sovereign debt is larger for (regulated) resident banks, relative to other domestic financial institutions, and that this increase accelerates after regulatory changes that favor government debt.

Third, in the model, the incentive to gamble with sovereign debt (when the debt is risky but treated as safe by regulators) is stronger for risky less capitalized banks. Using detailed information on the exposure of regulated domestic banks to sovereign debt across countries, we show that as long as sovereign debt is safe (i.e., at low levels of spreads), regulation is effective and exposure to sovereign debt is relatively homogeneous across banks. However, once sovereign debt becomes risky, lax regulation results in sovereign debt being allocated mostly to low capital ("gambling") banks. The change in this correlation between banks' capitalization and their sovereign debt exposure is present in both Argentina and European banks.

Fourth, another prediction of the model is that gambling banks with a 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 a financial asset more correlated with the government default than (a derivative on) the exchange rate of the domestic currency. And as Ippolito (2002) documents, a number of Russian banks took vast positions in "currency forward" contracts in 1998. Using a unique dataset of balance sheets of Russian banks from 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. Notably, this correlation disappears after the crisis happens, lending further support to our key mechanism. We document a similar pattern in Argentina using detailed balance sheet information for all active banks around the default episode in 2001. The correlation of domestic sovereign bond holdings and foreign currency exposure increases in the run-up to the default, and it is stronger for domestic private banks and banks with low capital.

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 summarizes our theoretical findings (all proofs are relegated to Appendix B). Subsection 4.4 presents a simple extension of our model, which explicitly endogenizes the risk of government default, and highlights the gambling-for-redemption nature of the banking regulation failure in our environment. Section 5 lays out testable implications of our model and provides a set of observations which offer empirical evidence in support of these key predictions. 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), Crosignani, Faria-e-Castro, and Fonseca (2020)). These papers highlight that the exposure of domestic banks to government debt changes the repayment incentives of a (benevolent) government, lowering the risk of default and, hence, the interest rates on government bonds. In contrast, we treat the risk of default itself as largely exogenous (as in Bocola (2016), for example) and focus instead on how macro-prudential 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.

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. 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. One key distinction between the mechanism we are highlighting and the existing work is that the government debt is *mispriced* in our model.

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. 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. Contemporaneously, Crosignani (2021) highlights the incentives of under-capitalized banks to hold domestic bonds, and the effects of these banks' purchases of domestic bonds on the sovereign's debt capacity.

Our analysis highlights that "financial repression" (as in Reinhart and Sbrancia (2015), Becker and Ivashina (2018), Krishnamurthy, Nagel, and Vissing-Jorgensen (2018), 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), as well as Alessandro (2009) for non-banks). Rather, our story is complementary to it. 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 presumably had much less sway.

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 banks in Greece, Ireland, Italy, Portugal, and Spain (Eurozone periphery countries) 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 document 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.

We contribute to the empirical literature linking sovereign debt and the financial sector by providing a set of tests of the key findings of our theoretical model. First, we provide additional evidence of LTROs' effect on sovereign spreads by studying the link between sovereign yields and CDS spreads. Our findings of significant disconnect between the spreads on bonds and those on CDS in Spain and Italy are consistent with the evidence presented in Krishnamurthy, Nagel, and Vissing-Jorgensen (2018), who find that LTROs affected mostly Spanish sovereign yields via an increase in the share of domestic debt in the hands of local banks. Second, we observe an increase in the fraction of sovereign debt in the hands of the domestic financial sector during periods of stress. This evidence is consistent with Acharya and Steffen (2015), Crosignani, Faria-e-Castro, and Fonseca (2020), Coimbra (2020), Crosignani (2021), Krishnamurthy, Nagel, and Vissing-Jorgensen (2018), and Brutti and Sauré (2016). We contribute to this literature by showing that the increase in sovereign debt exposure is larger for regulated resident banks, and that this change speeds up after regulatory changes that favor sovereign debt.

We also contribute to the empirical literature by showing that sovereign debt exposure in the domestic financial sector is relatively homogeneous across banks when sovereign spreads are low and confirming that the sovereign debt exposure is concentrated in less capitalized banks when the spreads are high. Guided by our model, we show that incentives to load up on sovereign debt depend on whether sovereign debt is considered risky or not. This observation is consistent with the evidence presented in Drechsler et al. (2016) who relate bank credit ratings before the crisis and borrowings from the ECB. Like Acharya and Steffen (2015), Brutti and Sauré (2016), and Drechsler et al. (2016) we find that once sovereign debt becomes risky, lax regulation implies that sovereign debt is allocated mostly to low-capitalized ("gambling") banks. We complement the evidence from the European crisis with new data from Argentina. Finally, we present novel evidence from Russia and Argentina on the portfolio composition of domestic banks and show that banks' government bond holdings and their foreign currency exposure increase dramatically in the run-up to sovereign defaults and that this correlation is stronger for private and low capitalized banks.

2 Environment

We present 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.

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 a 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 the 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. 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. Investors can pick projects with any correlation of returns they want. 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.

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 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's 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 (promised) interest rate on the government bonds, i^g, is endogenous.

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 the 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 4.4, 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. 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.

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.

2.5 Banking Regulation

The government also sets prudential regulation that the banks must abide by, which 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 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 required 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

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

where β^* is specified in the statement of Proposition 1 as a function of r^*, and r^* is defined by equation (4). We will further assume that total household deposits are large enough to purchase the entire stock of government debt, i.e., $D > B$. This ensures that the marginal holder of government bonds in an economy with $\alpha^B = 0$ is a gambling bank and not an investor investing his own wealth. That in turn leads to mis-pricing of the default risk of government bonds and creates the incentive for the government not to recognize the riskiness of its bonds.

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

$$r = \theta A K^{\theta-1}, \tag{3}$$

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 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. Furthermore, if a gambling bank invests in risky government bonds, it would then choose risky projects perfectly correlated with government debt repayment. Such a gambling bank then survives only when the government repays (which coincides with the states in which their risky projects succeed). Gambling banks that do not purchase government bonds do not care about the correlation of their investments with the government repayment, but also fail with probability $(1-p)$ when all their risky projects (perfectly correlated within the portfolio) fail. 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

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

Problems (6), (7), and (8) above lay out the possible strategies for an investor. The value for an investor is then

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

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 (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 $D = \int \mathbf{1}_{\chi_i \in \{S,G\}} d_i di$.*

While equilibria of the model may feature financial institutions engaged in a variety of activities, it is convenient to think of an outcome-equivalent equilibrium, in which all investors and banks specialize in a single type of investment activity. Equilibrium characterizations in the next section present such simplified equilibria. In Section 4.3, we discuss the possibility of combining multiple activities in a single financial institution, which is important for taking the model to the data.

4 Equilibrium Characterization

In this section, we characterize the equilibrium outcomes and derive key theoretical findings. We begin by establishing the benchmark of effective regulation, both when government debt is safe and when government debt is risky. We then proceed to the analysis of capital regulation and the role of risk weights when the government debt is risky. We focus our presentation on the case of prudential regulation sufficient to prevent investment in risky projects (sufficiently high β), but we offer the characterization of equilibrium outcomes for the full range of capital requirements in the Appendix A (see also Figure 2). We characterize the equilibria 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). All proofs are in Appendix B.

4.1 Effective Capital Regulation

In order to establish a clear benchmark, we begin by characterizing the effective banking regulation both when sovereign debt is safe ($p^g = 1$) and when it is risky ($p^g = p$).

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

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: $(1 + i^d) = r^*$. Proposition 1 thus establishes the minimal level of capital requirements such that no bank gambles with risky investments when government debt is safe:

$$\beta^* = \frac{p(R - r^*)}{r^*(1 - p)}. \tag{11}$$

In the rest of this section, we analyze 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 $\alpha^B\beta < 1$).*

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. 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

$$1 + i^g = \frac{r}{p} \quad \text{whenever} \quad \alpha^B \geq \frac{1}{\beta}. \tag{12}$$

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).

Combining the insights from Propositions 1 and 2, we can now state necessary and sufficient conditions for implementing an effective regulation in the presence of risk of government default.

Corollary 1. *When government debt is risky ($p^g = p < 1$), banking regulation is effective (at preventing bank failures) if and only if $\beta \geq \beta^*$ and $\alpha^B \geq 1/\beta$.*

The first condition is needed to discourage investment in risky technology, while the second condition prevents banks from gambling by purchasing government bonds. Of course, an effective regulation does not eliminate the risk of government default. But it succeeds in shifting this risk away from risk-averse households and into the hands of risk-neutral investors.

4.2 Capital Regulation and the Role of Risk Weights

In the rest of the section, we focus on the case when government debt is risky ($p^g = p$) and the prudential regulation is sufficient to prevent investment in risky projects ($\beta \geq \beta^*$), though our key findings apply for lower levels of capital requirements as well (see Figure 2 and Appendix A). 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 4.4, is that the lax banking regulation can be the only way for a heavily indebted government to avoid an immediate default.

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 banking regulation does not recognize the risk of government debt ($\alpha^B = 0$), 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 $\beta \in \left[\beta^*, \frac{\Omega}{\Omega+D-B}\right)$ 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. $(1 + i^g) = (1 + i^d) = r^*$.

In this equilibrium, zero-equity banks buy up the entire stock of government bonds. Competition among these banks implies $(1 + i^g) = (1 + i^d)$. At these prices, safe banks do not invest in government bonds. And high capital requirements ($\beta > \beta^*$) guarantee that it is not profitable to operate a gambling bank that invests in the risky technology. The regulation not recognizing the risk of government default ($\alpha^B = 0$) results in the entire risk of default being borne by 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 $\beta \in \left[\beta^*, \frac{\Omega}{\Omega+D}\right)$ 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. $(1 + i^g) = r^*(\beta/p + (1 - \beta))$.

Like in the previous proposition, investing in risky technology is unprofitable, and all the wealth is invested in the safe asset and government bonds, implying $r = r^*$. However, gambling banks buying government bonds now have to hold some equity. Since investors providing this equity must be compensated for the risk of failure, the return on government bonds is no longer equal to that on deposits. More specifically, $(1 + i^d) < (1 + i^g) < \frac{r^*}{p}$, where the second inequality follows from $\beta < 1$ and guarantees that safe banks do not purchase government bonds.

The takeaway from this subsection (illustrated in the right portion of graphs in Figure 2) is that 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.

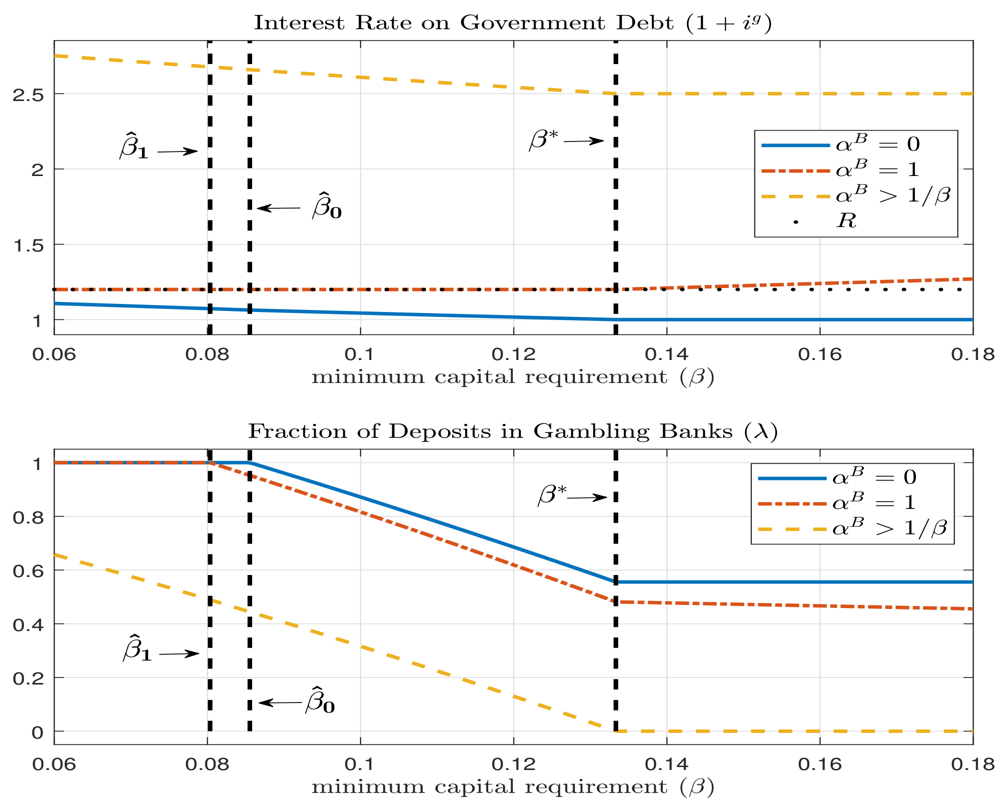
To simplify the exposition, we described equilibria in which all investors and banks specialize in a single type of investment. But for the purposes of empirical analysis, it is worth pointing out that there are outcome-equivalent equilibria with richer (more realistic) financial institutions. Specifically, private investors and safe banks could be combined into an over-capitalized bank. Critically, no financial institution in these equilibria is ever willing to merge with a gambling bank.

4.3 Summary and Key Insights

This subsection summarizes the key theoretical findings from our model. Figure 2 illustrates how the cost of borrowing for the government $(1+i^g)$ and the fraction of deposits allocated to gambling banks λ are affected by the choice of the key policy parameter α^B for different values of β (analytical expressions for these variables come from Propositions 3 through 9 and equation (12)).

This figure illustrates the main takeaways from our model. Comparing the values of $(1 + i^g)$ across the three lines in the top panel makes evident the incentives of the regulator not to recognize the riskiness of government debt. Setting α^B to 0 substantially reduces the cost of borrowing for the government, for any level of the capital requirement β. A key cost of such policy, on the other hand, can be seen by comparing the value of λ (bottom panel) for different values of α^B. Not recognizing sovereign risk results in a larger fraction of deposits in gambling banks, i.e., a greater exposure of households to the risk of bank failure. Thus, Figure 2 shows that the government faces a trade-off between reducing its cost of borrowing on the one hand and shifting its risks of default to the household sector on the other hand.[3]

Figure 2: Equilibrium Conditions Under Different Capital Regimes



Parameter values are as follows: $R = 1.2$, $p = 0.4$, $\theta = 0.8$, $\Omega = 2.5$, $B = 1.0$, $D = 1.8$. A is normalized so that $r^* = 1$. This results in the following thresholds for capital requirements: $\beta^* = 0.1333$, $\hat{\beta}_0 = 0.0855$, and $\hat{\beta}_1 = 0.0804$.

Finding 1. *Interest rate on government debt is lower when the banking regulation does not recognize the riskiness of government debt (i.e., i^g is lower when $\alpha^B = 0$ than when $\alpha^B = 1$, which in turn is lower than under $\alpha^B \geq \frac{1}{\beta}$).*

The first part of the finding (that i^g is lower when $\alpha^B = 0$ than when $\alpha^B = 1$) follows di-

[3] The left-most portion of the bottom panel may give an impression that the cost of setting α^B to 0 is absent for the lowest values of β (relative to setting α^B to 1), since the entirety of households' savings are at risk in either case. But while the low value of α^B does not increase the misallocation of risk in this case, the lower cost of borrowing does not come for free. The low value of α^B increases misallocation of investment, leading to a larger share of resources going into (un)productive risky projects. From the households' perspective, it manifests in lower promised (and expected) interest rates when α^B is low. Note that this misallocation is complementary to the crowding out highlighted in Broner et al. (2014) as investment is diverted not just to domestic bonds but also to unproductive risky projects.

rectly from comparisons of equilibria characterized in Proposition 3 with those in Proposition 4, of equilibria in Proposition 6 with Proposition 7, and of equilibria in Proposition 8 with Proposition 9. The second part of the finding (that i^g is lower when $\alpha^B = 1$ than when $\alpha^B \geq \frac{1}{\beta}$) follows from the comparison of these equilibrium values to those given by equation (12). This finding is illustrated in the top panel of Figure 2, as the interest on government debt is higher when α^B is higher (regardless of the level of β).

Finding 2. *The share of government debt held by domestic banks is larger when the debt is risky but that riskiness is not recognized by banking regulation (than when the debt is safe).*

This follows from the fact that the entire stock of government debt is held by domestic banks whenever the debt is risky (and the regulation doesn't prevent banks from holding it, i.e., when $\alpha^B < \frac{1}{\beta}$).

Finding 3. *No gambling bank holds excess capital, i.e., capital in excess of the minimum required by regulation. Only safe banks can be over-capitalized.*

Gambling banks take advantage of limited liability in the event of a bank failure. If such a bank were over-capitalized, we could split it into a minimally capitalized gambling bank and an investor that invests its own funds into risky projects. But we know that investors do not find such investments profitable. In contrast, there is no problem merging a safe bank and a non-bank investor into a single entity (which would be an over-capitalized bank) as neither party takes advantage of limited liability.

Finding 4. *If a bank invests in both risky government debt and productive projects, it chooses to invest in risky projects perfectly correlated with the government debt.*

4.4 Banking Regulation and Endogenous Default

Our analysis thus far treated the (risk of) government default as exogenous. We now provide a simple two-period extension of our model, which offers an explicit micro-foundation of the government default risk in our model and highlights the trade-offs faced by indebted governments in determining how banking regulation treats their bonds. Notably, all of the findings derived above carry over to the extended model.

Consider the following two-period extension of the model, where a government enters the first period with a budget deficit B and finances the deficit with new debt issuance of B', which it may or may not be able to repay in the second period. There are two aggregate states of nature in the second period, which differ in the amount of 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 parameter α^B adopted in that period.

Proposition 5. *Assume that* $\beta \in \left[\beta^*, \frac{\Omega - \frac{pS_H}{r^*}}{\Omega + D - \frac{pS_H}{r^*}}\right)$. *Then*

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 how banking regulation treats government debt.*

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. As the interest rate on risky sovereign debt depends on how it is treated by banking regulation, 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.

While the proposition is stated for $\beta \geq \beta^*$, the key insight applies at lower values of β as well, with slight adjustments to the expressions for the current debt thresholds (these thresholds get shifted to the left due to higher equilibrium interest rate r obtained under lower values of β).

5 Testable Implications

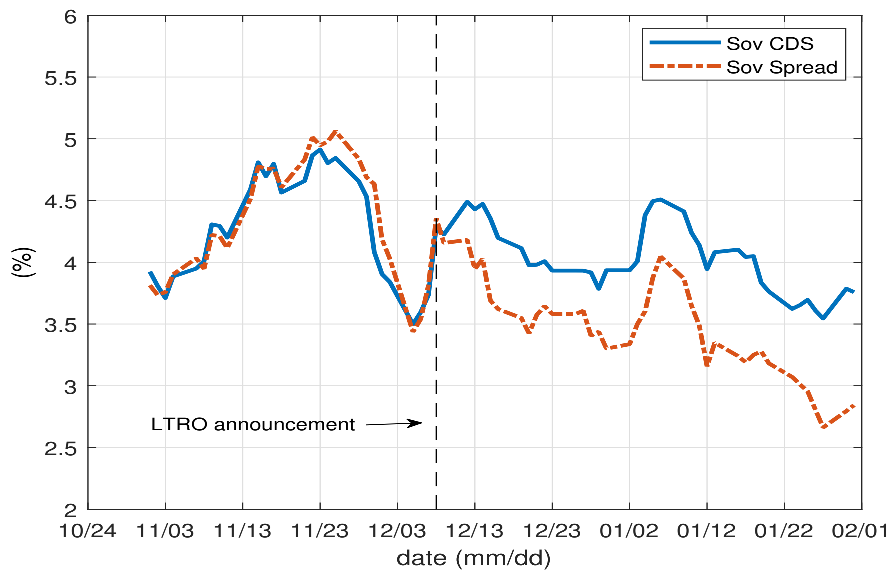
In this section, we bring the predictions of the model to the data. We focus our attention on the Russian crisis in 1998, the crisis in Argentina in 2001, and the more recent sovereign debt crisis in the Eurozone. Regulatory incentives to hold sovereign debt were strong in all these cases as bank capital regulation followed the guidelines presented in the Basel accords. In this section, we list a set of testable implications and provide the corresponding empirical evidence. We use data from several sources. We use proprietary data from commercial banks in Russia and Argentina for the analysis of crisis episodes in developing economies and data from commercial banks in the Eurozone to study the dynamics around the European debt crisis. We describe our data sources in detail in Appendix C.

At the center of our model are capital regulation and the treatment of domestic sovereign debt. The Basel Accords grant the option to apply low capital risk weights for exposures to domestic government debt. Most countries take advantage of this benefit which makes it easier for the government to pressure financial institutions into buying domestic sovereign debt. When the risk of sovereign default increases, we observe proactive changes in regulation that make the failure of capital regulation, which is at the core of our paper, even more pronounced. E.g., in April 2001, less than a year before the default, the Argentinean government placed US$ 2 billion of bonds with banks in Argentina by allowing banks to use those bonds to meet up to 18 percent of the liquidity requirement. In a more recent example, the European Central Bank (ECB) announced the Long-Term Refinancing Operation (LTRO) program on December 8, 2011 (see Krishnamurthy, Nagel, and Vissing-Jorgensen (2018) for a detailed description of this program). That leads to our first testable implication and the empirical observation consistent with it.

Testable Implication 1. Not recognizing the risk of sovereign debt leads to lower than actuarially fair sovereign debt interest rates (see Finding 1 above).

Observation 1.1. After policy changes that favor the use of government debt by financial institutions, there appears to be a disconnect between the perceived probability of a sovereign default and the price of government debt.

Figure 3: Sovereign Default Risk and Bond Prices Divergence (Spain)



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

We use one such regulatory change (the LTRO program implemented by the ECB) to document the disconnect between the perceived probability of a sovereign default and the price of government debt. We study the link between 5-year sovereign Credit Default Swaps premia (our measure of government default probability) and the sovereign 5-year bond yield spread (measured as the difference between the 5-year yield on a government bond against a German bond of the same maturity). To illustrate this change in the relationship, Figure 3 presents the evolution of 5-year CDS premia and 5-year sovereign bond yield spreads for Spain around the LTRO announcement. This figure shows, for the case of Spain, the disconnect between the sovereign default risk and the price of sovereign debt. This disconnect derives from the increase in demand for domestic government bonds from the local banking sector, which in turn reduced the cost of borrowing for the government but had no (immediate) effect on the sovereign default probability.

Now, we analyze more formally the link between sovereign CDS and sovereign spreads in countries in the periphery (Ireland, Italy, Portugal, and Spain) around the LTRO announcement (we exclude Greece here since its CDS premia were constant at a high level of 3535.67 basis points). In particular, using daily data on spreads and CDS around the LTRO announcement, we estimate the following equation

$$spread_{it} = a_i + b_0 cds_{it} + b_1 cds_{it} \times LTRO_t + u_{it} \tag{13}$$

where $spread_{it}$ denotes the 5-year sovereign spread for country i on day t, cds_{it} denotes the 5-year CDS premia, and $LTRO_t$ takes value 1 post announcement and 0 otherwise. The coefficient of interest is b_1 as it captures the relationship between spreads and CDS. To capture the effect of this program, we use a six-month window for the analysis around the announcement (results are robust to using a 1-month window and estimating a fixed effect panel regression). Table 1 presents the estimated coefficients country by country.

Table 1: Relationship between Sovereign Spreads and CDS (European Crisis)

	Dependent Variable $spread_{it}$			
	Ireland	Italy	Portugal	Spain
cds_{it}	1.719***	1.018***	1.009***	1.149***
	(0.0873)	(0.0314)	(0.0651)	(0.0330)
$cds_{it} \times LTRO_t$	-0.0494	-0.0521***	0.0308**	-0.130***
	(0.0302)	(0.0139)	(0.0153)	(0.0106)
N	263	263	263	263
R^2	0.736	0.815	0.631	0.843

Note: Standard Errors in parentheses. Statistically significant at 10% *, at 5% **, at 1% ***. $spread_{it}$ denotes the 5-year sovereign spread for country i on day t, cds_{it} denotes the 5-year CDS, and $LTRO_t$ takes value 1 post announcement (Dec 08, 2011) and 0 otherwise. N denotes number of observations. Source: Bloomberg

Table 1 shows that, on average, there is a positive relationship between sovereign yield spreads and sovereign CDS and that CDS premia explain a significant amount of the time series variation of spreads (as measured by the relatively high R^2). Importantly, Table 1 also shows that the estimated relationship between sovereign spreads and sovereign CDS declines after the LTRO announcement for most countries (i.e., the coefficient on $cds_{it} \times LTRO_t$ is negative and significant). We find that this relationship changes post-LTRO for Spain but also for Italy and Ireland (not a statistically significant change in the latter case) in the direction our model predicts. This is in line with the evidence presented by Krishnamurthy, Nagel, and Vissing-Jorgensen (2018), who find that LTROs affected mostly Spanish sovereign yields.

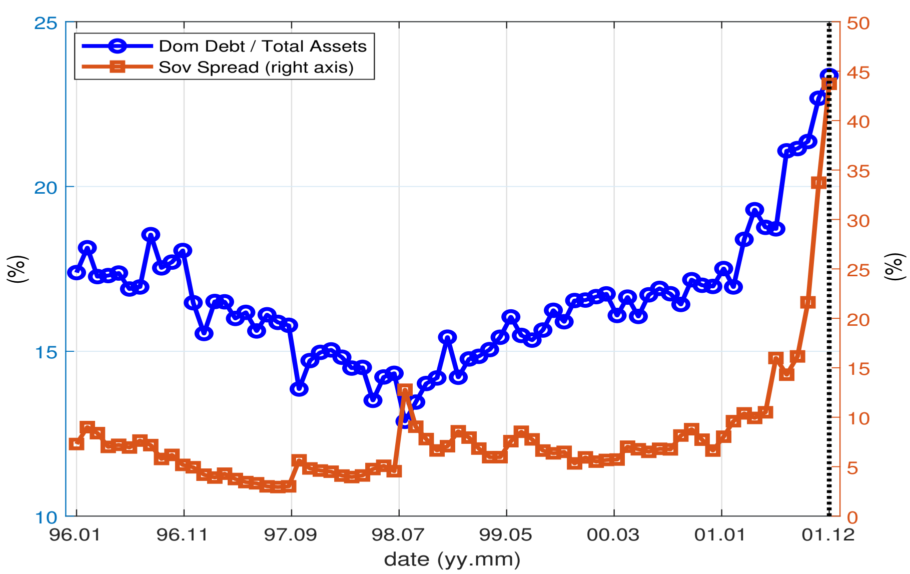
Testable Implication 2. The increase in sovereign spreads during a crisis combined with the regulatory treatment of sovereign debt as safe (passive or active due to policy changes) creates (or increases) the incentives for regulated banks to gamble by holding domestic sovereign debt (see Finding 2 above).

We provide three observations that are consistent with our Testable Implication 2.

Observation 2.1. We observe an increase in the fraction of sovereign debt in the hands of the domestic financial sector during periods of stress.

In the case of Argentina, total banking system claims on the government gradually rose from less than 10 percent of total bank assets at the end of 1994 to 15 percent at the end of 2000, and then jumped to over 20 percent by the end of 2001 (see de la Torre et al. (2003)). Figure 4 presents the evolution of the sovereign spread (the difference between the yield on a sovereign bond for Argentina and one with similar maturity for the US) and the ratio of total domestic sovereign debt over total assets in commercial banks in Argentina that we computed using our sample (a similar increase in the holdings of domestic sovereign bonds is observed in pension funds in Argentina (AFJP's), where it grew from 51% of their portfolio in 1999 to 64% in November of 2001). Figure 4 shows that as the crisis accelerated and spreads increased commercial banks increased their exposure to government debt significantly.

Figure 4: Sovereign Default Risk and Fraction of Domestic Sovereign Debt (Argentina)



Note: "Dom Debt / Total Assets" refers the ratio of total domestic bond holdings over total assets in the banking sector in Argentina. "Sov. Spread" refers to the sovereign spread computed as the difference in yields between a 5-year bond and a U.S. bond of the same maturity. Sources: Haver and Banco Central Argentina (BCRA)

In the case of the European sovereign debt crisis, Figure 1 makes it clear that domestic financial institutions hold a significant fraction of domestic sovereign debt and that this fraction increased significantly in countries where there was an increase in spreads or after the introduction of the long-term lending facilities. The bottom-right panel in Figure 1 makes it evident that there was almost no change in the fraction of domestic sovereign debt in the hands of domestic financial institutions in Germany. The ECB extended €489 billion in loans to more than 500 banks on December 21, 2011, and €530 billion more on March 1, 2012. We use the Bruegel database of sovereign bond holdings one more time to show how exposure to domestic sovereign debt changed during this period. Table 2 presents the evolution of domestic sovereign debt holdings by domestic banks.

Table 2: Changes in Domestic Bank Holdings of Domestic Sovereign Debt (Billions €)

	2010.Q1	2011.Q1	2012.Q1	2013.Q1	Δ € 2011.Q1 - 2010.Q1	Δ € 2012.Q1 - 2011.Q1
Ireland						
Residents	12.33	15.22	18.76	51.60	2.89	3.53
Domestic Banks	8.42	12.65	17.16	19.13	4.23	4.51
Domestic Other Fin Inst.	3.35	1.78	1.04	0.00	-1.57	-0.74
Non - Residents	68.53	74.58	60.89	68.48	6.05	-13.69
Total	80.86	89.81	79.65	120.08	8.95	-10.16
Italy						
Residents	759.49	832.84	1,022.63	1,077.46	73.35	189.79
Domestic Banks	224.20	234.55	327.98	390.07	10.35	93.43
Domestic Other Fin Inst.	241.34	297.37	305.05	350.46	56.03	7.68
Non - Residents	749.05	740.21	613.84	622.82	-8.84	-126.37
Total	1,508.55	1,573.06	1,636.47	1,700.28	64.51	63.41
Portugal						
Residents	25.14	48.67	60.97	61.31	23.53	12.30
Domestic Banks	11.90	20.87	29.68	30.74	8.97	8.81
Domestic Other Fin Inst.	5.45	13.39	15.75	14.47	7.94	2.35
Non - Residents	101.05	99.82	76.77	71.41	-1.23	-23.05
Total	126.18	148.49	137.74	132.722	22.31	-10.75
Spain						
Residents	306.61	372.96	492.91	555.52	66.35	119.95
Domestic Banks	143.01	162.30	243.43	269.05	19.29	81.13
Domestic Other Fin Inst.	72.59	97.18	117.61	134.04	24.58	20.43
Non - Residents	260.35	257.31	215.26	250.79	-3.04	-42.05
Total	566.96	630.27	708.17	806.31	63.31	77.90

Note: Values reported in € billions. Δ € denotes the change in € billions. Ireland Domestic Banks includes the Central Bank. Source: Bruegel database of sovereign bond holdings developed in Merler and Pisani-Ferry (2012)

Table 2 shows that the change between pre- (Δ € 2011.Q1 - 2010.Q1) and post-LTRO (Δ € 2012.Q1 - 2011.Q1) 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. 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). 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. Our analysis emphasizes that "financial repression" might not be necessary to induce banks to hold risky sovereign debt, but the interpretation we provide can be viewed as complementary and not necessarily contradicting the idea that expected discriminatory treatment or moral suasion (i.e., the case where banks are forced to hold the risky debt) drives the dynamics of domestic bond holdings.

Table 2 and Figure 1 make evident that capital regulation, and domestic sovereign debt capital risk weights in particular, allowed banks to load up on government debt and generated the incentives to shift the risk of sovereign default from other investors to the domestic financial sector. The evidence we present here is consistent with Acharya and Steffen (2015), Crosignani, Faria-e-Castro, and Fonseca (2020), Coimbra (2020), and Crosignani (2021). Like Krishnamurthy, Nagel, and Vissing-Jorgensen (2018), we use data from the Brugel database to show that domestic banks in Italy, Spain, Portugal, and Ireland increased their exposure to domestic sovereign debt after the introduction of the LTRO program (measured as the change in domestic bonds in the hands of domestic banks between 2011.Q1 and 2012.Q1). In line with the (pre-LTRO) evidence shown in Brutti and Sauré (2016), we also show that during a period of stress (as captured by elevated sovereign spreads) non-residents reduced their exposure to sovereign debt from crisis countries.

Observation 2.2. The increase in sovereign debt is larger for (regulated) resident banks (relative to other domestic financial institutions).

Data from the European debt crisis allow us to analyze separately the evolution of bond holdings for resident banks and other financial institutions during periods of elevated sovereign spreads. The data are in line with the model, as the evidence presented in Figure 1 shows that most of the increase in domestic holdings between 2010.Q1 and 2012.Q1 was concentrated in resident banks as opposed to other financial institutions (many of which are unregulated). The difference between resident banks and other financial institutions is very stark in the case of Greece, Ireland, Portugal, and Spain. In Italy, the fraction of domestic debt in other financial institutions increases almost one by one with the increase in resident banks. The evidence we present is consistent with Brutti and Sauré (2016), which focuses on the pre-LTRO period. We contribute by highlighting that during the period of elevated spreads domestic banks increased their holdings of domestic debt disproportionately relative to other domestic financial institutions. Ongena, Popov, and van Horen (2019) focus on the difference between domestic banks and foreign banks and identify "moral suasion" as the mechanism behind the change in bond holdings.

Observation 2.3. The increase in the fraction of sovereign debt in the hands of the domestic banks accelerates in response to regulatory changes that favor government debt.

Regulatory changes that favor the holdings of sovereign debt change the dynamics of bond holdings more so during periods of stress (i.e., periods of elevated sovereign spreads). We observe these changes in Argentina after the regulatory change (that we described above) in April of 2001. Table 3 (column (1)) shows that the ratio of domestic bond holdings over assets for domestic banks increases after these regulatory changes (this is robust to controlling for sovereign spreads).

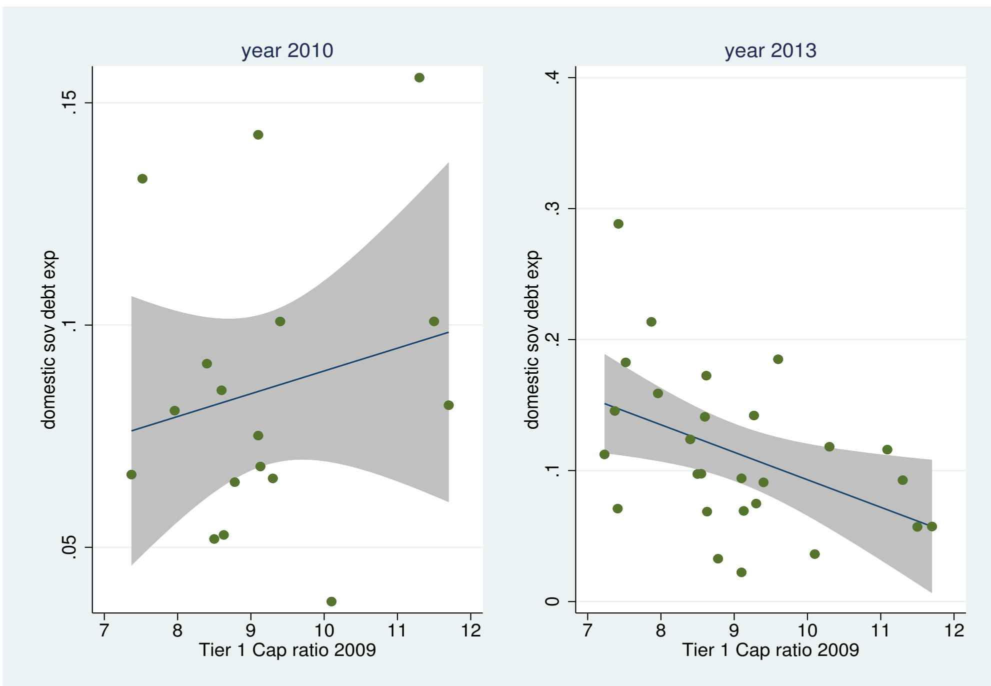
In the case of Europe, Table 2 and Figure 1 show that the increase in exposure to domestic sovereign debt by domestic banks speeds up after the introduction of the LTRO program. This can be seen, for example, by comparing the column Δ € 2012.Q1 - 2011.Q1 with the column Δ € 2011.Q1 - 2010.Q1 in Table 2. In all countries, we observe that the change in domestic banks' exposure increases significantly or remains elevated (for example, the change in Spanish banks is €19.29 billion between 2011.Q1 and 2010.Q1 while it is €81.13 billion between 2012.Q1 and 2011.Q1). The behavior of domestic banks contrasts with the behavior of of all other sectors that present a reduction in the change of exposure between the two periods.

Testable Implication 3. The incentive to gamble with sovereign debt (when the debt is risky but treated as safe by regulators) is stronger for risky under-capitalized banks (see Finding 3 above).

We present two observations consistent with this testable implication.

Observation 3.1. As long as sovereign debt is safe (i.e., at a low level of spreads), regulation is effective and exposure to sovereign debt is relatively homogeneous across banks.

Figure 5: Domestic Sovereign Debt Exposure and Bank Capital (European Crisis)



Note: "domestic sov debt exp" refers to domestic sovereign debt exposure as measured by domestic sovereign debt over total assets at the bank level. "Tier 1 Cap ratio 2009" refers to the Tier 1 capital ratio in 2009. Each dot corresponds to a bank located in Eurozone periphery countries. The line corresponds to the estimated linear regression and the shaded area the 95% confidence interval. Source: European Banking Authority and Bloomberg

The events in Europe are particularly fitted to analyze the first observation of Testable implication 3 as most countries (including those in the periphery) have enjoyed a low level of spreads since the launch of the Euro in 2002. The stress test performed in 2011 (data for December of 2010) allows us to look at the relationship between domestic sovereign debt exposure (as measured by domestic sovereign debt over total assets) and bank capital (Tier 1 capital ratio) prior to sovereign spreads reaching their peak between 2011 and 2013. The left panel in Figure 5 presents this cross-correlation for countries in the periphery (Greece, Ireland, Italy, Portugal, and Spain). The panel on the left makes clear that before the peak in sovereign spreads observed between 2011 and 2013, the correlation between sovereign debt exposure and bank capital is slightly positive. That is, as our model predicts, as long as sovereign spreads are relatively low, financial institutions across the capital distribution (i.e., level of risk-taking) have similar incentives to hold sovereign debt. This observation is consistent with the evidence presented in Drechsler et al. (2016) who find that bank credit ratings in 2007 (as a measure of bank solvency) have no effect on bank borrowings from the ECB up to May of 2010 but explain the dynamics between that date and December 2011.

Observation 3.2. Once sovereign debt becomes risky, lax regulation implies that sovereign debt is allocated mostly to low-capitalized ("gambling") banks.

We start by providing evidence using our panel of banks for Argentina. We document that the increase in spreads prior to the default event, in combination with changes in regulation that made the failure of capital regulation more pronounced, induced banks to increase their holdings of domestic sovereign debt, and that these gambles were significantly larger in risky banks. In order to do so, we estimate the following model

$$
\begin{aligned}
(Bonds/Assets)_{it} = \alpha_0 + \alpha_1 REG_t + \alpha_2 (\text{bank capital})_{it-1} + \sum_j \alpha_3^j \text{Bank Type}^j \quad (14) \\
+\delta_1 REG_t \times (\text{bank capital})_{it-1} + \sum_j \delta_2^j REG_t \times \text{Bank Type}^j + \epsilon_{it},
\end{aligned}
$$

where $(Bonds/Assets)_{it}$ is the ratio of government bonds and public debt over assets for bank i at time t (the frequency of our data is monthly), REG_t takes value equal to 1 after April 2001 to capture the regulatory changes that we described before, $(\text{bank capital})_{it-1}$ is the (lagged) ratio of equity to assets, $j \in \{\text{Public Bank}, \text{Domestic Private}, \text{Foreign Private}\}$ and Public Bank takes value 1 if the bank is a state-owned (i.e., public) bank, Domestic Private takes value 1 if the bank is a domestic (local) private bank, and Foreign Private (omitted category) takes value 1 if the bank is a foreign private bank. Table 3 presents the results.

Table 3 shows that, consistent with the model, bank capital is negatively correlated with the exposure to domestic sovereign debt throughout the period as spreads are always elevated in Argentina. This table also shows that relaxing regulation led to an increase in the domestic sovereign bonds to asset ratio in the banking sector (by up to 4.5% on average, as shown in column (1)). Importantly, and providing evidence for Testable implication 3, columns (2) and (3) show that the relationship between bank risk-taking and domestic sovereign debt exposure becomes stronger after the regulatory change (as captured by the negative coefficient on $REG_t \times (\text{bank capital})_{it-1}$), implying that riskier banks' incentives to gamble increased and that lead to an increase in their holdings of sovereign debt. Finally, Table 3 also shows that, on average, public and domestic private banks are the main drivers of the increase in sovereign debt holdings (note also the increase in adjusted

R^2 in column (3)). In Appendix D.2, we show that these results are robust to including sovereign spreads in the estimated model providing further evidence in support of the key mechanism of the model.

Table 3: Bank Regulation, Bank Gov Bond Holdings, and Bank Risk (Argentina)

	Dep. Var. Domestic Sov. Debt to Assets Ratio $(Dom\ Bonds/Assets)_{it}$		
	(1)	(2)	(3)
(bank capital)$_{t-1}$		-0.164***	-0.182***
s.e.		(0.0000)	(0.0000)
REG_t	0.0510***	0.0653***	0.00820***
s.e.	(0.0000)	(0.0000)	(0.0000)
$REG_t \times$(bank capital)$_{it-1}$		-0.125***	-0.172***
s.e.		(0.0000)	(0.0000)
Public Bank			0.148***
s.e.			(0.0000)
Domestic Private Bank			0.0739***
s.e.			(0.0000)
$REG_t \times$ Public Bank			0.0719***
s.e.			(0.0000)
$REG_t \times$ Domestic Private Bank			0.0885***
s.e.			(0.0000)
constant	0.159***	0.175***	0.103***
s.e.	(0.0000)	(0.0000)	(0.0000)
N	2471	2465	2465
adjusted R^2	0.044	0.083	0.576
Time Period	1998-2001	1998-2001	1998-2001

Note: Standard Errors in parentheses. Statistically significant at 10% *, at 5% **, at 1% ***. $(Dom\ Bonds/Assets)_{it}$ corresponds to the ratio of government bonds and public debt over assets for bank i at time t (the frequency of our data is monthly), REG_t takes value equal to 1 after April 2001 to capture the regulatory changes that we described before, (bank capital)$_{it-1}$ is the ratio of equity to assets (lagged), Public Bank takes value 1 if the bank is a state-owned (i.e., public) bank, Domestic Private Bank takes value 1 if the bank is a domestic (local) private bank, and Foreign Private (omitted category) takes value 1 if the bank is a foreign private bank. Source: Banco Central Argentina (BCRA)

Further evidence in line with Observation 3.2 and in favor of Testable implication 3 derives from the right panel of Figure 5 which shows the cross-correlation between bank capital (Tier 1 capital ratio) and domestic sovereign debt exposure in the European periphery in the year 2013 (i.e., post increase in spreads and the implementation of the LTRO). The figure shows a clear negative correlation between bank capital and sovereign debt exposure. Of particular relevance is the observed change in the cross-correlation of sovereign debt exposure of domestic banks in the periphery (countries that show an increase in spreads in Figure 1) to their capital level (as measured by Tier 1 Capital ratio) in 2009 (pre-crisis level). The cross-correlation changes from slightly positive in 2010 to negative (and significant) in 2013, implying that low-capitalized banks (i.e., risky banks) increased their exposure to sovereign debt as spreads rose more than banks with high capital ratios. This is consistent with our model as it shows that risky banks (as measured by their capital level) have strong incentives to gamble using risky sovereign debt when regulation does not correctly capture the riskiness of sovereign debt. We explore this relationship further by studying the dynamics of domestic bond holdings (as a share of total assets) in banks from Eurozone periphery countries vs banks from advanced economies as a function of regulatory changes interacted with capital levels. The estimated model follows the same format as the model estimated for the case of Argentina (see equation (14)). Table 4 presents the results.

Table 4: Bank Regulation, Bank Gov Bond Holdings, and Bank Risk (European Crisis)

	Dep. Var. Domestic Sov. Debt to Assets Ratio $(Dom\ Bonds/Assets)_{it}$			
	(1) Eurozone periphery	(2) Advanced	(3) Eurozone periphery	(4) Advanced
(bank capital)$_{i09}$	0.00513	-0.0265	0.00450	-0.0221
	(0.0088)	(0.0166)	(0.0083)	(0.0161)
$LTRO_t$	0.235**	-0.207	0.228**	-0.214
	(0.0959)	(0.1871)	(0.0905)	(0.1797)
$LTRO_t \times$ (bank capital)$_{i09}$	-0.0233**	0.0205	-0.0230**	0.0200
	(0.0103)	(0.0182)	(0.0098)	(0.0175)
Other Controls	No	No	Yes	Yes
Observations	58	48	58	48
R^2	0.206	0.068	0.306	0.160

Note: Yearly bank-level data cover years 2010, 2012, and 2013 (data as of December of each year). Standard Errors in parentheses. Statistically significant at 10% *, at 5% **, at 1% ***. "Domestic Sov. Debt to Assets Ratio" refers to the domestic sovereign debt to asset ratio. Columns denoted by Eurozone periphery include only Eurozone periphery countries. Columns denoted by Advanced include data from France and Germany. (bank capital)$_{i09}$ corresponds to the Tier 1 capital ratio in 2009. $LTRO_t$ takes value 1 for years 2012 and 2013 and 0 otherwise (i.e., it takes value 1 after the implementation of LTRO). Other controls include variables such as total assets. Sources: Bloomberg and European Banking Authority (EBA)

The increase in exposure to domestic debt is muted in advanced economies like Germany or France where spreads did not move or remained low. This table shows that pre-crisis and prior to the implementation of most of the programs put in place by the ECB (i.e., when $LTRO_t = 0$) the correlation between bank capital and the exposure to domestic debt is not significant for all countries. However, during the crisis domestic holdings of sovereign debt are negatively (and statistically significant) correlated with bank capital in Eurozone periphery countries. That is, consistent with the evidence presented in Figure 5 and the workings for our model, low capitalized banks located in Eurozone periphery countries are those that appear to gamble using domestic sovereign debt. In summary, the evidence shows that regulation leads to gambling behavior in countries where sovereign spreads rise and gambling is concentrated in less capitalized banks. This evidence is in line with the findings of Brutti and Sauré (2016), Acharya and Steffen (2015), Crosignani (2021), and Drechsler et al. (2016) that show that weakly capitalized banks drove the increase in holdings of domestic government bonds during the European sovereign debt crisis.

Testable Implication 4. If prudential regulation considers risky government bonds safe, some banks gamble by constructing portfolios composed of a mix of government bonds and risky assets strongly correlated with the bonds (when β is not too high). This follows from Finding 4 above.

We provide two observations consistent with this testable implication using data from Russia and Argentina.

Observation 4.1. Correlation of banks' government bond holdings and their foreign currency exposure increases dramatically in the run-up to sovereign defaults.

In the case of the crises in Russia (1998) and Argentina (2001), in the run-up to the default, it was evident that a sovereign cease of payments would lead to the devaluation of the currency. For that reason, analyzing the correlation between domestic sovereign debt holdings and exposure to assets which are subject to currency risk provides an almost perfect test to show that gambling banks were not only investing in domestic sovereign debt but also on assets whose risk was correlated with a default.

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).[4] Having realized that the government's 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 5 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.

Table 5: Estimates of Forward Liabilities to Non-residents (Russia)

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	

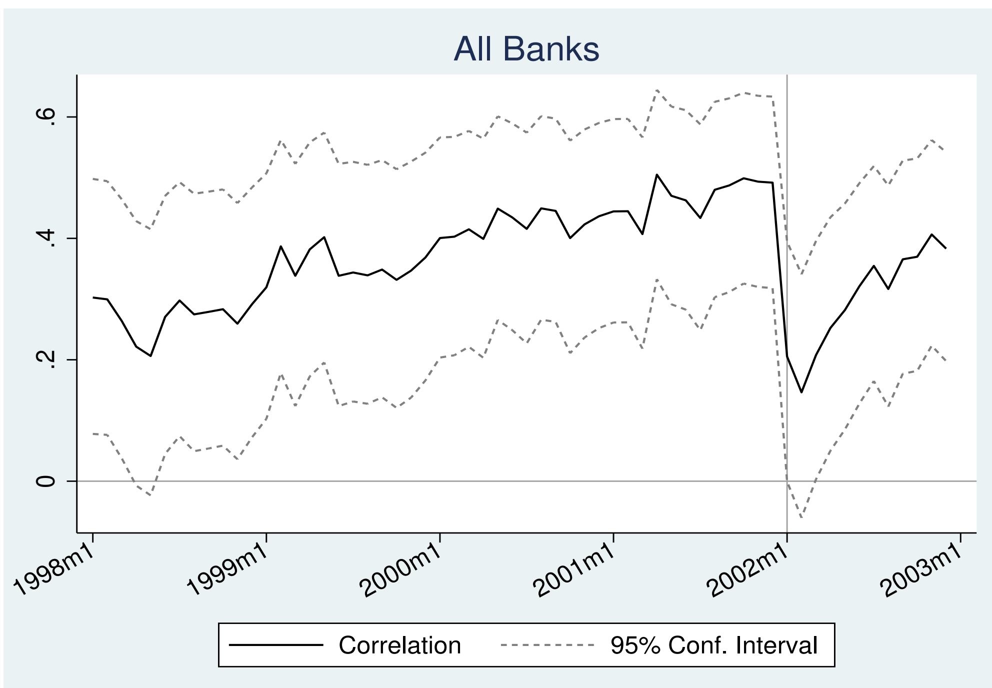
Source: Table 1.2 in Ippolito (2002), based on Troika Dialog data as of 01.07.98

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. Unfortunately,

[4]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.

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 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. 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 (we measure currency risk exposure as net foreign currency liabilities as a share of total assets). These correlations, reported in Table 6, 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.

Figure 6: Correlation Exposure to Sovereign Debt and Foreign Currency (Argentina)



Note: Series plotted correspond to the cross-sectional correlation between government debt exposure and foreign currency exposure. Dotted lines correspond to the 95% confidence intervals. The vertical line marks the date of the sovereign default (December 2001/January 2002). Source: Central Bank of Argentina

In the case of Argentina, we study the correlation between government debt exposure (as measured by the ratio of domestic sovereign bonds to assets) and foreign currency exposure (as measured by net liabilities denominated in foreign currency to assets) at the bank level over time. As we showed in Figure 4, the period that goes from 1998 to mid 2000 is a period in which the risk of default (as measured by the spread of Argentinean bonds to U.S. treasuries) is relatively stable and not too elevated (with a peak just after the Russian crisis) and the period that follows, from mid 2000 to the end of 2001, is a period in which the probability of a sovereign default increases constantly. Argentina effectively defaults at the end of December of 2001 and a large devaluation follows. The exchange rate with the dollar jumps from 1 in December of 2001 to 3.60 in June of 2002. Figure 6 presents the evolution of the cross-sectional correlation between government debt exposure and foreign currency exposure from 1998 to the end of 2002 for all banks.

Figure 6 shows that the correlation between government debt exposure with foreign currency exposure is significantly different from 0 starting in May of 2000, remains significant until the sovereign default (December 2001) and becomes insignificant right after the default.[5] This shows that when sovereign debt is risky banks have an incentive to take gambles that are correlated with a sovereign default.

Observation 4.2. The correlation between government bond holdings and foreign currency exposure in the run-up to the sovereign default is higher for private than for public banks.

We start by presenting evidence from Russia. We look one more time at the correlation between banks' GKO holdings and their on-balance-sheet exposure to currency risk but focusing on differences across bank type, reported in Table 6. The correlations in the run-up to the default 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 state-owned banks.

Table 6: Correlation of GKO Holdings and Currency Risk Exposure by Bank Type (Russia)

Period	All Banks	State	Private	Foreign	Domestic
1998.Q1	0.2173	0.0966	0.2228	0.7431	0.1421
1998.Q2	0.1776	0.1675	0.1796	0.5173	0.1201
1998.Q3	0.0206	-0.1576	0.0279	0.2910	0.0116
1998.Q4	-0.0004	-0.2649	0.0076	0.3717	-0.0178

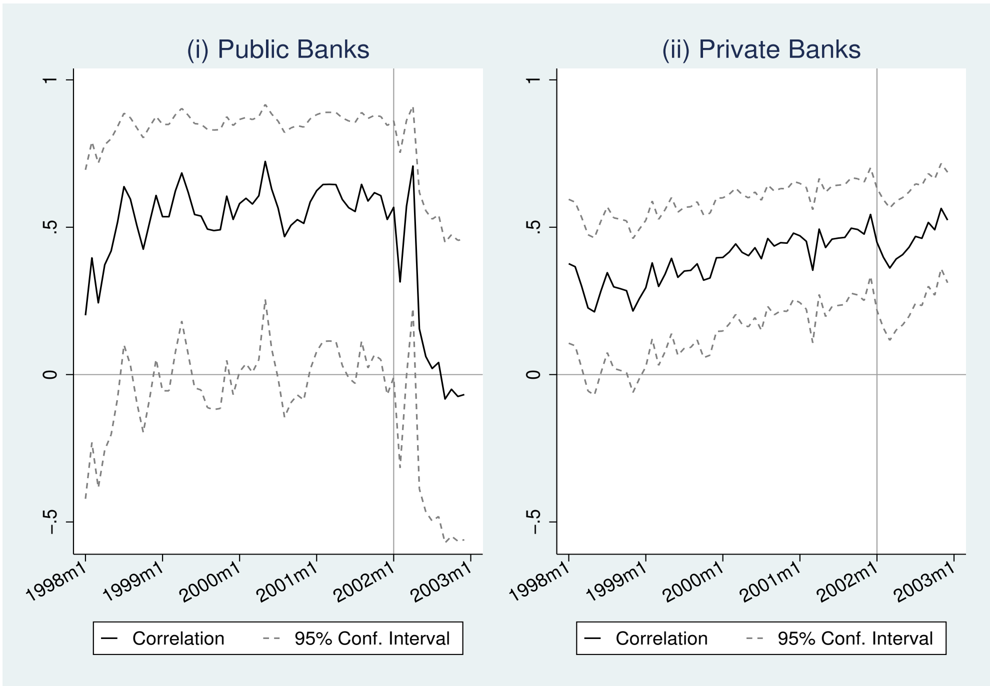
Note: Correlations based on quarterly bank balance sheet statements. Source: Authors' calculations

In the case of Argentina, in order to analyze the correlation between sovereign debt exposure and foreign currency risk in depth, we decompose the cross-sectional correlations by bank type (public vs private). Figure 7 shows that the increase in the cross-sectional correlation pre-default is driven mostly by private banks. Appendix D.3 shows that the relationship is stronger for weakly capitalized banks.

The evidence presented in Figure 7 is consistent with the results presented in Table 3 that show that after the relaxation of liquidity requirements in April of 2001 the increase in exposure to domestic sovereign debt is more pronounced for domestic private banks than for public banks.

[5]During the first quarter of 2002, the Argentine government announced the conversion of all dollar denominated deposits (74% of the total) to pesos at the exchange rate of $1.4=US$1 and their indexation to the CPI. All loans to the private sector denominated in dollars were also converted to pesos at the rate of $1=US$1. Sovereign bonds and public credit denominated in dollars (under domestic law) were converted to pesos at $1.4=US$1.

Figure 7: Correlation Exposure to Sovereign Debt and Foreign Currency by Bank Type (Argentina)



Note: Series plotted correspond to the cross-sectional correlation between government debt exposure and foreign currency exposure. Dotted lines correspond to the 95% confidence intervals. The vertical line marks the date of the sovereign default (December 2001). Source: Central Bank of Argentina

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 crises 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 its debt and may postpone (and give a chance to avoid) a default. The cost of not recognizing sovereign risk for regulatory purposes is the added risk of bank failure, which shifts the burden of this risk from risk-neutral investors to risk averse depositors. Moreover, this regulatory failure may increase misallocation of investment away from the most productive projects and into risky projects correlated with domestic government debt. We derive several key testable implications of the basic mechanism we are highlighting and use aggregate and bank-level data from the episodes in Russia (1998), Argentina (2001) and the Eurozone (2011-2013) to provide a set of observations which offer empirical support for these key predictions.

References

Abad, Jorge. 2018. "Breaking the Feedback Loop: Macroprudential Regulation of Banks' Sovereign Exposures." CEMFI mimeo.

Acharya, Viral V., Itamar Drechsler, and Philipp Schnabl. 2014. "A Pyrrhic Victory? Bank Bailouts and Sovereign Credit Risk." *Journal of Finance* 69 (6):2689–2739 (DOI: 10.1111/jofi.12206).

Acharya, Viral V. and Sascha Steffen. 2015. "The "Greatest" Carry Trade Ever? Understanding Eurozone Bank Risks." *Journal of Financial Economics* 115 (2):215–236 (http://dx.doi.org/10.1016/j.jfineco.2014.11.004).

Alessandro, Mauro. 2009. "Concentrated Financial Markets and Sovereign Debt: Coordinating Domestic Investors to Increase Domestic Demand of Government Debt." MIT Working Paper.

Becker, Bo and Victoria Ivashina. 2018. "Financial Repression in the European Sovereign Debt Crisis." *Review of Finance* 22 (1):83–115.

Bocola, Luigi. 2016. "The Pass-Through of Sovereign Risk." *Journal of Political Economy* 124 (4):879–926.

Boz, Emine, Pablo D'Erasmo, and C. Bora Durdu. 2014. "Sovereign risk and bank balance sheets: The role of macroprudential policies." Mimeo, International Monetary Fund.

Broner, Fernando, Aitor Erce, Alberto Martin, and Jaume Ventura. 2014. "Sovereign debt markets in turbulent times: Creditor discrimination and crowding-out effects." *Journal of Monetary Economics* 61:114–142.

Brusco, Sandro and Fabio Castiglionesi. 2007. "Liquidity Coinsurance, Moral Hazard, and Financial Contagion." *Journal of Finance* 62 (5):2275–2302.

Brutti, Filippo and Philip Sauré. 2016. "Repatriation of Debt in the Euro Crisis." *Journal of the European Economic Association* 14 (1):145–174.

Chari, V. V., Alessandro Dovis, and Patrick J. Kehoe. 2018. "On the Optimality of Financial Repression." Federal Reserve Bank of Minneapolis Staff Report 1000.

Coimbra, Nuno. 2020. "Sovereigns at risk: A dynamic model of sovereign debt and banking leverage." *Journal of International Economics* 124:103298.

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

Crosignani, Matteo. 2021. "Bank capital, government bond holdings, and sovereign debt capacity." *Journal of Financial Economics* 141:693–704.

Crosignani, Matteo, Miguel Faria-e-Castro, and Luís Fonseca. 2020. “The (unintended?) consequences of the largest liquidity injection ever.” *Journal of Monetary Economics* 112:97–112.

de la Torre, A., E. Levy-Yeyati, S. Schmukler, A. Ades, and G. Kaminsky. 2003. “Living and Dying with Hard Pegs: The Rise and Fall of Argentina’s Currency Board.” *Economia* 3 (2):43–107.

Díaz-Cassou, Javier, Aitor Erce-Domínguez, and Juan Vázquez-Zamora. 2008. “Recent Episodes of Sovereign Debt Restructurings. A Case-Study Approach.” Bank of Spain Occasional Paper No. 0804.

Drechsler, Itamar, Thomas Drechsel, David Marques-Ibanez, and Philipp Schnabl. 2016. “Who borrows from the lender of last resort?” *The Journal of Finance* 71 (5):1933–1974.

Farhi, Emmanuel and Jean Tirole. 2017. “Deadly embrace: Sovereign and financial balance sheets doom loops.” *The Review of Economic Studies* 85 (3):1781–1823.

Gennaioli, Nicola, Alberto Martin, and Stefano Rossi. 2014. “Sovereign default, domestic banks, and financial institutions.” *Journal of Finance* 69 (2):819–866.

Hurwicz, Leonid. 2008. “Who Will Guard the Guardians?” *American Economic Review* 98 (3):577–585.

Ippolito, Filippo. 2002. “The Banking Sector Rescue in Russia.” Bank of Finland Institute for Economies in Transition, BOFIT. No. 12.

Jenkins, Patrick. 2019. “EU’s Wilful Blindness to Sovereign Risk Adds to Eurozone Danger.” *Financial Times* January 7.

Jensen, Michael C. and William H. Meckling. 1976. “Theory of the Firm: Managerial Behavior, Agency Costs, and Ownership Structure.” *Journal of Financial Economics* 3 (4):305–360.

Johnson, Juliet. 2000. *A Fistful of Rubles: The Rise and Fall of the Russian Banking System.* Ithaca, NY: Cornell University Press.

Juvenal. 1891. *The Satires of Juvenal.* London: MacMillan and Co.

Karas, Alexei, William Pyle, and Koen Schoors. 2010. “How do Russian depositors discipline their banks? Evidence of a backward bending deposit supply function.” *Oxford Economic Papers* 62 (1):36–61.

Krishnamurthy, Arvind, Stefan Nagel, and Annette Vissing-Jorgensen. 2018. “ECB policies involving government bond purchases: Impact and channels.” *Review of Finance* 22 (1):1–44.

Merler, Silvia and Jean Pisani-Ferry. 2012. “Sudden Stops in the Euro Area.” *Bruegel Policy Contribution* 2012/06.

Morris, Stephen and Patrick Jenkins. 2018. "Policymakers Urge Action on EU Sovereign Debt 'Doom Loop'." *Financial Times* December 23.

Ongena, Steven, Alexander Popov, and Neeltje van Horen. 2019. "The invisible hand of the government: Moral suasion during the European sovereign debt crisis." *American Economic Journal: Macroeconomics* 11 (4):346–379.

Perez, Diego. 2015. "Sovereign debt, domestic banks and the provision of public liquidity." SIEPR Discussion Paper 15-016.

Reinhart, Carmen M. and M Belen Sbrancia. 2015. "The liquidation of government debt." *Economic Policy* 30 (82):291–333.

Smith, Adam. 1776. *The Wealth of Nations*. London: Methuen & Co.

Sosa-Padilla, Cesar. 2018. "Sovereign defaults and banking crises." *Journal of Monetary Economics* 99:88–105.

Uhlig, Harald. 2014. "Sovereign default risk and banks in a monetary union." *German Economic Review* 15 (1):23–41.

Appendix (for online publication only)
Banking Regulation with Risk of Sovereign Default
by Pablo D'Erasmo, Igor Livshits, and Koen Schoors

Appendix A Equilibrium Characterization: Lower Capital Requirements

A.1 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 (17)-(18), for $\alpha^B = 0$ and $\alpha^B = 1$, respectively. We shall denote these bounds $\hat{\beta}_0$ and $\hat{\beta}_1$, respectively. 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 6. *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. $r = \frac{pR}{\beta(1-p)+p}$.

Much like in Proposition 3, competition among zero-equity banks investing in government bonds implies $(1 + i^d) = (1 + i^g)$, while the presence of safe banks implies $(1 + i^d) = r$. The key difference arises from the presence of gambling banks investing in risky projects. Since these banks pull resources away from safe projects, the rate of return on safe projects goes up to $r = \frac{pR}{\beta(1-p)+p}$, at which point investors are indifferent between running a safe bank and a bank investing in risky projects. This equilibrium requires that some wealth is channeled to safe banks, which occurs when the capital requirement is sufficiently high. Specifically, the minimum value of β such that this is the case is given by $\hat{\beta}_0$, which solves

$$\hat{\beta}_0 = \frac{p(R - \hat{r}_0)}{\hat{r}_0(1-p)} \tag{15}$$

$$\hat{r}_0 = \theta A \left(\Omega - (D - B)\frac{\hat{\beta}_0}{1-\hat{\beta}_0} \right)^{\theta - 1}. \tag{16}$$

If β falls below $\hat{\beta}_0$ and $\alpha^B = 0$, then safe banks can no longer be sustained and the equilibrium (described in the next subsection) features only gambling banks. Figure 2 offers graphical illustration of all these equilibria.

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 7. *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, gambling banks that invest in the risky assets, and gambling banks that invest in 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. $r = \frac{pR}{\beta(1-p)+p}$.

Just like in Proposition 6, three types of banks co-exist in this equilibrium — safe, those gambling with risky projects, and those gambling with government bonds. But since banking regulation treats government bonds just like risky projects (unlike in Proposition 6), the bankers now demand the same rate of return on these two assets: $(1 + i^g) = R$. The existence of safe banks in equilibrium can again be sustained for sufficiently high capital requirements, though the minimal threshold $\hat{\beta}_1$ is lower when α is larger. Safe banks operate in equilibrium with $\alpha = 1$ if $\beta \geq \hat{\beta}_1$, which solves

$$\hat{\beta}_1 = \frac{p(R - \hat{r}_1)}{\hat{r}_1(1-p)}. \tag{17}$$

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

In summary, in this 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 $\alpha^B = 1$, as illustrated in Figure 2. This means that misallocation of risk is greater when government debt is presumed safe, as the risk-averse households bear a larger portion of the default risk in that case. Furthermore, if $\beta < \hat{\beta}_0$, ignoring the risk of government debt leads to additional misallocation of investment, as more of the resources end up invested in risky projects when $\alpha^B = 0$ than when $\alpha^B = 1$, and any such investment in risky projects is (socially) inefficient. We discuss this in more detail in Section 4.3.

For simplicity, the above descriptions of equilibria had all investors and banks specialize in a single type of investment. Turning again to the possibility of more realistic-looking banks in equilibrium, several types of "mergers" are possible in this intermediate range of capital requirements. As in the previous subsection, private investors and safe banks could be combined into an over-capitalized bank. More interestingly perhaps, there is now the possibility of a merger between a bank investing in government bonds and another one investing in risky projects, but only if the payoff on these risky projects is perfectly correlated with the government debt being repaid. Such a combined gambling bank would still hold only minimal capital required by the regulation, and would never merge with a safe bank (nor invest in safe projects).

A.2 Low Capital Requirements

Lastly, we characterize the outcomes obtained when the levels of capital requirements are too low to sustain any safe banking in equilibrium (corresponding to the left-most segment in Figure 2). The following two propositions characterize the equilibria for the two key values of α^B.

Proposition 8. *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. *$r = \theta A \left(\Omega - (D - B)\frac{\beta}{1-\beta}\right)^{\theta-1}$.*

Once again, zero-equity banks absorb the entire stock of government debt when $\alpha^B = 0$, and competition among them implies $(1 + i^g) = (1 + i^d)$. The rate of return on deposits is pinned down by the gambling banks investing in risky projects, whose equity-holders must be compensated for the risk of failure, implying $(1 + i^d) = \frac{R - r\beta/p}{(1-\beta)}$. The rate of return on safe projects is determined by the amount of investors' wealth not tied-up in gambling banks' equity. Ironically, this means that the extent of misallocation of investment is actually increasing in β, as long as $\beta < \hat{\beta}_0$ (this observation also holds for $\alpha^B = 1$ when $\beta < \hat{\beta}_1$).

Proposition 9. *If $\beta < \hat{\beta}_1$ and $\alpha^B = 1$, the equilibrium is characterized by the following:*

1. *The banking sector is composed of gambling banks, some of which invest in the risky assets, while others invest in 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. $(1+i^g) = R$*;*
6. $r = \theta A \left(\Omega - D\frac{\beta}{1-\beta}\right)^{\theta-1}$.

Gambling banks absorb the entire stock of government bonds, and since these bonds are treated by regulation the same as risky projects, they must yield the same rate of return: $(1+i^g) = R$. Only investors' wealth that is not tied up as equity in the banking sector is invested in safe productive assets.

As in the other region of the parameter space (higher β's), the cost of government debt is lower when $\alpha^B = 0$ than when $\alpha^B = 1$. But the fraction of deposits in gambling banks equals 1 in both scenarios when β is sufficiently low. Yet, the misallocation of investment (amount invested in risky projects) is higher when $\alpha^B = 0$. There can be no over-capitalized bank in this equilibrium, but a merger of two gambling banks is possible, as long as the payoffs of their portfolios (of risky projects and government bonds) are perfectly correlated.

Appendix B Proofs

B.1 Proof of Proposition 1

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 $V^G(\omega) = p\left[\frac{\omega}{\beta}\left(R-(1-\beta)r^*\right)\right]$, 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 $\beta \geq \beta^*$.

B.2 Proof of Proposition 2

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)).

B.3 Proof of Proposition 3

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 imply 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

$$V^S_{q^S=0}(\omega) = \max_d \left[(d + \omega)r - d(1 + i^d)\right] = \max_d \left[\omega r + d(r - (1 + i^d))\right]. \tag{19}$$

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

$$V^S_{q^S=0}(\omega) = \omega r > ((d + \omega)pr - dr) = \omega r + (p - 1)dr = V^S_{q^S>0}(\omega). \tag{20}$$

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 a 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 $\beta > \beta^*$. (Note that the condition

$\beta < \frac{\Omega}{\Omega+D-B}$ ensures that there is enough equity in the banking system to channel the entire supply of households' deposits D.) Since zero equity banks are the only ones investing in government bonds, we conclude that $\lambda = \frac{B}{D}$ and $\mu = 0$.

B.4 Proof of Proposition 4

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

$$V^S_{q^S=0}(\omega) = \max_d \left[(d+\omega)r - d(1+i^d)\right] = \max_d \left[\omega r + d(r-(1+i^d))\right]. \tag{21}$$

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

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

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 $r = r^*$. (Note that the condition $\beta < \frac{\Omega}{\Omega+D}$ ensures that there is enough equity in the banking system to channel the entire supply of households' deposits D.) 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, $\mu = 0$.

B.5 Proof of Proposition 5

We prove this proposition in the same order the claims are presented. (Note that the condition $\beta < \frac{\Omega - \frac{pS_H}{r^*}}{\Omega + D - \frac{pS_H}{r^*}}$ ensures that there is enough equity in the banking system to channel the entire supply of households' deposits D for "reasonable" levels of government debt.) Denote the aggregate face value of government debt issued in period 1 by B' (i.e., how much the government is promising to repay in period 2).

1. If the government sells bonds with aggregate face value $B' \leq S_L$, such debt is risk-free, since the government is definitely able to repay the debt in the second period. Since the rate of return on such safe debt is the same as the rate of return on safe projects, $(1 + i^g) = r^*$, regardless of the value of α^B, and the government raises $\frac{B'}{r^*}$ in the first period from the sales of these bonds. Hence, if $B \leq \frac{S_L}{r^*}$, the government can *safely* finance the period 1 shortfall by issuing one-period debt.
   Note that the rate of return on safe projects is r^*, since $\beta \in \left[\beta^*, \frac{\Omega - \frac{pS_H}{r^*}}{\Omega + D - \frac{pS_H}{r^*}}\right)$. This guarantees that β is large enough to prevent diversion of funds into risky projects, and yet not too high to prevent intermediation of the entire stock of households' deposits.

2. If $B > \frac{S_L}{r^*}$, it is no longer possible to finance period-1 expenses by issuing *safe* one-period bonds, since the face value of the debt issuance B' has to exceed S_L. But the government can promise to repay up to S_H in period 2 (with understanding that such debt would only be repaid with probability p). As can be seen from Propositions 3 and 4 and equation (12), the interest rate on this risky debt depends on how it is treated by the banking regulation (the interest rate is increasing in α^B, until it reaches the maximum at $\alpha^B = \frac{1}{\beta}$). But even at the highest possible interest rate on government bonds, $(1 + i^g) = \frac{r^*}{p}$, the sales of these risky bonds are sufficient to finance $B \leq \frac{pS_H}{r^*}$, thus avoiding the default in the first period. Of course, the severity of the possible crisis in the second period does depend on α^B (e.g., if $\alpha^B \geq \frac{1}{\beta}$, then the possible government default in the second period would not be accompanied by a systemic banking crisis).

3. When $B > \frac{pS_H}{r^*}$, issuing risky debt at the actuarially fair interest rate is no longer sufficient to cover the budget shortfall in the first period. Thus, equation (12) implies that effective regulation of banks would lead to immediate default of the government in the first period. On the other hand, since the interest rate on government debt can be lowered by lowering α^B, the immediate default can be avoided, as long as $B \leq \frac{S_H}{r^*}$. This upper bound follows from Proposition 3, which established that the interest rate on (risky) government debt is r^* when $\alpha^B = 0$.

4. Lastly, if $B > \frac{S_H}{r^*}$, there is no way to avoid immediate default. Even under the most favorable (to the government debt) banking regulation, when $(1 + i^g) = r^*$, the government can raise at

most $\frac{S_H}{r^*}$ in the first period (by promising to repay $B' = S_H$ in the second period). A promise to repay any more than that is, of course, worthless.

B.6 Proof of Proposition 6

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, 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:

$$\hat{r}_0 = \theta A\left(\Omega - (D-B)\frac{\hat{\beta}_0}{1-\hat{\beta}_0}\right)^{\theta-1} \tag{22}$$

$$\hat{\beta}_0 = \frac{p(R-\hat{r}_0)}{\hat{r}_0(1-p)}. \tag{23}$$

It is simple to show that equation (22) is increasing in β and equation (23) 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 (22)). The fraction of assets allocated to gambling banks is $\mu = \frac{\Omega+D-B-K(r)}{\Omega+D}$.

B.7 Proof of Proposition 7

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:

$$\omega r = p\left(\frac{\omega}{\beta}[R-(1-\beta)r]\right) \qquad \Leftrightarrow \qquad r = \frac{pR}{\beta(1-p)+p}. \tag{24}$$

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:

$$\hat{r}_1 = \theta A\left(\Omega - D\frac{\hat{\beta}_1}{1-\hat{\beta}_1}\right)^{\theta-1} \tag{25}$$

$$\hat{\beta}_1 = \frac{p(R-\hat{r}_1)}{\hat{r}_1(1-p)}. \tag{26}$$

It is easy to show that equation (25) is increasing in β and equation (26) is decreasing in β, so a solution exists.

B.8 Proof of Proposition 8

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, $\lambda = 1$.

B.9 Proof of Proposition 9

If $\beta < \hat{\beta}_1$, it is straightforward to show (using the results from the proofs to Propositions 6 and 7) 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 $\mu = \frac{D/(1-\beta)-B}{\Omega+D}$.

Appendix C Data Sources

We use data from several sources. We use proprietary data from commercial banks in Russia and the Central Bank of Argentina for the analysis of the crisis in developing economies. We use quarterly data for all banks active in Russia around the time of the default. These data are described in detail in Karas, Pyle, and Schoors (2010). The data for Argentina contain detailed information on domestic sovereign debt exposure by local banks at the monthly frequency. We also use data from Haver and the Ministerio de Economia de Argentina (MECON). In order to study the dynamics around the European debt crisis, we use public data from the European Banking Authority (EBA), together with proprietary bank-level data from Bloomberg, and the Bruegel database of sovereign bond holdings described in Merler and Pisani-Ferry (2012). Data from the EBA cover the stress tests conducted in 2011 (data for December 2010), the EU-wide transparency exercise conducted in 2013 (data for December of 2012 and June 2013), and the stress test conducted in 2014 (data for December of 2013) and provide information at the bank level on bank sovereign debt exposure by country (i.e., issuer) as well as capitalization levels across banks. The data cover the most important banks for each country. The annual frequency is a limitation relative to the exposure data from Argentina, but the data allow us to perform cross-country comparisons around the same set of events and for countries that share a common currency. Data from Bloomberg offer information on banks' balance sheets at the yearly frequency as well as information on sovereign yields, sovereign Credit Default Swaps (CDS), and bank bond yields and CDS.[6]

Appendix D Robustness Checks

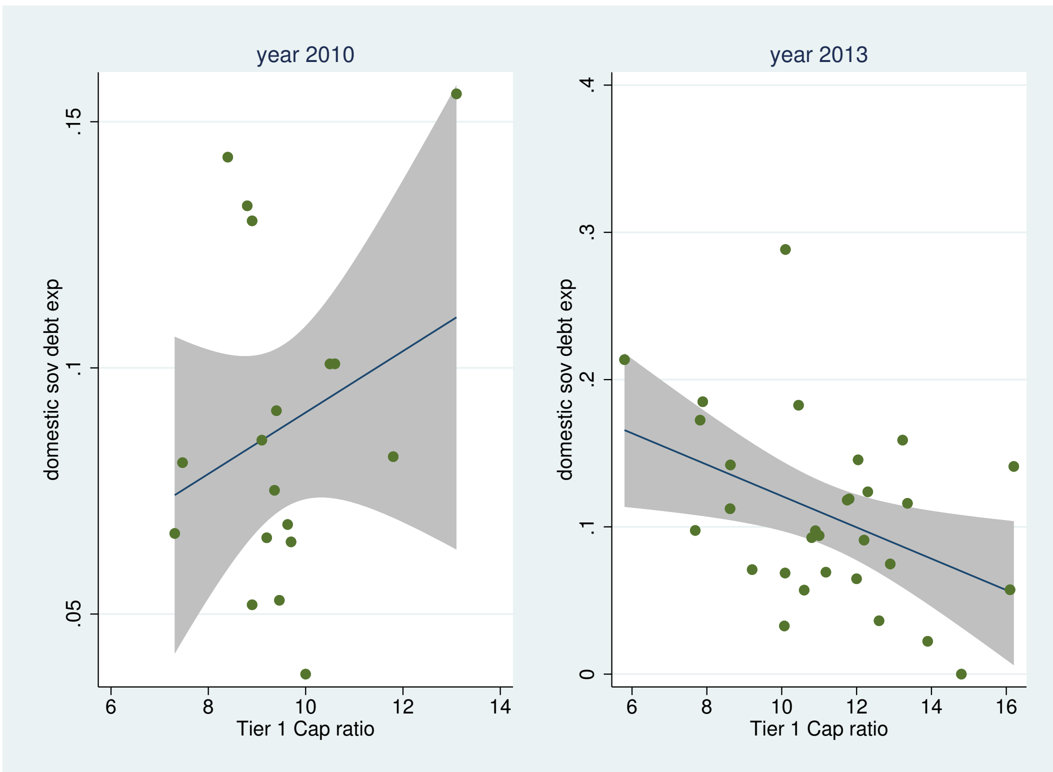
D.1 Bank Capital and Domestic Debt Exposure

This section discusses the pattern described in Figure 5. In particular, we show that the results are robust to using contemporaneous measures of domestic debt exposure and bank capital. The left panel in Figure 8 presents this cross-correlation for countries in the periphery (Greece, Ireland,

[6] The EBA data are publicly available and can be found here: https://www.eba.europa.eu/.

Italy, Portugal, and Spain). The panel on the left makes clear that before the sovereign debts became risky, the correlation between sovereign debt exposure and bank capital (also in 2010) is slightly positive. The panel on the right shows a clear negative correlation between bank capital and sovereign debt exposure. That is, there is a change in the cross-correlation of sovereign debt exposure of domestic banks in the periphery (countries that show an increase in spreads in Figure 1) to their capital level (as measured by Tier 1 Capital ratio).

Figure 8: Sovereign Spreads and Exposure in Domestic Banks



Note: “domestic sov debt exp” refers to domestic sovereign debt exposure as measured by domestic sovereign debt over total assets at the bank level. “Tier 1 Cap ratio” refers to the Tier 1 capital ratio in 2009. Each dot corresponds to a bank located in Eurozone periphery countries. The line corresponds to the estimated linear regression and the shaded area the 95% confidence interval. Sources: European Banking Authority and Bloomberg

D.2 Bank Regulation and Domestic Debt Exposure: The Role of Sovereign Spreads

In this section, we incorporate sovereign spreads into the regression presented in Table 3. Table 7 shows that results are robust to including spreads for Argentina (using Embi +). Columns (1)-(3) incorporate spreads to the specification in the paper, and columns (4)-(5) also add spreads interacted with the reform dummy. Columns (1) - (3) show that changes in regulation still explain the shift towards domestic bonds even after controlling for the riskiness of the bonds as measured by the EMBI + spreads for Argentina (the “risk-shifting” effect). Column (1) shows that the effect is smaller in this specification relative to the baseline specification but still significant. Relaxing regulation led to an increase in the domestic sovereign bonds-to-asset ratio of up to 3.34 percent. Columns (2) and (3) in Table 7 also show that, in line with the baseline, this relationship is stronger for banks with lower levels of capital.

Table 7: Bank Regulation and Bank Gov Bond Holdings (Incorporating Spreads)

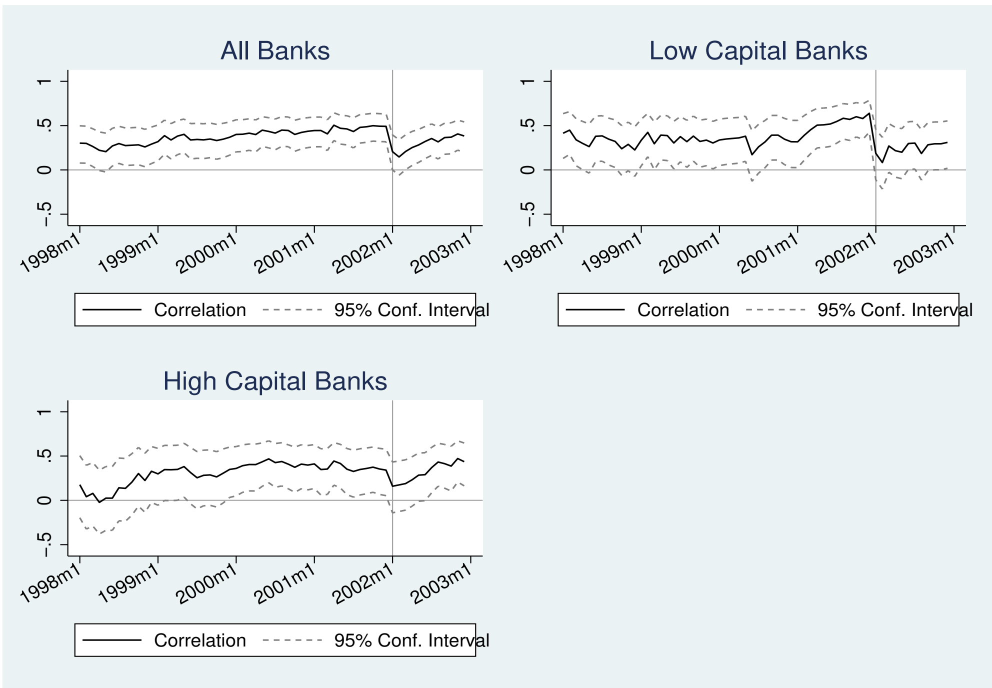
	Dep. Var. Domestic Sov. Debt-to-Assets Ratio $(Dom\ Bonds/Assets)_{it}$				
	(1)	(2)	(3)	(4)	(5)
(bank capital)$_{it-1}$		-0.161***	-0.179***	-0.157***	-0.175***
s.e.		(0.0000)	(0.0000)	(0.0000)	(0.0000)
REG_t	0.0334***	0.0475***	-0.00670***	0.0384***	-0.0152***
s.e.	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$REG_t\times$(bank capital)$_{it-1}$		-0.163***	-0.207***	-0.203***	-0.244***
s.e.		(0.0000)	(0.0000)	(0.0000)	(0.0000)
Public Bank			0.148***		0.148***
s.e.			(0.0000)		(0.0000)
Domestic Private Bank			0.0740***		0.0738***
s.e.			(0.0000)		(0.0000)
REG_t × Public Bank			0.0695***		0.0690***
s.e.			(0.0000)		(0.0000)
REG_t × Domestic Private Bank			0.0888***		0.0902***
s.e.			(0.0000)		(0.0000)
Sov. Spreads$_{t-1}$	0.0000190***	0.0000233***	0.0000204***	0.00000674***	0.00000538***
s.e.	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
$REG_t\times$Sov. Spreads$_{t-1}$				0.0000193***	0.0000176***
s.e.				(0.0000)	(0.0000)
constant	0.146***	0.159***	0.0885***	0.170***	0.0984***
s.e.	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
N	2465	2465	2465	2465	2465
adjusted R^2	0.050	0.091	0.582	0.092	0.584
Time Period	1998-2001	1998-2001	1998-2001	1998-2001	1998-2001

Note: Standard Errors in parentheses. Statistically significant at 10% *, at 5% **, at 1% ***. $(Dom\ Bonds/Assets)_{it}$ corresponds to the ratio of domestic government bonds and public debt over assets for bank i at time t (the frequency of our data is monthly), REG_t takes value equal to 1 after April 2001 to capture the regulatory changes that we described before, (bank capital)$_{it-1}$ is the ratio of equity to assets (lagged), Public Bank takes value 1 if the bank is a state-owned (i.e., public) bank, Domestic Private Bank takes value 1 if the bank is a domestic (local) private bank, and Foreign Private Bank (omitted category) takes value 1 if the bank is a foreign private bank. Sov. Spreads refers to the sovereign spreads in Argentina as measured by the EMBI + spread. Sources: Banco Central Argentina (BCRA) and Haver

D.3 Correlation Between Sovereign Debt Exposure and Foreign Currency Exposure: The Role of Bank Capital

In this section, we analyze the role of bank capital in driving the correlation between sovereign debt exposure and foreign currency exposure. We find that results go in line with the predictions of the model, as Figure 9 shows that most of the increase for the "average" bank comes from banks with low capital ratios (defined as below the median at the end of the year 2000). The correlation for low capitalized banks reaches 63.95% in December of 2001 prior to the default (statistically significant), while the correlation for well capitalized banks is barely statistically significant (the point estimate is 34.2%).

Figure 9: Correlation Exposure to Sovereign Debt and Foreign Currency (Argentina)
by Capital Levels



Note: Series plotted correspond to the cross-sectional correlation between government debt exposure and foreign currency exposure. Dotted lines correspond to the 95% confidence intervals. The vertical line marks the date of the sovereign default (December 2001/January 2002). Source: Central Bank of Argentina