A Pyrrhic Victory?
Bank Bailouts and Sovereign Credit Risk

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ABSTRACT

We model a loop between sovereign and bank credit risk. A distressed financial sector induces government bailouts, whose cost increases sovereign credit risk. Increased sovereign credit risk in turn weakens the financial sector by eroding the value of its government guarantees and bond holdings. Using credit default swap (CDS) rates on European sovereigns and banks, we show that bailouts triggered the rise of sovereign credit risk in 2008. We document that post-bailout changes in sovereign CDS explain changes in bank CDS even after controlling for aggregate and bank-level determinants of credit spreads, confirming the sovereign-bank loop.

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Prior to the financial crisis of 2007 to 2008, there was essentially no sign of sovereign credit risk in the developed economies, and the prevailing view was that such risk was unlikely to be a concern for these economies in the near future. However, since the fall of 2008 sovereign credit risk has become a significant problem for a number of developed countries, most notably in Europe. In this paper, we examine three closely related questions surrounding this development. First, were the financial sector bailouts an integral factor in igniting the rise of sovereign credit risk in the developed economies? We show that they were. Second, what was the mechanism that caused the transmission of risks between the financial sector and the sovereign? We propose a model wherein the government can finance a bailout through increased taxation and via dilution of existing government debtholders. The bailout is beneficial, as it alleviates a distortion in the provision of financial services. However, financing is costly because increased taxation reduces the nonfinancial sector's incentives to invest. Therefore, when the optimal bailout is large, dilution becomes a relatively attractive option, leading to deterioration in the sovereign's creditworthiness. Finally, we ask whether sovereign credit risk also feeds back into the financial sector, leading to a feedback loop between the credit risk of sovereigns and banks. We show, and verify empirically, that such a feedback loop is indeed present, due to the financial sector's implicit and explicit guarantees and holdings of sovereign bonds.

This two-way feedback between financial sector and sovereign credit risks calls into question the usually implicit assumption that government resources are vastly deep and that the main problem posed by bailouts is moral hazard, that is, the distortion of future financial sector incentives. While the moral hazard cost is pertinent, our conclusion is that bailout costs are not just in the future. Rather, they are tangible at the time of a bailout and are priced into the sovereign's credit risk and cost of borrowing, weakening the financial sector further. Thus, aggressive bailout packages that stabilize the financial sector in the short run but ignore the ultimate cost to taxpayers can end up being a Pyrrhic victory.

Motivation: The Case of the Irish Bailout. On September 30, 2008, the government of Ireland announced that it had guaranteed all deposits of six of its biggest banks. The immediate reaction that grabbed newspaper headlines the next day was whether such a policy of a full savings guarantee was anticompetitive in the Euro area. However, there was something deeper manifesting itself in the credit default swap (CDS) markets for purchasing protection against the sovereign credit risk of Ireland and its banks. Figure 1 shows that while the cost of purchasing such protection on Irish banks – their CDS rate – fell overnight from around 400 basis points (bps) to 150 bps, the CDS rate for Irish government debt rose sharply. Over the next month, this rate more than quadrupled to over 100 bps and within six months reached 400 bps, the starting level of the banks' CDS. While there was a general deterioration in global economic health over this period, the event-study response in Figure 1 suggests that the risk of the Irish financial sector was substantially transferred to the government's balance sheet, a cost that Irish taxpayers – or taxpayers of countries that share the cost – eventually bear. By the fall of 2010 this cost had risen even further, leading to a significant widening of the spread between Irish and German government bonds, and a bailout of the Irish government by the stronger Eurozone countries.[1]

[Figure 1 is about here.]

This episode is not isolated to Ireland, though it is perhaps the most striking case. Using country- and bank-level data, we find systematic evidence that bank bailouts were an important factor behind the rise in sovereign credit risk across Eurozone countries. Our paper develops a theoretical model and discusses empirical evidence that shed light on this phenomenon and its implications.

Model. Our theoretical model consists of three economic sectors: financial, nonfinancial (corporate), and government. The financial and corporate sectors contribute jointly to produce aggregate output: the corporate sector makes productive investments and the financial sector invests in intermediation "effort" (e.g., information gathering and capital allocation) that enhance the return on corporate investments. Both sectors, however, face a potential underinvestment problem. The financial sector is leveraged (in a crisis, it may in fact be insolvent) and underinvests due to the well-known debt overhang problem (Myers (1977)). We assume that restructuring financial sector debt is impossible or prohibitively expensive. However, the government may undertake a "bailout" of the financial sector, a transfer from the rest of the economy that results in a net reduction in financial sector debt. This transfer must be funded in the future (at least in part) through taxation of the corporate sector, which induces the corporate sector to underinvest.

The government determines the optimal size of the bailout to maximize the economy's current and future output. To fund the bailout it issues bonds, which are repaid by future tax proceeds. We show that the tax proceeds that can be used to fund the bailout have a

Laffer curve property (as the tax rate is varied), so that the optimal bailout size and tax rate are interior.

As a consequence, there are two constraints on the bailout size. First, the greater is the existing debt of the government, the lower is its ability to undertake a bailout. This is because the Laffer curve of tax proceeds leaves less room for the government to increase tax rates for repaying bailout-related debt. Second, the announcement of the bailout lowers the price of government debt due to the anticipated dilution from additional debt issuance. This causes some "collateral damage" for the financial sector because of its significant holdings of government debt and its reliance on explicit and implicit government guarantees.[2]

We solve for the optimal size of the government's bailout and additional debt issuance. If the debt overhang in the financial sector is severe and existing government debt is large, then the underinvestment cost of fully funding the bailout with tax revenues is high. It can then be optimal for the government to "sacrifice" its creditworthiness and fund the bailout by diluting existing debt, issuing additional debt without enacting a matching increase in tax revenue. This triggers an increase in the government's credit risk and gives rise to a positive relationship between its level of debt and its credit spread.

Due to the collateral damage channel, any subsequent adverse shocks to output growth, and hence tax revenues, not only lower the sovereign's own debt values, but also increase the financial sector's risk of default. This is because there is a decrease in both the value of the financial sector's government bond holdings, and the value of government guarantees that benefit the financial sector. These channels induce post-bailout comovement between the financial sector and sovereign's credit risks, even though the immediate effect of the bailout is to lower the financial sector's credit risk and raise the sovereign's.

Empirics. Our empirical work analyzes the two-way feedback between financial sector and sovereign credit risk in Europe. We examine sovereign and bank CDS during the crisis period of 2007 to 2011 and identify three distinct periods.

The first period begins in January 2007, before the start of the financial crisis, and continues until the first bank bailout announcement in late September 2008. Across all countries, we document a large, sustained rise in bank CDS as the financial crisis deepens. At the same time, sovereign CDS rates remain low. This evidence is consistent with a significant increase in the default risk of the financial sector with little effect on sovereigns.

The second period covers the bank bailouts starting with the announcement of a bailout in Ireland in late September 2008 and ending with a bailout in Sweden in late October 2008. During this one-month period, we find a significant decline in bank CDS and a corresponding increase in sovereign CDS across countries, suggesting that the bank bailouts transferred default risk from the financial sector to sovereigns.

The third period starts after the bank bailouts and continues until April 2011. Consistent with the model, we document that post-bailouts there emerges a strong, positive relationship between public debt-to-GDP ratios and sovereign CDS, though no relationship existed before the bailouts. The increase in sovereign CDS is larger for countries whose banking sector was more distressed prior to the bailouts, and whose public debt-to-GDP ratio was higher. We further show that countries with a more distressed banking sector spent a larger amount on bank recapitalization. Hence, we show that bank bailouts transferred default risk from the financial sector to sovereigns, triggering the rise in sovereign credit risk.

Next, we quantify the *direct* feedback loop between sovereign and financial credit risk emphasized by our model. Before the bailouts we find no relationship between financial and sovereign credit risk. In contrast, in the post-bailout period we find a statistically and economically significant relationship: a 10% increase in the level of sovereign CDS is associated with a 0.9% increase in the level of bank CDS. This result is robust to controlling for common variation in sovereign and bank CDS, country-level differences in foreign exposure, and heterogeneity in banks' exposure to CDS market and volatility conditions.

We conduct several robustness tests. First, we examine robustness to adding a bank's equity return as a control variable. Since bank bailouts are targeted at bank debt rather than equity, controlling for equity returns allows us to examine the impact of sovereign CDS on bank CDS while controlling for changes in the value of bank assets. We find that all our results remain statistically significant, though the point estimates are slightly smaller. Second, we measure sovereign credit risk based on government bond yield spreads instead of sovereign CDS rates and show that our results are robust to using this alternative sovereign risk measure. Third, we measure the value of government support implied by the difference between standard and stand-alone credit ratings assigned by Moody's Investor Services. We find that the value of government support depends on sovereign credit risk. Fourth, we show that our results are robust to adding controls for leverage, using an unbalanced panel, estimation at different frequencies, and lengthening the analysis period.

Finally, we find that holdings of government bonds are an important channel for the transmission of both domestic and foreign sovereign credit risk to banks, consistent with our model. Using data released as part of the 2010 Eurozone bank stress tests, we document a significant home bias in banks' holdings of sovereign bonds, as 69% of the average bank's sovereign bonds (roughly one-sixth of its risk-weighted assets) were in the home sovereign.

Related Literature. The theoretical literature on bank bailouts focuses mainly on *how* to structure bank bailouts efficiently. While the question of *how* necessarily involves an optimization with some frictions, the usual friction assumed is the inability to resolve a failed bank's distress due to agency problems.[3] Our paper instead focuses on the cost and benefit of bank bailouts. A large body of existing literature in banking analyzes the ex-ante moral hazard cost of bank bailouts at the individual bank level (Mailath and Mester (1994)) and at the aggregate level through herding (Penati and Protopapadakis (1988), Acharya and Yorulmazer (2007)). Only a small part of this literature considers *ex-post* fiscal costs of bailouts as we do. Acharya and Yorulmazer (2007, 2008) and Philippon and Schnabl (2013) assume, in a reduced-form manner, a cost of bank bailouts to the government that is increasing in the quantity of bailout funds. As a possible motivation they provide taxation-related fiscal costs, which we derive endogenously. Panageas (2010a, 2010b) considers the optimal taxation to fund bailouts in a continuous-time dynamic setting, also highlighting when banks might be too big to save, but does not consider the reverse feedback from sovereign credit risk to banks. Reinhart and Rogoff (2009) and Reinhart and Reinhart (2010) document empirically that economic activity remains in a deep slump "after the fall" (that is, after a financial crisis), and that private debt shrinks significantly while sovereign debt rises, effects that are consistent with our model.

In the theoretical literature on sovereign default risk, Bulow and Rogoff (1989a, 1989b) initiate a body of work that focuses on ex-post costs to sovereigns defaulting on external debt, for example, due to a reputational cost in future borrowing, imposition of international trade sanctions, and conditionality in support from multi-national agencies. Broner and Ventura (2005), Broner, Martin and Ventura (2008), Acharya and Rajan (2013) and Gennaioli, Martin, and Rossi (2010), Bolton and Jeanne (2011), among others, consider collateral damage to the financial institutions and bond markets when a sovereign defaults. They employ this as a possible commitment device that incentivizes the sovereign to pay its creditors. Our model considers both of these effects–an ex-post deadweight cost of sovereign default in external markets and an internal cost to the financial sector through bank holdings of government bonds–in addition to modeling the transmission of risk from the financial sector to the sovereign when bank bailouts are undertaken.

In related empirical work, one strand focuses on quantifying the *ex-post* cost of bank bailout packages. Veronesi and Zingales (2010) conduct an event study of the U.S. government intervention in October 2008 through TARP and find that the government intervention increased the value of banks by over $100 billion, primarily through bank creditors, but also estimate a tax payer cost between $25 to $47 billion. Kacperczyk and Schnabl (2013) show that the U.S. money market fund bailout in September 2008 transferred the entire credit risk of this $3 trillion industry to the government. Panetta et al. (2009) and King (2009) assess the Eurozone bailouts and conclude that while bank equity was wiped out in most cases, bank creditors were backstopped reflecting a waiting game on part of bank regulators and governments. Drechsler et al. (2012) assess the cost of the lender-of-last resort intervention by the European Central Bank, which followed the bailouts. Laeven and Valencia (2010, 2012) compile a time series of banking crises and examine their economic costs. They too find that the median output loss of recent banking crises was large, accounting for about 25% of GDP.

Another strand of recent empirical work relating financial sector and sovereign credit risk during the European financial crisis shares some similarity to our paper. Sgherri and Zoli (2009), Attinasi, Checherita, and Nickel (2009), Alter and Schueler (2011), Mody and Sandri (2012), and Ejsing and Lemke (2011) focus on the effect of bank bailouts on sovereign credit risk measured using CDS rates. Some of their evidence mirrors our descriptive evidence. Dieckmann and Plank (2009) analyze sovereign CDS of developed economies around the crisis and document a significant rise in comovement following the collapse of Lehman Brothers. Demirguc-Kunt and Huizinga (2010) conduct an international study of equity prices and CDS rates around bank bailouts and show that some large banks may be too big to save rather than too big to fail. Gennaioli, Martin, and Rossi (2013) show that banks on average hold a significant share of their assets in government bonds and that these holdings may crowd out loans during sovereign debt crises.

Our analysis corroborates and complements these two strands of the empirical literature. In particular, (i) identifying a causal linkage between bank CDS and sovereign CDS by exploiting the pre-bailout, bailout, and post-bailout periods, and (ii) isolating empirically the effect of government guarantees on bank credit risk represent important novel contributions of our analysis.

Finally, our paper contributes to the literature on the determinants of credit spreads (e.g., Collin-Dufresne, Goldstein, and Martin (2001), Huang and Huang (2012), Eom, Helwege, and Huang (2004), Longstaff, Mithal, and Neis (2005)). On the theory side, we present a model in which sovereign credit risk is an independent determinant of credit spreads on financial bonds. Empirically, we show that changes in sovereign CDS rates are important for explaining changes in bank CDS, even after controlling for the determinants of credit spreads predicted by structural models.

The remainder of the paper is organized as follows. Section I sets up the model. Section II presents the equilibrium outcomes. Section III provides empirical evidence and examines the case of Iceland as a possible counterfactual for the case of Ireland. Section IV discusses the relevance of our results for other financial crises. Section V concludes. Proofs and derivations are in the Internet Appendix.[4]

I. Model

There are three time periods in the model: $t = 0$, 1, and 2. The productive economy consists of two parts, a financial sector and a nonfinancial sector. In addition, there is a government and a representative consumer. All agents are risk-neutral. A timeline of the model is shown in Figure 2.

[Figure 2 is about here.]

Financial sector: The manager of the financial sector solves the following problem. At time $t = 0$ he chooses the amount of financial services to supply in order to maximize his expected payoff at $t = 1$ net of the effort cost required to produce these services:

$$\max_{s_0^s} E_0 \left[\left(w_s s_0^s - L_1 + \tilde{A}_1 + A_G + T_0 \right) \times 1_{\left\{ -L_1 + \tilde{A}_1 + A_G + T_0 > 0 \right\}} \right] - c(s_0^s). \tag{1}$$

The quantity s_0^s is the amount of financial services supplied by the financial sector at $t = 0$. In return, the financial sector earns revenues at time $t = 1$ at an equilibrium-determined rate w_s per unit of financial service supplied. To produce s_0 units, the manager of the financial sector incurs a cost of $c(s_0)$, measured in units of the consumption good. We assume that $c'(s_0) > 0$ and $c''(s_0) > 0$.

The financial sector has both liabilities and assets on its books. The liabilities have face value L_1 and are due (i.e., mature) at time $t = 1$. This implies that the manager of the financial sector receives the revenues from supplying financial services only if the value of assets at time $t = 1$ exceeds L_1. This solvency condition is given in equation (1) by the indicator function for the expression $\{-L_1 + \tilde{A}_1 + A_G + T_0 > 0\}$.[5] There are two types of assets held by the financial sector: A_G, the value of the financial sector's holdings of a fraction k_A of the existing stock of government bonds (before the bailout), and $\tilde{A}_1$, the value at $t = 1$ of all of the other assets held by the financial sector. We model $\tilde{A}_1$ as a continuously valued random variable that takes values in $[0, \infty)$. The payoff and value of government bonds is discussed below. The variable T_0 represents the value of the transfer made by the government to the financial sector at $t = 0$ and is also discussed below. Finally, in the case of insolvency, debtholders receive ownership of all financial sector assets and wage revenue.

We highlight several important features of the financial sector that together make it particularly well-suited for the role that it has in our model. First, due to the nature of its business the financial sector is both highly leveraged and exposed to (systematic) risk, making it particularly susceptible to debt overhang and the resulting distortions in incentives. For the same reasons, it is subject to runs. Second, financial sector debt is difficult to restructure (i.e., "hard" debt), perhaps because it is subject to runs. This makes private-sector resolution of the debt overhang problem difficult and thus creates a role for government intervention. Third, the financial sector is large, even in comparison with national output. This means that the resources required to address a crisis are large, even relative to total tax revenues, and leads to the trade-offs highlighted by our model.

Nonfinancial Sector: The nonfinancial sector comes into time $t = 0$ with an existing capital stock K_0. Its objective is to maximize the sum of the expected values of its net payoffs, which occur at $t = 1$ and $t = 2$:

$$\max_{s_0^d,\, K_1} E_0 \left[f(K_0, s_0^d) - w_s s_0^d + (1 - \theta_0)\tilde{V}(K_1) - (K_1 - K_0) \right]. \tag{2}$$

The function f is the production function of the nonfinancial sector. It takes as inputs the capital stock, K_0, together with the amount of financial services demanded by the nonfinancial sector, s_0^d, and produces consumption goods at time $t = 1$. The output of f is deterministic and f is increasing in both arguments and concave. At $t = 1$, the nonfinancial sector decides how much capital K_1 to invest, at cost $(K_1 - K_0)$, in a project $\tilde{V}$ whose payoff is realized at $t = 2$. This project represents the continuation value of the nonfinancial sector and is in general subject to uncertainty. The expectation at $t = 1$ of this payoff is given by $V(K_1) = E_1[\tilde{V}(K_1)]$, which is a function of the level of investment K_1. Moreover, we assume that $V'(K_1) > 0$ and $V''(K_1) < 0$, so that the expected payoff is increasing but concave in investment. A proportion θ_0 of the payoff of the continuation project at $t = 2$ is taxed by the government to pay its debt, both new and outstanding, as we explain next.

Government: The government's objective is to maximize the total output of the economy and hence the welfare of the consumer. It does this by reducing the debt overhang problem of the financial sector, which increases the supply of financial services and thereby increases output. To do so, the government issues new bonds at $t = 0$ and transfers them to the balance sheet of the financial sector.[6] Note that there is no difference between these "new" bonds and the "old" bonds; they are assumed to be pari-passu. All bonds mature at time $t = 2$ and are repaid with the tax revenues generated by the tax of θ_0 on the time-2 payoff of the nonfinancial sector. The government sets the tax rate θ_0 at $t = 0$, and it is levied at $t = 2$ when the payoff $\tilde{V}(K_1)$ is realized.[7]

We denote the number of bonds that the government has issued in the past – its outstanding stock of debt – by N_D. For simplicity, bonds have a face value of one, so the face value of outstanding debt equals the number of bonds, N_D. To accomplish the transfer to the financial sector, the government issues N_T new bonds. Let P_0 denote the price of governments bonds (both old and new) at $t = 0$, which is determined in equilibrium based on the government's actions. At $t = 2$ the government receives realized taxes equal to $\theta_0 \tilde{V}(K_1)$ and then uses these funds to pay bondholders $N_T + N_D$. We assume that if there are tax revenues left over (a surplus), the government spends them on programs for the representative consumer, or equivalently, rebates them to the consumer. On the other hand, if tax revenues fall short of $N_T + N_D$, then bondholders receive all of the tax revenues but the government defaults on its debt. We further assume that default creates a fixed deadweight loss of D. This loss proxies for loss of government reputation internationally, loss of domestic government credibility, degradation of the legal system, and so forth. Hence, default is costly and there is an incentive to avoid it.

The government's objective is to maximize the expected utility of the representative consumer, who consumes the combined output of the financial and nonfinancial sectors. The government thus faces the following problem:

$$\max_{\theta_0, N_T} E_0 \left[f(K_0, s_0) + \tilde{V}(K_1) - c(s_0) - (K_1 - K_0) - 1_{def} D + \tilde{A}_1 \right], \tag{3}$$

where s_0 is the equilibrium provision of financial services. This maximization is subject to both the budget constraint $T_0 = P_0 N_T$, with P_0 determined in equilibrium, and the simultaneous choices made by the financial and nonfinancial sectors. Note that 1_{def} is an indicator function that equals one if the government defaults (if $\theta_0 \tilde{V}(K_1) < N_T + N_D$) and zero otherwise.

Consumer: The representative consumer consumes the output of the economy. He allocates his wealth W between consumption and the bonds and equity of the government, financial, and nonfinancial sectors. Let $P(i)$ and $\tilde{P}(i)$ denote the price and payoff of asset i, respectively. Since the consumer is risk-neutral and has no time-discounting, he chooses his optimal portfolio allocations, $\{n_i\}$, at time $t = 0$ to solve the following problem:

$$\max_{n_i} E_0 \left[\Sigma_i n_i \tilde{P}(i) + (W - \Sigma_i n_i P(i)) \right] \tag{4}$$

The first-order condition then implies that the equilibrium price of an asset is given by its expected payoff, $P(i) = E_0[\tilde{P}(i)]$.

Since the empirical analysis focuses on the prices of CDS, for completeness we introduce a CDS contract on the government bond. The CDS contract pays the buyer the difference between the bond's face value and its recovery value upon default. For simplicity, assume the CDS contract matures at $t = 2$ and that the buyer makes one payment of the CDS fee at that time. It then follows that the CDS fee (i.e., price) is $1 - P_0$.[8]

II. Equilibrium Outcomes

We begin by analyzing the maximization problem (1) of the financial sector. Let $p(\tilde{A})$ denote the probability density of $\tilde{A}$. Furthermore, let $\underline{A}_1$ be the minimum realization of $\tilde{A}_1$ for which the financial sector does not default: $\underline{A}_1 = L_1 - A_G - T_0$. The first order condition of the financial sector can be written as

$$w_s p_{solv} - c'(s_0^s) = 0, \tag{5}$$

where $p_{solv} \equiv \int_{\underline{A}_1}^{\infty} p(\tilde{A}_1) d\tilde{A}$ is the probability that the financial sector is solvent at $t = 1$. Henceforth, we parameterize $c(s_0)$ as $c(s_0) = \beta \frac{1}{m} s_0^m$, where $m > 1$.

Next, consider the problem of the nonfinancial sector at $t = 0$, given by (2). Its demand for financial services, s_0^d, is determined by the first-order condition[9]

$$\frac{\partial f(K_0, s_0^d)}{\partial s_0^d} = w_s \ . \tag{6}$$

We parameterize f as Cobb-Douglas with the factor share of financial services given by ϑ: $f(K_0, s_0) = \alpha K_0^{1-\vartheta} s_0^{\vartheta}$.

In equilibrium the demand and supply of services are equal: $\hat{s}_0^d = \hat{s}_0^s$. We subsequently drop the superscripts and simply denote the equilibrium quantity of services by s_0.

A. *Transfer Reduces Underprovision of Financial Services*

Together, the first-order conditions of the financial sector (5) and nonfinancial sector (6) show how debt overhang impacts the provision of financial services by the financial sector. The marginal benefit of an extra unit of services to the economy is given by w_s, while the marginal cost, $c'(s_0)$, is less than w_s when there is a positive probability of financial sector insolvency. In this case, the equilibrium allocation is suboptimal. The reason is that the possibility of liquidation ($p_{solv} < 1$) drives a wedge between the social and private marginal benefit of an increase in the provision of financial services. There is thus an underprovision of financial services relative to the first-best case ($p_{solv} = 1$). Consequently, we have the following:

LEMMA 1: *An increase in the transfer T_0 leads to an increase in the provision of financial services by raising the probability p_{solv} that the financial sector is solvent at $t = 1$.*

Hence, the government can alleviate the under-provision of financial services via the transfer to (i.e., bailout of) the financial sector.

B. Tax Revenues: A Laffer Curve

To understand the government's problem in (3), we first look at how expected tax revenue responds to the tax rate, θ_0. Let the expected tax revenue, $\theta_0 V(K_1)$, be denoted by $\mathcal{T}$. Raising taxes has two effects. On the one hand, an increase in the tax rate θ_0 captures a larger proportion of the future value of the nonfinancial sector, thereby raising tax revenues. On the other hand, this decreases the incentive of the nonfinancial sector to invest in its future projects, thereby reducing $V(K_1)$ and in turn tax revenues.[10]

To see this, consider the first-order condition for investment of the nonfinancial sector at $t = 1$:

$$(1-\theta_0)V'(K_1) - 1 = 0. \tag{7}$$

Taking the derivative with respect to θ_0 and rearranging gives $\frac{dK_1}{d\theta_0} = \frac{V'(K_1)}{(1-\theta_0)V''(K_1)}$. Since the production function $V(K_1)$ is concave ($V''(K_1) < 0$), investment decreases with the tax rate ($\frac{dK_1}{d\theta_0} < 0$). At the extreme, if $\theta_0 = 1$, tax revenue will be reduced to zero. Hence, tax revenues satisfy the Laffer curve property with the marginal tax revenue decreasing until it eventually becomes negative, as summarized in the following lemma.

LEMMA 2: *The tax revenues, $\theta_0 V(K_1)$, are at first increasing in the tax rate θ_0 as it increases from zero (no taxes), but eventually decline.*

Henceforth, we parameterize V with the functional form $V(K_1) = K_1^{\gamma}$, $0 < \gamma < 1$. This functional form is a natural choice for an increasing and concave function of K_1. As we discuss in the Internet Appendix, one can motivate this functional form based on the nonfinancial sector's production function, suggesting that it would take a similar form in a multiperiod model. It follows that:

LEMMA 3: *The tax revenue $\mathcal{T}$ is maximized at $\theta_0^{max} = (1-\gamma)$, is increasing ($d\mathcal{T}/d\theta_0 > 0$) and concave ($d^2\mathcal{T}/d\theta_0^2 < 0$) on $[0, \theta_0^{max})$, and is decreasing ($d\mathcal{T}/d\theta_0 < 0$) on $(\theta_0^{max}, 1)$.*

C. Optimal Transfer Under Certainty

We now analyze the government's optimal policy. To make the trade-offs faced by the government clear, we start with a simplified version of the general setup. We make two simplifying assumptions: (A1) the variance of time $t = 2$ output is zero, so that it is known with certainty, that is, $\tilde{V}(K_1) = V(K_1)$; and (A2) government policy has to maintain solvency.

Forcing the government to maintain solvency means that it is constrained to issue at most the number of new bonds N_T that it can pay off in full. Of course this depends on the amount of tax revenue it chooses to raise. By assumption (A1), the tax revenue is exactly equal to $\mathcal{T}$ (since there is no uncertainty), and hence by assumption (A2) we have $N_T + N_D = \mathcal{T}$. Moreover, since bonds have a sure payoff of 1, the bond price is $P_0 = 1$. The transfer to the financial sector is $T_0 = \theta_0 V(K_1) - N_D$, and there is no probability of default, $E[1_{def}] = 0$. Hence, the tax rate is the only choice variable for the government in this case.

Instead of looking at the government's first-order condition with respect to the tax rate, it turns out to be clearer to analyze the first-order condition for the optimal tax revenue ($\mathcal{T}$). The optimal tax revenue equates the marginal gain ($\mathcal{G}$) and marginal loss ($\mathcal{L}$) of increasing tax revenue:

$$\frac{d\mathcal{G}}{d\mathcal{T}} + \frac{d\mathcal{L}}{d\mathcal{T}} = 0 \text{ , where } \frac{d\mathcal{G}}{d\mathcal{T}} \quad = \frac{\partial f(K_0, s_0)}{\partial s_0}(1 - p_{solv})\frac{ds_0}{dT_0} \text{ , and } \frac{d\mathcal{L}}{d\mathcal{T}} = \theta_0 V'(K_1)\frac{dK_1}{d\mathcal{T}} \text{ .} \qquad (8)$$

The derivation is provided in the Internet Appendix. The term $d\mathcal{G}/d\mathcal{T}$ is the marginal gain to the economy of increasing expected tax revenue. Increasing tax revenue increases the transfer T_0, which induces an increase in the supply of financial services ($ds_0/dT_0 > 0$). This expression shows that all else equal, the marginal gain is large when the financial sector's probability of solvency (p_{solv}) is low and hence debt overhang is significant. The term $d\mathcal{L}/d\mathcal{T}$ is the marginal underinvestment loss to the economy of increasing expected tax revenue. This quantity is negative since increasing tax revenue leads to a decrease in investment ($dK_1/d\mathcal{T} < 0$). The following proposition characterizes the solution to the government's problem under (A1) and (A2) and assuming that $m \geq 2\vartheta$.

PROPOSITION 1: *There is a unique optimal tax revenue* $\hat{\mathcal{T}}$*, which is generated by an optimal tax rate that is strictly less than* θ_0^{max}*. The optimal transfer* T_0 *is given by* $T_0 = \hat{\mathcal{T}} - N_D$*. Moreover,*

1. *the optimal tax revenue* $\mathcal{T}$ *is increasing in the the financial sector's debt overhang* (L_1) *and in the amount of existing government debt* (N_D)*, and*
2. *the optimal transfer* T_0 *is increasing in the financial sector's debt overhang* (L_1) *and decreasing in the amount of existing government debt* (N_D)*.*

The optimal tax rate is less than θ_0^{max} due to the Laffer curve property of tax revenues. Moreover, the optimal tax rate will be strictly greater than zero if there is financial sector debt overhang ($p_{solv} < 1$) since the transfer provides a marginal benefit.

The marginal gain from an increase in the transfer is larger when there is a bigger distortion in the provision of financial services. Hence, more severe financial sector debt overhang induces the government to raise more tax revenue to generate a larger transfer.

The effective transfer generated by any level of tax revenue $\mathcal{T}$ is smaller when the amount of existing government debt (N_D) is increased. This raises the marginal benefit of additional tax revenue and increases the optimal tax revenue. However, since the underinvestment cost of taxation is convex, optimal tax revenues increase less than one-for-one with existing government debt, and a greater existing government debt is associated with a smaller optimal transfer.

D. Default

Next we remove assumption (A2) and allow the government to default. When there is no uncertainty about future output and tax revenues, this occurs only if the government issues new bonds N_T in excess of $\mathcal{T} - N_D$. It will be useful in the ensuing analysis to map the decision on how much new debt to issue to a new variable:

$$H = \frac{N_T + N_D}{\mathcal{T}},$$

which is the ratio of the total face value of debt to expected tax revenue. We call this the sovereign's "insolvency ratio". When there is no uncertainty, default occurs if the government increases H above a value of one. Doing so has both a cost and a benefit. The cost is the deadweight default loss D. The benefit is that increasing H above one generates a larger transfer by diluting the claim of existing debt on tax revenues. This allows the government to increase the transfer without increasing taxes and incurring greater underinvestment.

When there is no uncertainty, the optimal choice of H is either one or infinity, since it is suboptimal to incur the default cost D without obtaining the full benefits of dilution. Raising H to infinity lets the government fully dilute existing debt, thereby capturing all tax revenues towards the transfer. The following proposition characterizes how different factors affect the value to the sovereign of defaulting, net of the default loss D.

PROPOSITION 2: *The net benefit to defaulting is:*

1. *increasing in the financial sector's debt overhang (L_1) and in the amount of existing government debt (N_D), and*
2. *decreasing in the fraction of existing government debt held by the financial sector (k_A), and in the dead-weight loss D.*

An increase in the financial sector's debt overhang increases the marginal gain from the transfer and, as defaulting enables the sovereign to generate a larger transfer, raises the benefit to defaulting. An increase in the amount of existing government debt also implies a larger benefit from defaulting by freeing up more resources for the optimal transfer and by decreasing the optimal tax rate and associated underinvestment. Lastly, an increase in the fraction of existing sovereign debt held by the financial sector makes default less attractive since defaulting causes greater collateral damage to the financial sector balance sheet.

E. Uncertainty

Lastly, we remove assumption (A1) and introduce uncertainty about future output $\tilde{V}(K_1)$. To that end we let

$$\tilde{V}(K_1) = V(K_1)\tilde{R}_V,$$

where $\tilde{R}_V$ is the shock to output growth, and $\tilde{R}_V \geq 0$, $E[\tilde{R}_V] = 1$, and $\sigma(\tilde{R}_V) > 0$. We assume that $\tilde{R}_V$ is independent of the other variables in the model.

With uncertainty the sovereign no longer faces a binary decision of default or no default. Instead, the probability of default and the sovereign bond price are continuous functions of the insolvency ratio H,

$$P_0 = E_0\left[\min\left(1, \frac{1}{H}\tilde{R}_V\right)\right] \tag{9}$$

$$p_{def} = \text{prob}\left(\tilde{R}_V < H\right), \tag{10}$$

while the transfer T_0 is a function of both $\mathcal{T}$ and H.[11] The government now chooses both the optimal value tax revenue $\mathcal{T}$ and insolvency ratio H. The first-order condition for the optimal tax revenue is essentially the same as under certainty, except for an adjustment to account for a value of H different from one. The first-order condition for H is

$$\frac{d\mathcal{G}}{dT_0}\frac{dT_0}{dH} - D\frac{dp_{def}}{dH} = 0 \tag{11}$$

Raising H dilutes existing bondholders since it raises the total face value of debt without increasing expected tax revenue. By capturing a greater fraction of tax revenues, it generates a bigger transfer (i.e., $dT_0/dH > 0$) without the need to worsen underinvestment. The cost of this is that it raises the sovereign's probability of default. Hence, the sovereign 'sacrifices' its own creditworthiness in order to alleviate debt overhang in the financial sector.

Figure 3 illustrates this trade-off. For simplicity, we assume that $\tilde{R}_V$ is uniformly distributed. The top panle of the figure shows the marginal gain (solid line) and loss (dashed line) of increasing H, holding $\mathcal{T}$ fixed. The marginal cost of increasing H is the increase in expected deadweight default cost. The figure indicates two candidate optimal values for H. The first is where the marginal gain and loss curves intersect. The second is where $H \to \infty$, representing complete dilution of existing debt. The dash-dot line shows the impact of an increase in financial sector debt overhang L_1 on the marginal gain curve.

[Figure 3 is about here.]

The bottom panel of Figure 3 plots of the government's objective function (i.e., total welfare) as a function of H. The plot shows that for the given configuration, the optimum occurs at the intersection of the gain and loss curves. Note that this optimal value of H exceeds the lower end of the support of $\tilde{R}_V$ (the origin in the figure), implying a positive probability of default. Note also that the objective function starts to rise again once H exceeds the upper end of the support of $\tilde{R}_V$. This occurs because once debt issuance is large enough that default is certain, it is optimal to fully dilute existing bondholders and capture all tax revenues for the transfer.

The following proposition shows that when financial sector debt overhang is large enough, any further increases in it induce the government to increase the insolvency ratio, which triggers an increase in the sovereign's probability of default. Financial credit risk thus "spills over" onto sovereign credit risk.

PROPOSITION 3: *Let $(\hat{\mathcal{T}}, \hat{H})$ be an interior solution to the government's problem on a region of the parameter space. Then the optimal insolvency ratio $\hat{H}$ and expected tax revenues $\hat{\mathcal{T}}$ are increasing in the financial sector's debt overhang L_1.*

Note that this spillover is *strategic*. Since tax revenues are below their maximum value, the government could instead choose to fund the transfer with increased tax revenues. Instead, it chooses to dilute existing debt to avoid further costly underinvestment.

Figure 4 examines the emergence of sovereign credit risk. The figure plots the equilibrium values of the expected tax revenue ($\mathcal{T}$), insolvency ratio (H), transfer size (T_0), and sovereign bond price (P_0) as financial sector debt overhang L_1 varies. The top-right subplot shows that $\mathcal{T}$ increases monotonically in L_1 up to the discontinuity indicated by the dotted line. This discontinuity represents the point at which total default ($H \to \infty$) is optimal, which permit less tax revenue to be raised since existing debt gets fully diluted.

[Figure 4 is about here.]

The subplot for H (top left) tells a different story. For low levels of debt overhang the sovereign holds the insolvency ratio H constant at a low value, implying a zero default probability (the lower support of the $\tilde{R}_V$ distribution) and hence a bond price of one. However, when financial sector debt overhang is severe (high L_1), as in a financial crisis, it is optimal for the sovereign to increase H and thereby "sacrifice" its creditworthiness to generate a larger transfer. This is reflected in the plot for P_0 (bottom right), which shows that sovereign credit risk only emerges–that is, P_0 decreases–when financial sector debt overhang L_1 is high. If debt overhang is made more severe still, the optimal response can become total default, causing P_0 to approach zero.[12] By fully diluting existing debt, total default frees up maximum tax revenues for the transfer. This is reflected by a jump up in the optimal transfer size T_0 (bottom-left subplot).

Figure 5 provides another look at the emergence of sovereign credit risk. It plots the relationship between the sovereign's CDS rate $(1 - P_0)$ and the ratio of government debt to expected future output, $(N_T + N_D)/V(K_1)$, corresponding to Figure 4. The plot shows that when government debt is low, the sovereign credit spread remains zero as debt increases. In this region financial sector debt overhang is low and the government increases the transfer solely via increases in tax revenues. Consequently, in this region there is no relationship between the sovereign's level of debt (to output) and its CDS rate. In contrast, when debt overhang is increased sufficiently, the government begins to dilute existing debt to help generate the transfer. This event triggers an increase in the credit spread and leads to a positive relationship between the sovereign's debt level and credit spread.

[Figure 5 is about here.]

Figure 6 plots the corresponding equilibrium responses of the variables as the level of existing government debt N_D varies. For low levels of existing debt, the sovereign chooses low H, there is no probability of default, and P_0 is one. In this region the size of the transfer is decreasing in N_D. When N_D is sufficiently large, high underinvestment costs make it optimal to increase H to generate the transfer. The probability of default then rises and P_0 begins to decline. In this region the transfer size is actually *increasing* in N_D, since dilution of existing bondholders is an effective way to increase the transfer when existing debt is large.

[Figure 6 is about here.]

F. Government Guarantees

A large part of many governments' bailout programs has been to provide explicit guarantees of nondeposit debt as well as various "troubled" assets. Moreover, government efforts to prevent the liquidation of banks by guaranteeing their debt strongly suggests that there is an implicit safety net.

We extend the model to capture government guarantees of financial sector debt. We do this for two reasons. First, guarantees serve to prevent liquidation of banks by debtholders, a necessary pre-condition for increasing the provision of financial services. Second, guarantees are rather unique in that, by construction, their benefits are targeted at debtholders and not equityholders. This unique feature will be important for our empirical work to help identify a direct channel between sovereign and financial sector credit risk. In the interest of simplicity, and since debt overhang alleviation is the central objective of bailouts in the model, we do not explore the feedback of guarantees on the transfer and taxation decisions analyzed above. Instead, we set the stage for the implications of guarantees for our empirical strategy.

We model debtholders as potentially liquidating (or inducing a run on) the financial sector if they are required to incur losses in the case of financial sector default. To prevent debtholders from liquidating, the government "guarantees" their debt by pledging to them tax revenues equal to $L_1 - \tilde{A}_1 - T_0$, the face value of bank debt minus bank assets, in the case of insolvency. We assume the guarantee is pari-passu with other claims on tax revenue. Therefore, it has the same credit risk as other sovereign liabilities. The guarantee is thus equivalent to a claim that issues bank debtholders $L_1 - \tilde{A}_1 - T_0$ new government bonds in the case of insolvency.

Note that the payoff from this claim accrues exclusively to debtholders. This differentiates it from general assets of the financial sector, such as $\tilde{A}_1$ or the transfer T_0. While a change in the value of general assets changes the values of equity and debt in a fixed proportion (depending on the bank's leverage), a change in the value of the guarantee only impacts the value of debt. Therefore, when there are guarantees, changes in equity value are *not* sufficient to capture changes in debt value. This is formalized by the following proposition.

PROPOSITION 4: *Assume that $\tilde{A}_1 \sim U[A_{min}, A_{max}]$. Let D denote the value of the bank's debt and E the value of its equity. In the absence of a guarantee, the equity return is sufficient for capturing the debt return. In contrast, in the presence of a guarantee, capturing the debt* *return requires both the equity return and the government bond return,*

$$\frac{dD}{D} \approx \beta_E \frac{dE}{E} + \beta_g \frac{dP_0}{P_0}. \tag{12}$$

The idea that the equity return should be (locally) sufficient to capture the debt return goes back to the contingent claims model of Merton (1974).[13] The loading on the equity return ($\frac{dE}{E}$) captures the impact of changes in the value of the firm's assets, including expected profits, on its debt return. This 'one-beta' representation of the debt return is sufficient in the absence of a guarantee. In contrast, the presence of a guarantee necessitates a 'two-beta' representation since changes in sovereign credit risk ($\frac{dP_0}{P_0}$) are needed to capture variation in the value of the guarantee, which impacts debt but not equity.[14]

G. The Sovereign-Bank Loop

Propositions 1 through 3 highlight a loop between financial sector and sovereign credit risk. To alleviate severe financial sector debt overhang (large L_1), the sovereign needs to make a large transfer to the financial sector. When the underinvestment costs of taxation are high, an efficient means of doing so is to raise the insolvency ratio (Proposition 3) and thereby dilute existing debt. Hence, the sovereign accepts a positive probability of default, resulting in a positive relationship between the sovereign's debt level and credit risk (Figure 4). In this way, financial sector credit risk "spills over" into sovereign credit risk, with a higher level of existing sovereign debt making dilution more likely (Proposition 2 and Figure 4).

Once the sovereign takes on credit risk, there is feedback loop from the credit risk of the sovereign to that of the financial sector. In particular, when sovereign is susceptible to credit risk, a negative shock (e.g., to output and hence tax revenue) that reduces the sovereign's creditworthiness feeds back to the financial sector's credit risk via its sovereign exposure. As highlighted in the model, this direct sovereign-bank feedback loop occurs through decreases in the value of the transfer pledged to the financial sector, decreases in the value of large financial sector government bond holdings, and decreases in the value of explicit and implicit government guarantees (Propostion 4). The result of this post-bailout sovereign-bank feedback loop is positive comovement between sovereign and bank credit risk, which contrasts with the immediate impact of the bailout announcement, namely a reduction in financial sector credit risk and an increase in sovereign credit risk.

H. State-Contingent Taxation

The Internet Appendix presents a modification of the model in which we allow the government to set the tax rate at time $t = 2$, in which case the rate is fully state-contingent. We solve for the optimal state-contingent tax rate and show that the government's optimal policy continues to involve a positive probability of default, due to the trade-off between increased taxation and increased sovereign credit risk.[15] Moreover, the expression for the optimal expected tax revenue shows how raising the probability of default increases the dilution of existing debt (N_D), and hence reduces the expected tax revenues required to generate a given bailout size. We further derive analogs to Propositions 1 and 2, and show that the optimal probability of default is zero when financial sector debt overhang is low, but increases in debt overhang when its level is sufficiently high.

III. Empirical Analysis

In this section we test the main theoretical predictions from the model: (1) bank bailouts reduced financial sector credit risk but were a key factor in triggering the rise in sovereign credit risk in developed countries, and (2) there is a feedback loop between the credit risk of the sovereign and that of the financial sector.

Our empirical analysis consists of two parts. The first part focuses on the emergence of sovereign risk during the European financial crisis of 2007 to 2011. We present evidence that bank bailouts transferred risk from bank balance sheets to sovereigns, triggering the rise in sovereign credit risk. We further show that a country's pre-bailout level of financial sector distress predicts its post-bailout increase in sovereign credit risk, as suggested by our model. This result supports the view that the bailouts led to the emergence of sovereign credit risk in Europe.

The second part of our analysis focuses on the feedback loop between sovereign and bank credit risk. We use a broad panel of bank and sovereign CDS data to carry out tests that establish this channel and show that it is quantitatively important. A significant challenge in demonstrating a *direct* feedback loop between sovereign and bank credit risk is the concern that another (unobserved) factor drives both bank and sovereign credit risk, and hence gives rise to comovement between them even in the absence of any direct feedback. We address these concerns by utilizing a particularly useful feature of government "guarantees", namely, their focus on protecting bank debtholders, not equity. This allows us to control for bank fundamentals using equity returns and establish a direct feedback loop between sovereign and bank credit risk.

A. Data and Summary Statistics

The focus of our study is the financial crisis in Europe that started in 2008. We include all countries in the Eurozone plus Denmark, Norway, Sweden, Switzerland, and the U.K. We use Bankscope to identify all banks headquartered in these countries with more than $10 billion in assets. We then use Datastream to determine whether a bank has publicly traded CDS. We verify our results with other data sources (Markit, Bloomberg) to ensure that we include all banks with publicly-traded CDS. We drop banks that were merged or acquired by other banks prior to the bank bailouts. We identify 58 banks with publicly traded CDS. Next, we search in Datastream whether the bank has publicly traded equity. We identify 43 banks that have both publicly traded equity and CDS. We limit our data set to banks that have publicly traded CDS rates throughout the sample period. This yields our main data set of 36 banks. We match our dataset to Bankscope for bank characteristics. We also match our data to Datastream for sovereign CDS and to OECD Economic Outlook for government debt data. We further collect data on sovereign bond holdings from the first round of European bank stress tests conducted in March 2010.

Our analysis focuses on the period from January 2007 to April 2011. We drop observations with missing bank or sovereign CDS data. We further drop observations with two consecutive zero changes in bank CDS or sovereign CDS to avoid stale data. This yields a total of 34,204 observations.

Panel A of Table I presents summary statistics for European banks. As of January 2007, the average bank had assets of €498.6 billion and book equity of €19.7 billion. The main sources of funding were deposits (49.5%), long-term debt (33.1%), short-term debt (12.6%), and equity (4.7%). The average bank rating was AA (we assign numerical values to ratings such that AAA=1, AA+=2, etc.).

[Table I is about here.]

Panel B of Table I presents summary statistics on bank and sovereign credit risk. We divide the analysis into three separate periods relative to the bank bailouts: *pre-*, *during-* and *post-* bailout. We define the pre-bailout period as starting January 1, 2007 and ending September 25, 2008. This period captures the gradual but steady increase in bank credit risk in 2007/08 and the Lehman bankruptcy on September 15, 2008. We define the during-bailout period as the period covering bank bailout announcements in Europe, that is September 26, 2008 to October 21, 2008. We define the post-bailout period as the period October 22, 2008 to April 30, 2011.

In the pre-bailout period, the average bank CDS rate and sovereign CDS rate is low at 63 basis points and 14 basis points, respectively. In the bailout period, we see a significant rise in both bank and sovereign credit risk, with average bank and sovereign CDS of 148 basis points and 48 basis points, respectively. In the post-bailout period, we see a further increase in bank and sovereign credit risk, with average bank and sovereign CDS of 184 basis points and 112 basis points, respectively. These CDS levels indicate the emergence of significant bank and sovereign credit in Europe.

Panel C of Table I presents summary statistics for all banks that participated in the European stress tests.[16] The evidence suggests that sovereign bond holdings constitute a significant share of a bank's assets. As of March 2010, the average bank holds about one-sixth of risk-weighted assets in sovereign bonds. Banks have a strong home bias in their sovereign holdings: 69% of bonds are issued by the country in which the bank is headquartered. Most of the bonds are held in the banking book, which indicates that banks plan to hold these bonds for an extended period. This finding provides direct support for the model's assumptions that banks are exposed to home-country sovereign risk through their holdings of sovereign bonds.

B. The Sovereign Risk Trigger

B.1. Bank and Sovereign Credit Risk

We start by examining bank and sovereign credit risk during the pre-bailout, during-bailout, and post-bailout period. Figure 7 plots the change in average bank and sovereign

CDS by country in the pre-bailout period. The figure shows a large increase in bank CDS, but almost no change in sovereign CDS. For example, the average bank CDS in Ireland increased by 461 bps, whereas there was almost no change in Ireland's sovereign CDS. The pattern is qualitatively similar in other countries. Hence, the credit risk of the financial sector greatly increased during the pre-bailout period but there was almost no impact on sovereign credit risk.[17]

[Figure 7 is about here.]

Next, we examine the evolution of bank and sovereign CDS during the bailout period. Within one month of the Irish bailout on September 30, 2008, almost every other Western European country also announced a bailout. In fact, many countries followed Ireland's example, in part to offset outflows from their own financial sectors to newly secured financial sectors. The bailouts consisted of asset purchase programs, debt guarantees, equity injections, or some combination thereof. The costs of these programs were substantial, at an estimated 54% of GDP in U.K., 28% of GDP in Germany, and 22% of GDP in the U.S. (Panetta et al. (2009), Laeven and Valencia (2012)).[18]

Figure 8 plots the change in average bank and sovereign CDS during the bailout period. For most countries, bank CDS decreased during this period, while sovereign CDS increased. For example, the average bank CDS in Ireland decreased by 104 bps, while the sovereign CDS increased by about 53 bps. Most other countries followed a similar pattern. This result suggests that the bank bailouts led to a substantial reduction in bank credit risk across a broad cross-section of countries. However, this also caused a contemporaneous, immediate increase in sovereigns' credit risk, consistent with our model.

[Figure 8 is about here.]

Figure 9 plots the change in bank CDS and sovereign CDS in the post-bailout period until June 2010, but the pattern is robust to the end date. We find that both sovereign CDS and bank CDS increased across most countries and the magnitudes of the changes are similar within countries.

[Figure 9 is about here.]

In addition, we examine the comovement of bank and sovereign CDS for each month. We focus on the largest five countries in Europe (France, Germany, U.K, Italy, Spain) to limit the impact of outliers. Figure 10 shows the scatterplot of bank and sovereign CDS by country and month from October 2008 to December 2012. We find that bank and sovereign CDS strongly comove after the bank bailouts, suggesting that they may feed back on each other, as we explore in detail below.

[Figure 10 is about here.]

B.2. Debt Ratios, Financial Distress, and Sovereign CDS

Our model predicts that the increase in a sovereign's credit risk upon its bailout should depend on its level of debt and the level of distress in its financial sector before the bailout. The model also predicts that bank bailouts can trigger an increase in sovereign credit risk, so that a positive relationship between sovereign credit risk and the level of government debt appears after a bailout, even if there is no such relationship beforehand.

Figure 11 examines the relationship between sovereign CDS and public debt-to-GDP ratios across countries. The left panel plots the relationship before the bailouts. The panel shows almost no correlation between the two variables. The right panel plots the relationship after the bank bailouts. The panel shows a strong and positive relationship between the two variables. These figures strongly suggest that a relationship between public debt and sovereign credit risk emerged because of the bailouts.

[Figure 11 is about here.]

To test this relationship formally, we estimate the impact of pre-bailout debt-to-GDP ratio and financial sector distress on sovereign credit risk. We measure financial sector distress at the country level as the weighted average of bank CDS prior to the bailouts (on September 22, 2008), with weights determined by bank assets as of January 2007. We measure the public debt-to-GDP ratio as government gross liabilities as a percentage of GDP as of June 2008.

We estimate the following OLS regression:

$$\mathrm{y}_i = \alpha + \beta(\textit{Debt-to-GDP Ratio}_i) + \gamma \log(\textit{Financial Sector Distress}_i) + \varepsilon_i,$$

where the outcome variable y_i is the natural logarithm of sovereign CDS of country i.

We first analyze the impact of financial distress and government debt on sovereign CDS before the bailouts. As shown in column (1) of Table II, we find a weak relationship between financial sector distress and sovereign CDS, the coefficient is small and statistically insignificant. In column (2), we add the public debt-to-GDP ratio as an additional explanatory variable. The coefficient on financial sector distress is almost unchanged and there is no economically or statistically significant effect of public debt-to-GDP on sovereign CDS. Hence, the level of government debt and financial sector distress have no predictive power for the level of sovereign CDS before the bailouts.

[Table II is about here.]

Next, we examine the impact of financial sector distress and government bailouts on sovereign CDS after the bank bailouts. Column (3) finds that a 10% increase in pre-bailout financial sector distress leads to a 10% increase in sovereign CDS. Column (4) shows that a 10 percentage point increase in the pre-bailout public debt-to-GDP ratio raises sovereign CDS by 13%. The coefficient on financial sector distress decreases slightly but remains statistically significant. The R^2 of the regression is high at 54%. These results suggest that pre-bailout financial sector distress and public debt-to-GDP ratio are highly predictive of post-bailout sovereign credit risk.

We also examine the channels for the emergence of sovereign credit risk. Our model suggests that the bank bailouts affect sovereign credit risk through an increase in the public debt-to-GDP ratio. We therefore examine whether financial sector distress predicts the change in public debt-to-GDP ratios after the bailouts. Our outcome variable is the change in the debt-to-GDP ratio from July 2008 to July 2010. As shown in column (5), we find that a 10% increase in financial sector distress predicts a 2.4 percentage point increase in the public debt-to-GDP ratio. As shown in column (6), this result is robust to controlling for the public debt-to-GDP ratio before the bailouts.

Our model further suggests that the increase in public debt-to-GDP ratios is caused by the cost of bank bailouts. To the extent that the cost can be measured accurately, we should observe that pre-bailout financial sector distress predicts the cost of bank recapitalization. Laeven and Valencia (2012) provide country-level estimates of the cost of bank recapitalization relative to GDP.[19] As shown in column (7), a 10% increase in pre-bailout financial sector distress raises the cost of bank recapitalization by 1.8 percentage points. As shown in column (8), this result is robust to controlling for the pre-bailout public debt-to-GDP ratio. This result indicates that increase in debt-to-GDP ratios after the bank bailouts is due at least in part to the direct cost of bank recapitalization.

C. The Sovereign-Bank Feedback Loop

C.1. Benchmark Specification

This section analyzes the two-way feedback loop between sovereign and bank sector credit risk. When the sovereign opens itself up to credit risk due to bailouts, the price of its debt becomes sensitive to macroeconomic shocks. Moreover, our model indicates that subsequent changes in the sovereign's credit risk should impact the financial sector's credit risk through its effect on the values of: (i) ongoing bailout payments and subsidies, (ii) direct holdings of government debt, and (iii) explicit and implicit government guarantees. In our empirical analysis, we estimate the aggregate effect of the two-way feedback loop between sovereign and bank credit risk.

The main challenging in establishing a *direct* feedback loop between sovereign and financial sector credit risk is that there may be another (unobserved) factor that affects both bank and sovereign credit risk. Such a factor could explain comovement between sovereign and bank credit risk without there necessarily being an underlying *direct* channel between sovereign and bank credit risk. For example, sovereign credit risk reflects changes in expectations about macroeconomic fundamentals, such as employment, economic growth, and productivity. These fundamentals also have a direct effect on the value of bank assets such as mortgages or bank loans. Hence, changes in macroeconomic conditions may generate a correlation between sovereign and bank credit risk even in the absence of a direct feedback mechanism.

We address this concern by including three sets of controls to capture the direct effect of macroeconomic fundamentals on bank and sovereign credit risk. First, we include day fixed effects to capture market-wide changes in macroeconomic fundamentals that directly affect both bank and sovereign credit risk. These fixed effects capture all macrofundamentals that have a common effect on the financial sector.

Second, we control for the foreign credit risk exposure of each country's financial sector. We compute foreign exposure as the weighted average of the other countries' sovereign CDS rates, where the weights are determined according to country-specific exposures. The country-specific exposures are computed based on total exposure according to quarterly Bank for International Settlements data relative to the size of a country's financial sector (collected from the European Central Bank Statistics website). This foreign exposure variable captures changes in banks' credit risk due to changes in the sovereign credit risk of other countries. The coefficient on this variable is also of independent interest because it provides a measure of the sensitivity of bank credit risk to foreign credit risk exposure.

Third, we control for heterogeneity in banks' exposure to changes in macroeconomic fundamentals by controlling for bank fixed effects and allowing for bank-specific coefficients on a CDS market index and a measure of aggregate volatility. Our CDS market index is the iTraxx Europe index, which consists of 125 of the most liquid CDS names referencing European investment grade credits. The CDS market index captures market-wide variation in CDS rates caused by changes in fundamental credit risk, liquidity, and CDS market-specific shocks.[20] For the volatility index we follow the empirical literature and use a VIX-like index, the VDAX, which is the German counterpart to the VIX index for the S&P 500. This index captures changes in aggregate volatility, which is an important factor in the pricing of credit risk.

We estimate all regressions at the daily level. Using daily data provides us a large data set and allows us to finely control for other variables. The downside of using daily data is that the data may be noisy. This could be because of lack of liquidity, which could lead to classical measurement error. In this case, we would expect our estimates to be biased downwards. We examine this issue in the robustness section.

Specifically, we estimate the following OLS regression:

$$\Delta \log(\mathit{Bank\ CDS}_{ijt}) = \alpha_i + \delta_t + \beta \Delta \log(\mathit{Sovereign\ CDS}_{jt}) + \gamma_i \Delta X_{ijt} + \varepsilon_{ijt}$$

where $\Delta \log(\mathit{Bank\ CDS}_{ijt})$ is the change in the natural logarithm of the CDS rate of bank i headquartered in country j from day t to $t+1$, $\Delta \log(\mathit{Sovereign\ CDS}_{jt})$ is the daily change in the natural logarithm of the sovereign CDS of country j, ΔX_{ijt} are daily changes in the control variables, γ_i are bank-specific coefficients, δ_t are day fixed effects, and α_i are bank fixed-effects. We cluster the standards errors at the bank-level to allow for correlation of errors terms within banks. The coefficient of interest β captures the relationship between changes in bank and sovereign CDS rates.

Table III presents the results. We separately present results for the period before, during, and after the bank bailouts. For each period there are two columns of results. The first column presents results for a specification with day fixed effects and controls for foreign exposure. The second column reports results for a specification that also includes bank fixed effects and bank-specific coefficients on CDS market and volatility indices.

[Table III is about here.]

We first examine the period before the bailouts. Column (1) finds no evidence of a relation between bank and sovereign credit risk in the pre-bailout period. The coefficient is economically small and statistically insignificant. Column (2) finds that the results are unchanged after including bank-level controls. These results suggests that there was no feedback loop between banks and sovereigns prior to the bailouts.

Next, we analyze sovereign-bank feedback during the bailout period. Column (3) finds a large, negative, and statistically significant coefficient. A 10% increase in the sovereign CDS rate leads to 5.8% decrease in the bank CDS rate. Column (4) finds that this result is robust to including bank-specific controls. These results support the view that bank bailouts triggered the rise in sovereign CDS and that banks transferred some of their credit risk to their sovereign.

Finally, we examine sovereign-bank feedback after the bailouts. Column (5) finds a positive and highly statistically significant coefficient. The magnitude is also economically important, implying that an increase in sovereign CDS of 10% translates into a 0.9% increase in bank CDS. Altogether, the variables explain 46% of the variation in daily changes in bank CDS. Column (6) adds bank fixed effects and includes bank-specific coefficients on market-level controls. The coefficient on sovereign CDS decreases slightly but remains highly statistically significant. Given the flexibility of this specification, we interpret the coefficients on sovereign CDS rates as robust evidence in favor of a direct sovereign-to-bank feedback loop.

We further note that the coefficient on foreign exposure CDS is positive and statistically significant in the period after the bailouts. A 10% increase in foreign exposure CDS raises bank CDS by 0.2%. This result suggests that exposure to foreign countries emerged as a factor in the pricing of bank credit risk after the bank bailouts. This result is of independent interest because it provides further evidence that sovereign (albeit foreign) credit risk affects banks' credit risk. Note that it is unlikely that this result is driven by aggregate-level shocks to fundamentals because the result is identified off variation in the exposure to foreign countries' sovereign CDS *after* controlling for common variation across countries and for bank-specific exposures to CDS market and volatility indices.

C.2. Controlling for Bank Fundamentals

Our results above establish that there is a strong sovereign-bank credit risk feedback loop. However, our strategy may not sufficiently control for country-specific macroeconomic shocks that affect both sovereign and bank credit risk. Though we have no particular reason to believe this is the case, we provide an alternative identification strategy for our results.

Our alternative identification strategy utilizes a particularly useful feature of bank bailouts. Specifically, most bailouts were partly structured in the form of government "guarantees", either explicitly or implicitly, that aimed to protect debt rather than equity. As Proposition 4 shows, this implies that sovereign-specific shocks should have a disproportionate impact on the price of debt relative to equity compared to other shocks to bank assets or fundamentals. In contrast, if there is no direct sovereign-bank credit channel, then controlling for banks' own equity returns will control for the impact of any country-level shocks on bank debt values and eliminate sovereign CDS as an explanatory variable. This second possibility is much more general than Proposition 4. It holds also under any defaultable bond model where debt and equity are contingent claims on total firm value, and hence the return on equity locally captures the return on debt.[21]

To establish whether there is a direct sovereign-to-bank feedback effect, we test whether changes in sovereign CDS continue to influence changes in bank CDS after controlling for banks' own equity returns. We give alternative models maximum flexibility to capture the explanatory power of sovereign CDS by incorporating bank-specific betas on a bank's own equity returns, the change in the volatility index, and the CDS market return. Hence, a finding that sovereign CDS continues to have explanatory power for bank CDS would provide strong evidence in support of a direct sovereign-to-bank channel.

The results of these regressions are shown in Table IV, which retains the same structure as Table III. Column (1) finds that the coefficient on sovereign CDS remains economically small and statistically insignificant during the pre-bailout period. The coefficient on the equity control is statistically significant and negative, as expected. Column (2) allows for bank-specific coefficients on the controls, including the bank equity returns, but the coefficient on the sovereign CDS rate remains unchanged.[22] Columns (3) and (4) examine the sovereign-bank feedback loop during the bailout period. The coefficients on sovereign CDS are similar to the ones in Table III.

[Table IV is about here.]

Columns (5) and (6) present the results for the post-bailout period. Although the bank stock return coefficient is highly statistically significant and possesses the expected negative sign, its inclusion has little impact on the magnitude of the sovereign CDS coefficient. We find that the coefficients on sovereign CDS rates are only slightly smaller than in Table III and remain highly statistically significant.[23]

Overall, our results are highly robust to including equity returns as a control variable and suggest that we identify a direct sovereign-bank feedback.

C.3. Estimation Using Government Bond Yields

We use sovereign CDS rates to measure sovereign credit risk. Instead, one could measure sovereign credit risk as the spread of the government bond yield over the maturity-matched risk-free yield. Under the textbook treatment of CDS pricing, the two should be equal. Like many other recent empirical studies of credit risk, we focus on CDS rates since their standardization and liquidity give them several important advantages over bond yield spreads for empirical work.[24] Moreover, without using CDS rates it is difficult to precisely identify the credit component of sovereign bond yields since there may not be a separate reading of the risk-free yield.

Nevertheless, since CDS rates and bond yield spreads sometimes diverge in practice (i.e., there is a “basis”), one may be concerned that the use of CDS rates somehow drives our results. To address this concern, we reestimate our main regressions from Table IV replacing each country’s sovereign CDS rate with its government bond yield. We focus on government bond yields because five-year government bond data are widely available and of high quality. We collect the government bond yield data from Datastream, which provides five-year bond yield data for all countries in our sample with the exception of Norway. We include time fixed effects in the regression to control for the risk-free rate.

Table V presents the results. Similar to Table IV, we find that the coefficients on changes in bond yields before the bailouts are economically small and statistically insignificant before the bailouts (columns (1) and (2)). We find that the coefficients are not statistically significant during the bailouts (columns (3) and (4)). The lack of statistical significance may be caused by the short duration of the bailout period. Most importantly, we find that the coefficients for the post-bailout period in columns (5) to (6) are almost identical to those in Table IV. Given that the estimates are not only qualitatively but also quantitatively the same, we believe these results provide strong robustness for our main findings.

[Table V is about here.]

C.4. Estimation Using Stand-Alone Credit Ratings

Our main tests use bank CDS to estimate the value of government support to banks. As an alternative, one can construct a direct measure of the value of government support. We construct such a measure based on banks' credit ratings.

Moody's Investor Services provides ratings for financial institutions with and without government support. Hence, the difference between the two ratings can be interpreted as a proxy for the value of government support. To construct this proxy, we use Moody's *Long-term issuer rating*, which incorporates government support, and Moody's *Bank financial strength rating*, which does not. The difference between the two ratings is an estimate of the value of government support to banks ("ratings uplift").

We hand collect data on *Long-term issuer ratings* and *Bank financial strength ratings* from Moody's website. We find 31 banks (out of 36 banks) that have both ratings. We construct the variable *Ratings uplift* in three steps. First, we use Moody's conversion table to transform stand-alone ratings into long-term issuer equivalent ratings (Moody's Investor Services (2007)). Second, we follow common practice in the analysis of credit ratings and assign numerical values to each rating (AAA=1, AA+2, etc.). Third, we compute the ratings uplift as the difference between the two variables, such that a higher number indicates a higher value of government support.

We analyze whether sovereign credit risk affects the ratings uplift. We consider two variables as proxies for sovereign credit risk. The first variable is *Country Rating* (Moody's Long-term issuer Rating (domestic)). We employ this variable because country ratings are based on the same methodology as bank ratings and updated at a similar frequency. The second variable is the natural logarithm of sovereign CDS. We use this variable because it is our main measure of sovereign credit risk throughout the paper. We estimate the same specifications as in Table IV.[25]

Table VI presents the results. Columns (1) and (2) find no statistically significant effect of sovereign credit risk on ratings uplift before the bailouts. The coefficients are negative, as one would expect, but they are economically small. In contrast, column (3) finds an economically and statistically significant effect of sovereign credit risk on bank credit ratings after the bailouts. Specifically, a one-notch decrease in a country's credit rating reduces the ratings uplift by 0.32 notches. As shown in column (4), we find a similar result if we use sovereign CDS instead of country credit ratings. The results strongly suggest that higher sovereign credit risk reduces the value of government support for banks. In short, our results are robust to using ratings uplift as an alternative dependent variable.[26]

[Table VI is about here.]

C.5. Bank-Level Heterogeneity

This section analyzes heterogeneity in the sensitivity of bank credit risk to sovereign credit risk. We focus on heterogeneity in country characteristics because our main variable of interest varies at the country level. In Table VII, we estimate the same specifications as in Table IV and add interaction terms for changes in sovereign CDS with specific country-level variables. We focus on the pre- and post-bailout period because the bailout period is too short to estimate interactions.

[Table VII is about here.]

We first examine the impact of sovereign credit risk on the sovereign-bank feedback effect. We measure the level of sovereign credit risk using the country's credit rating. Column (1) finds no effect before the bailouts. Column (2) finds that the interaction is positive and statistically significant after the bailouts. A one-notch decrease in the sovereign credit rating raises the sensitivity to a 10% increase in sovereign CDS rates by 0.3%. Columns (3) and (4) find a similar effect using the lagged sovereign CDS as an alternative measure of sovereign credit risk. This evidence is supportive of our model, which shows that bank bailouts trigger sovereign credit risk and this effect is larger for countries with a higher level of sovereign credit risk.

Next, we examine the effect of government debt on the sovereign-bank feedback loop. We measure government debt as the public debt-to-GDP ratio. Column (5) finds no effect before the bailouts. Columns (6) finds a positive and statistically significant effect after the bailouts. A one-standard-deviation increase in the public debt-to-GDP ratio increases the sensitivity to a 10% increase in sovereign CDS rates by 0.5%. This effect is comparable to the impact of lowering a country's credit rating by one notch. This evidence suggests that an increase in public debt raises the sovereign-bank feedback effect.

We further analyze whether our results differ between Eurozone and non-Eurozone countries. Column (7) finds no difference between Eurozone and non-Eurozone countries before the bailouts. Column (8) shows that the effect is larger for Eurozone countries after the bailouts. This result suggests that the sovereign-bank feedback loop may be stronger for countries within a monetary union.

In short, our results show that the bank-sovereign CDS relationship is stronger for riskier countries, countries with high levels of government debt, and countries in a monetary union.

C.6. Robustness

We conduct several additional tests to check the robustness of our results. First, our analysis ends in April 2011. We chose this date because the first version of this paper was finished in May 2011. As part of revising the paper, we collected data for the period from May 2011 to December 2012. We can therefore repeat our analysis for this additional period. We estimate the same specifications as in columns (5) and (6) of Table IV and present the results in Panel A of Table VIII. Our results are qualitatively and quantitatively unchanged.

[Table VIII is about here.]

Second, our analysis uses daily data. As discussed, daily data may suffer from classical measurement error. We therefore also estimate our results at a weekly level, which smooths out measurement error. Panel B of Table VIII presents the results. All the coefficients are qualitatively similar to Table IV. Consistent with some measurement error in the data, we find that the coefficients are somewhat larger than in Table IV.

Third, we examine the robustness of our results to controlling for changes in bank leverage. We compute bank leverage as the ratio of market equity plus book debt divided by market equity. We collect market equity from Datastream and book debt from Bankscope. Panel C of Table VIII presents the results. We find that all our results are essentially unchanged. Moreover, we find that changes in leverage have no explanatory power in specifications that control for bank equity returns.

Fourth, our analysis uses changes in the natural logarithm of CDS rates. We make this choice because the relationship between nonnegative financial variables is typically log-linear and the use of the natural logarithm reduces the impact of outliers. As an alternative, we also estimate the effect in levels. We present the results in the Internet Appendix. We find qualitatively similar results.

Fifth, our main regressions are estimated with a balanced panel to ensure that our results are not driven by bank entry and exit. Arguably though, most entry and exit is unrelated to the sovereign-bank feedback mechanism. We therefore also estimate our results for the unbalanced panel. We report the results in the Internet Appendix. The results are almost identical to those for the balanced panel.

Finally, we include foreign exposure as a control variable in all our regressions. We report coefficients on this variable because it provides direct evidence of the importance of foreign sovereign credit risk in pricing bank credit risk. However, our measure is constructed at the country-level and banks may have different loadings on this variable. Hence, we also estimate our results including bank-specific coefficients on foreign exposure. We again report the results in the Internet Appendix. The results are almost unchanged.

D. The Case of Iceland: A Counterfactual?

We conclude the analysis by considering the case of Iceland. By 2008 the Icelandic banking sector was extremely highly leveraged and very large compared to the size of the Icelandic economy. The three biggest Icelandic banks had active subsidiaries in the U.K., Scandinavia, and continental Europe. In late September 2008, fears of a run on the Icelandic banks led to their being put into receivership under the supervision of the Icelandic government. At the very onset of this crisis the Icelandic government moved to bail out the first of its failing banks. However, it soon became clear that the government would not be able to save the Icelandic banks since the outstanding debt of the three biggest banks alone included over $62 billion in foreign currency obligations, which is an order of magnitude bigger than Iceland's 2007 GDP.

Facing no possibility of a successful bailout, the Icelandic government separated the domestic and international parts of its banks' operations. It kept the foreign liabilities within the failed lenders and provided *no* support to banks' foreign creditors (either bondholders or depositors). Hence, Iceland's banks effectively became bankrupt and still owe creditors $85 billion today. The banking crisis was followed by high inflation, a large depreciation in the currency, and a severe contraction of the economy.

At the onset of the crisis, the CDS rate on *Euro*-denominated Icelandic government obligations increased tremendously, reaching well over 1,000 bps. Since Iceland's pre-crisis foreign-currency obligations were not large, this reflected the market's fear that the large foreign-currency obligations of the banks would end up on the government's balance sheet.[27] Hence, Iceland faced an extreme version of the problem faced by the government in our model.

Ultimately, Iceland did not take on significant foreign obligations from its banking sector. This was arguably due to the tremendous magnitude of the obligations relative to Iceland's resources. Moreover, most of the obligations where due to foreigners rather than domestic citizens, which further reduced the incentive to provide a bailout. Within our model, this outcome can be interpreted as the corner solution that arises when the government is incapable of increasing the financial sector's probability of solvency (p_{solv}) above zero for any level of taxation and corresponding transfer. Under such circumstances it is optimal within the model for the government to avoid increasing outstanding debt or giving any transfer to the financial sector.

As Figure 12 shows, Iceland CDS rates subsequently decreased tremendously. The figure compares the sovereign CDS of Iceland with that of Ireland. It shows that by the beginning of 2011 Iceland CDS rates were significantly below those of Ireland. This difference does not reflect Iceland's superior economic performance over the ensuing period since, by all estimates, Iceland experienced a contraction in output that was greater than that of Ireland. In this sense Figure 12 serves as a counterfactual that supports the inference that if sovereigns had abstained from financial sector bailouts, they would face lower sovereign credit risk.

[Figure 12 is about here.]

IV. Are Our Results Relevant to Other Financial Crises?

We believe our results are helpful for thinking about banking crises other than the Eurozone crisis. The reason is that almost all governments contemplate bank bailouts in the midst of a financial crisis – even if they eventually decide not to intervene. Our paper provides an analysis of the economic factors that affect this choice and the consequences of this choice for economic outcomes. However, some countries may not bail out their banks because of factors not considered in our model. We briefly discuss these factors and how they affect the interpretation of our results.

Our model assumes either that government debt is real, or that it is nominal but the government is in a monetary union (or, more generally, in a setting with fixed exchange rates). In either case, the government cannot reduce the real value of its debt by increasing the nominal price level, that is, causing inflation. This option is usually under consideration for large developed countries (e.g., U.K., U.S.) and emerging economies that can issue government debt in their own currency.

Nevertheless, we think that our model provides insights even when government debt is not real. The reason is that while "inflating away" is an option for governments with nominal debt, it comes at a large cost. Hence, in practice there are several reasons why it does not seem very helpful and may therefore play a limited role.

First, both default and inflation are ways to reduce the real amounts paid to debtholders. While small increases in inflation may not hurt a sovereign's credibility with bondholders as much as a default, meaningfully reducing high levels of debt requires a large surprise increase in inflation. The reputational costs for the government of targeting debt in this way would be similar to a default, since both high inflation and default are just means of reducing the real value of payments to bondholders.

Second, in terms of their other effects on the economy, a dramatic, surprise increase in inflation is arguably much worse than a default. Whereas the direct costs of a default are restricted to bondholders, a big increase in inflation would further impose large negative costs to everyone else in the economy by distorting private borrowing and saving, wages, employment, and investment. In other words, because inflation directly affects all aspects of the economy rather than just government debt, the collateral damage caused by increasing it in a dramatic fashion is far more widespread than that from an outright default. Faced with these alternatives, a highly indebted sovereign may well choose outright default even if a sufficiently high surprise inflation could, technically, allow it to be avoided.[28].

Third, a large increase in inflation also carries long-term costs. For instance, it would lead to an increase in the inflation risk premium that investors price into future government bonds. That is, investors' loss of faith in future price stability would lead them to price in an extra risk premium in bond yields to protect themselves against the possibility of inflation yet again if debt levels started to increase again. This would make it more expensive for the government to roll over its debt and offset the initial gains in debt reduction made possible by the initial surprise inflation. Moreover, the large increase in inflation could significantly damage the hard-won reputation of the government since it would be clear that inflation was increased to dilute debtholders. Hence, even the fact that default was technically avoided would not necessarily mean that it is less costly than an outright default.[29]

We further consider the issue of currency depreciation. While inflation can directly help reduce debt, a depreciation of the currency alone does not appear to do so, at least not directly. The reason is that both government debt and tax revenues are denominated in the local currency. Hence, by itself a depreciation in the exchange rate does not decrease the real liabilities of the government and make it easier for it to raise the tax revenues required to pay its debt.

A depreciation of the currency will, however, decrease the value of nominal bonds in terms of the foreign currency, and hence hurts foreign investors. But this does not help the government (unless it can pay the local debt with foreign currency reserves). Governments do often use a weakening of the currency to stimulate exports by making them cheaper to foreign consumers. This could help stimulate the economy and thereby increase tax revenues, but the effect is indirect and would be offset by the impact of higher import prices. So it is really inflation, and not the (often resulting) currency depreciation, that directly helps the government to pay its nominal debts.

Another issue is whether the government can raise sufficient future tax revenue to fund any kind of meaningful bailout. If not, then the banking sector is "too big to save." This issue is discussed above in the context of Iceland. The Icelandic government at first tried to bail out the banking sector, but ultimately decided not to since the required debt was too large. Not surprisingly, Iceland suffered a very severe recession. Yet its sovereign credit risk actually declined dramatically, implying that the bailouts were a key driver of the rise in sovereign credit risk. Hence, the case of "too big to save" can be understood within the model, but it is probably relevant only for countries whose financial sector dwarfs domestic GDP (Switzerland is potentially such a case).

Finally, our analysis does not distinguish between domestic and foreign claims on banks. However, in some countries foreigners provide much of the banking system's capital. Therefore, in a crisis the government may decide not to bail out banks because a large portion of the benefits accrue to outsiders. This consideration played a role in the case of Iceland because local banks were financed largely with foreign deposits, and is surely relevant for understanding crises in general, but only for countries in which the banking sector is mostly foreign-owned.

V. Conclusion

In this paper we examine the link between bank bailouts and sovereign credit risk. In our model the government faces an important trade-off: bank bailouts ameliorate the underinvestment problem in the financial sector but reduce the investment incentives of the nonfinancial sector due to the corresponding increase in future taxation. In the short run, bailouts are funded through the issuance of government bonds. A high level of issuance helps to fund the bailout but dilutes existing bondholders and raises sovereign credit risk. This creates a two-way feedback loop between sovereign and financial sector credit risk because financial firms are exposed to the value of government debt through both their direct bond holdings and the value of explicit government guarantees or an implicit safety net.

We find support for our model using bank- and country-level data from the 2007 to 2011 Eurozone crisis. We first show that greater financial sector distress predicts larger bank bailouts, higher sovereign credit risk, and greater debt-to-GDP ratios across countries. Using bank and sovereign CDS data, we further show that changes in sovereign CDS explain changes in bank CDS after the bank bailouts. We isolate the effect of sovereign credit risk on bank credit risk by controlling for aggregate and bank-level determinants of credit spreads. Hence, our results indicate that bank bailouts triggered sovereign credit risk in Eurozone countries and in turn weakened the financial sector, confirming the bank-sovereign feedback loop.

Overall, we consider the emergence of meaningful sovereign credit risk in developed countries and its damaging feedback effect on bank solvency as an important potential cost of bank bailouts. This cost can render the immediate stabilization of the financial sector a Pyrrhic victory, a point that has received little theoretical attention and has not been analyzed empirically. We believe incorporating the cost of bailouts has important consequences for the future resolution of financial crises, the design of fiscal policy, and the nexus between the two.

Notes

[1]Just one of the Irish banks, Anglo Irish, cost the government up to Euro 25 billion (USD 32 billion), or 11.26% of Ireland's Gross Domestic Product (GDP). The original bailout cost estimate of Euro 90 billion was reestimated to be 50% higher and Ireland's credit rating was revised downwards. See "Ireland's banking mess: Money pit – Austerity is not enough to avoid scrutiny by the markets," the Economist, August 19, 2010; "S&P downgrades Ireland" by Colin Barr, CNNMoney.com, August 24, 2010; and "Ireland stung by S&P downgrade," Reuters, August 25, 2010.

[2]For example, in mid-2011 the exposure of UniCredit and Intesa (two big Italian banks) to Italian bonds was 121% and 175% of their core capital, respectively. See "Europe's Banks Struggle With Weak Bonds" by Landon Thomas Jr., New York Times, August 3, 2011.

[3]This could be due to underinvestment problem as in our setup (e.g., Philippon and Schnabl (2013)), adverse selection (e.g., Gorton and Huang (2004)), risk-shifting or asset substitution (e.g., Acharya, Shin and Yorulmazer (2011) and Diamond and Rajan (2011)), or tradeoff between illiquidity and insolvency problems (e.g., Diamond and Rajan (2005)). Some other papers (Philippon and Schnabl (2013) and Bhattacharya and Nyborg (2013), among others) focus on specific claims through which bank bailouts can be structured to limit these frictions.

[4]The Internet Appendix is available in the online version of this article on the *Journal of Finance* website.

[5]We omit the revenue $w_s s_0^s$ from the solvency condition, since including it embeds an additional layer of complexity in the analysis without changing any of the conclusions.

[6]Note that we have intentionally kept the government's toolkit simple, since our focus is not the specifics of the optimal bailout structure. The results will continue to hold so long as the bailout obeys two key characteristics, no matter how it is structured: (i) the bailout is not free to the government (i.e., it involves a net transfer from the government to the financial sector, and (ii) the larger is the debt overhang problem, the greater is the cost of the bailout.

[7]Committing to carry through on imposing the tax is optimal ex-ante. Moreover, it is

incentive-compatible at $t = 2$ since the cost of taxation only depends on decisions made at $t = 1$.

[8]Let P_2 be the value of the government bond at $t = 2$, which is equal to one if there is no default and to the recovery value otherwise. Since the representative consumer is risk-neutral and has no time-discounting, the CDS fee equals $E[1 - P_2] = 1 - E[P_2] = 1 - P_0$.

[9]The second-order conditions of both the financial and the nonfinancial sectors are satisfied: $-c''(s_0) < 0$ and $\frac{\partial^2 f(K_0, s_0^d)}{\partial^2 s_0^d} < 0$.

[10]While the particular tax we model induces a distortion in investment, the model would work similarly under alternative tax-induced distortions that reduce overall output. For instance, we could have included a labor-leisure trade-off for the nonfinancial sector and incorporated a labor income tax. In this case the tax would decrease the marginal benefit of labor and reduce total output. Though we think the distortion in investment is important, our focus is not the particular tax-induced distortion or the optimal taxation mechanism, but rather the tax-induced cost of bailouts and the ensuing trade-off with sovereign creditworthiness.

[11]Since $N_T = (\mathcal{T} - N_D/H)H$, we can write $T_0 \quad = \quad N_T P_0 \quad = \quad (\mathcal{T} - \frac{N_D}{H})E_0\left[\min\left(H, \tilde{R}_V\right)\right]$.

[12]Though $P_0 \to 0$, $N_T \to \infty$ at the same time, so that $T_0 \to \mathcal{T}$.

[13]With stochastic volatility it also becomes necessary to know the change in firm volatility. Equation (12) can then be extended to include this additional term on the right-hand side.

[14]More generally, the second beta is required if changes in the guarantee value have a differential impact on equity relative to debt as compared to general changes in the firm's asset values.

[15]We thank a referee for suggesting this extension.

[16]This sample includes banks without a publicly traded CDS. The results are similar if we restrict the sample to banks with publicly traded CDS.

[17]We note that some investors may have expected bank bailouts even before the first official announcement on September 30, 2008. Such an expectation would reduce the observed increase in bank CDS and shift forward in time the increase in sovereign CDS. To the extent

that investors held such expectations prior to September 30, 2008, they can explain the small rise in sovereign CDS that occurs late in the pre-bailout period. However, the absence of any significant change in sovereign CDS during the pre-bailout periods suggests that the bailouts were a surprise to many investors.

[18]According to the systemic banking crises database by Laeven and Valencia (2012), all countries in our sample provided extensive liquidity support to banks. With the exception of Norway, all countries also engaged in other measures such as providing guarantees on bank liabilities, purchasing banks assets, and injecting equity into banks.

[19]Laeven and Valencia (2012) report that all countries in our data set had a banking crisis with the exception of Norway. We therefore impute a cost of zero for Norway. The results are robust to dropping Norway from the estimation.

[20]Collin-Dufresne, Goldstein, and Martin (2001) find that a substantial part of the variation in corporate credit spread changes is driven by a single factor that is independent of changes in risk factors or measures of liquidity. They therefore conclude that this variation represents "local supply/demand shocks" in the corporate bond market.

[21]The canonical example is the Merton (1974) model. Since debt guarantees discriminate in favor of debt over equity, they break the contingent-claims relationship inherent in the vast majority of defaultable-bond models.

[22]The interpretation of the coefficient on equity returns in column (2) changes relative to column (1) because it now represents the coefficient on one particular bank rather than a common coefficient across all banks.

[23]For the purposes of establishing the existence of a sovereign-bank feedback, we focus on changes in bank CDS. It is also interesting to look at the impact of bailouts on bank equity returns. From the perspective of the model, bank equity returns should reflect changes in sovereign credit risk due to their impact on the value of continuing bailout payments and banks' holdings of government bonds. To check this conjecture, we also estimate the regressions from Table III with equity returns as the outcome variable. We find a similar relationship for bank equity returns as for bank CDS in Table III (as expected, the coefficient in the post-bailout period has the opposite sign because an increase in sovereign CDS reduces equity returns). This finding supports the assumption that equity returns capture changes in bank fundamentals.

[24]CDS contracts are constant maturity contracts, which means there is no need to choose a roll-over date or worry about on-the-run versus off-the-run bonds and their differential liquidities. For the same reason, liquidity is concentrated in a single contract rather than being dispersed amongst many individual bonds. Selling CDS is also easier than shorting bonds, since it doesn't require borrowing a security. Blanco, Brennan, and Marsh (2005) argue that these factors cause CDS rates to lead those of bonds.

[25]We focus on the pre- and post-bailout periods. The reason is that the bailouts themselves only lasted four weeks, which is too short to analyze changes in slow-moving credit ratings.

[26]At the end of our sample period, rating agencies updated methodologies for valuing government support for bank ratings (Packer and Tarashev (2011)). It is likely that the ratings uplift for banks headquartered in countries with high sovereign credit risk decreased as a result. This would suggest that our estimates are a lower bound for the effect of sovereign credit risk on ratings uplift.

[27]The credit rating agencies expressed precisely this concern as they downgraded Iceland's sovereign debt in 2008, with Moody's stating that "the Icelandic authorities' resolution not to save the whole banking system at the cost of jeopardizing the government's creditworthiness – reflected in decisions damaging to bank creditors' interests – is fraught with operational difficulties," and "some of the banks' external liabilities will eventually filter through to the government's balance sheet" (Moody's Investors Services, October 8, 2008)

[28]A high inflation rate may also affect the pricing of sovereign debt through its effect on risk premia. Drechsler, Savov, and Schnabl (2014) build a model in which the *level* of the nominal interest rate affects risk premia in the economy by changing banks' cost of leverage.

[29]There is also the issue that even moderate inflation would not necessarily help reduce the debt of highly indebted sovereigns by a meaningful amount. For instance, consider a sovereign with a debt level of 100% of GDP. This is approximately the level of debt in the U.S., while a number of sovereigns, including Italy, Greece, and Japan, have significantly higher levels of debt (and these levels are projected to grow in the coming years due to structural deficits). The duration of U.S. debt is approximately five years and, with the exception of the U.K., is not far from this value for many governments (see the table in http://www.economist.com/node/15498265). This duration implies that a 1% surprise and permanent increase in the annual inflation rate would reduce the present value of debt by

approximately 5%. Hence, to reduce the present value of debt to 70% of GDP, which is still fairly high, one needs a surprise and permanent increase in the annual inflation rate of 6% per year. This is far above what would be considered acceptable in terms of price stability and its negative effects could be far-ranging.

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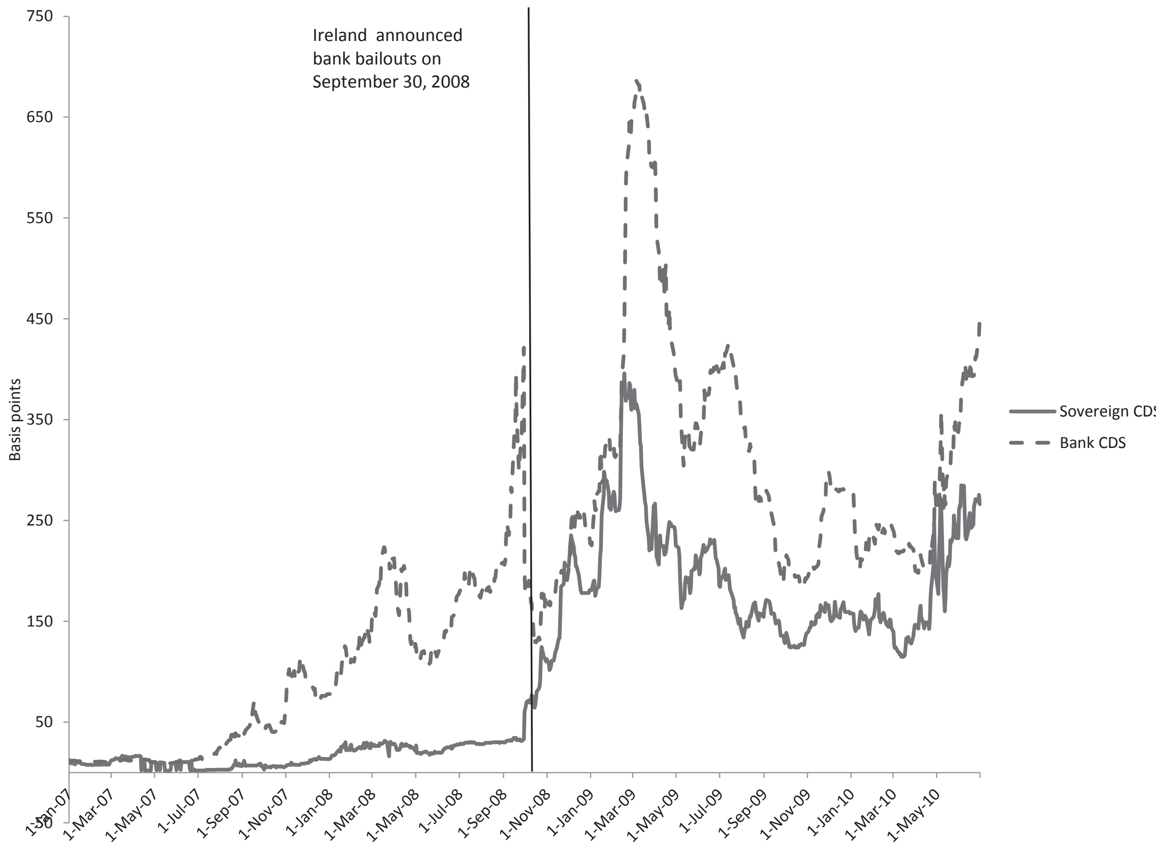


Figure 1. Sovereign CDS and Bank CDS of Ireland. This figure plots the sovereign CDS and bank CDS for Ireland for the period 3/1/2007 to 8/31/2010. The bank CDS is computed as the equal-weighted average of bank CDS for banks headquartered in Ireland (Allied Irish Bank, Anglo Irish Bank, Bank of Ireland, and Irish Life and Permanent). The data are from Datastream.

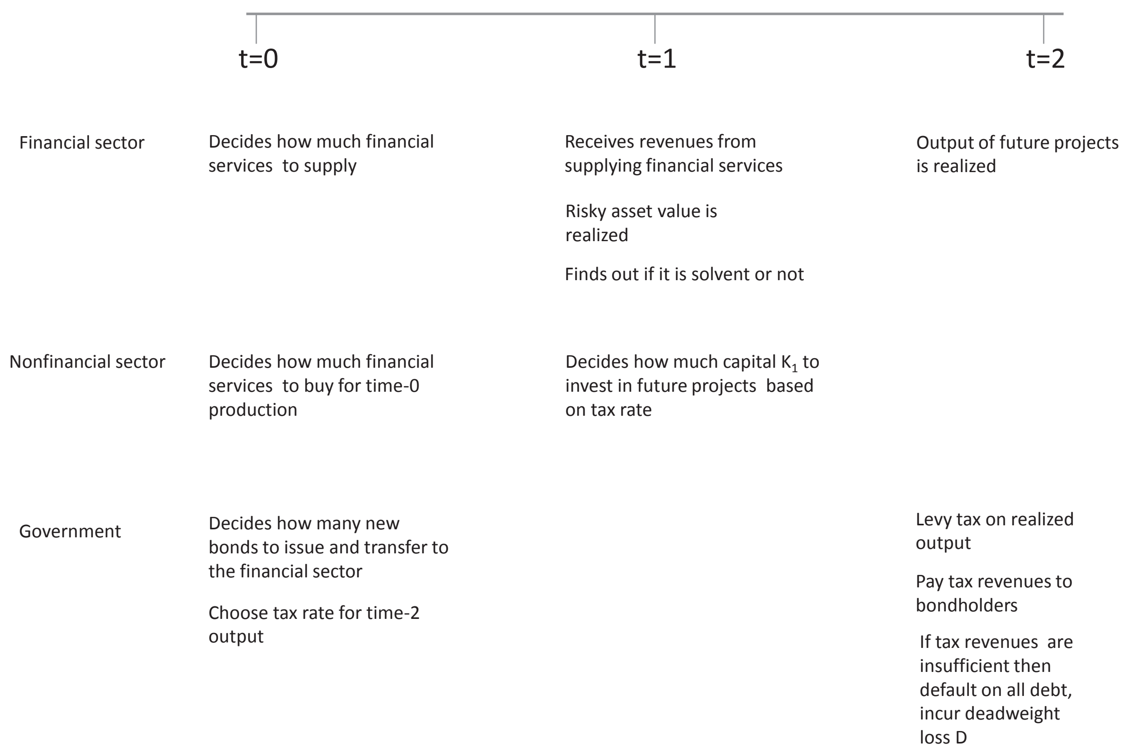
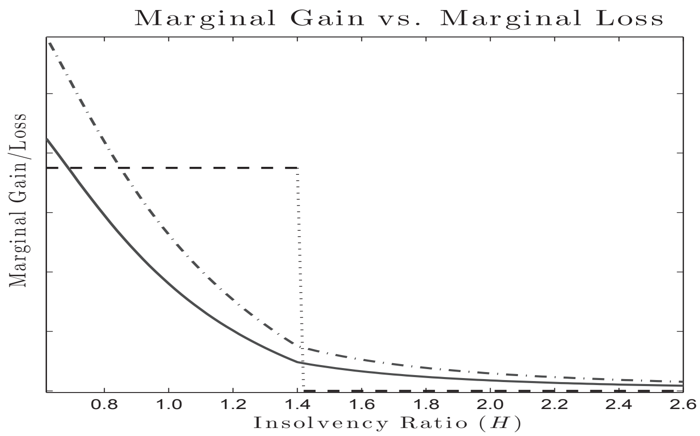


Figure 2. Timeline. This figure shows the timeline of the model.



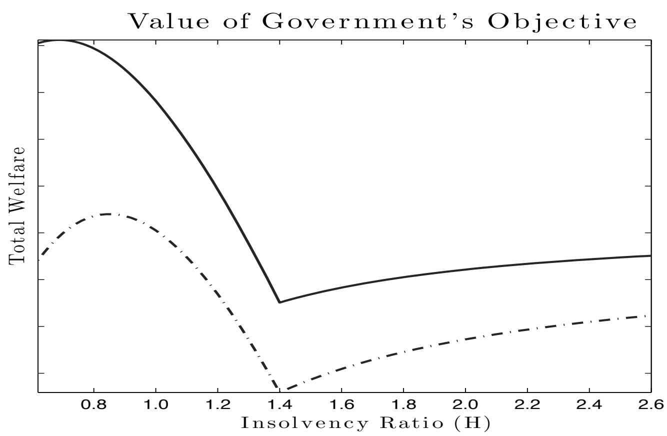


Figure 3. Marginal gain and loss of increasing the insolvency ratio. The top panel plots the marginal gain $d\mathcal{G}/dH$ (solid line and dash-dot line) of increasing the insolvency ratio H, holding constant expected tax revenues $\mathcal{T}$. The dash-dot line corresponds to a higher level of debt overhang (L_1) than the solid line. The top panel also plots the marginal loss $D\frac{dp_{def}}{dH}$ (dashed line) of increasing the insolvency ratio. The bottom panel shows the resulting values of the government's objective function, with the the solid and dash-dot lines corresponding to their counterparts in the top panel. The plots correspond to a parameterization of the model where $\tilde{R}_V \sim U[0.6, 1.4]$, $\tilde{A}_1 \sim U[0, 1]$, $L_1 = 0.5$ (solid line), $\alpha = 1$, $\vartheta = 0.3$, $\gamma = 0.2$, $\beta = 0.5$, $m = 1.3$, $D = 0.06$, $k_A = 0$, and $N_D = 0.25$.

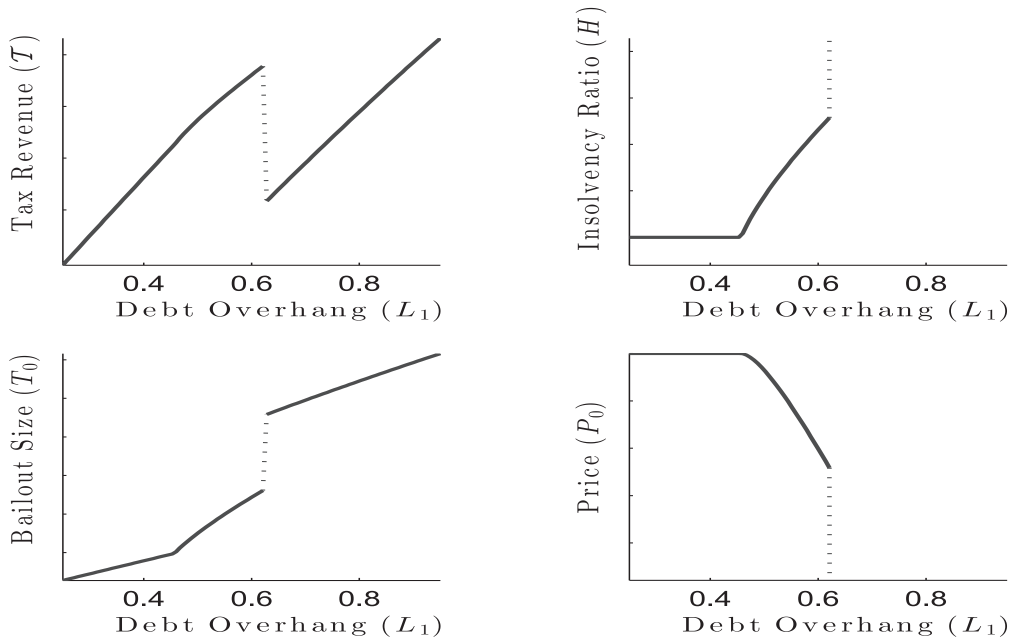


Figure 4. Comparative statics for debt overhang. This figure plots the equilibrium values for the expected tax revenue $\mathcal{T}$, the insolvency ratio H, the transfer T_0, and the sovereign bond price P_0 as the severity of debt overhang L_1 varies. The dotted line in the plots represents the point at which total default ($H \to \infty$) is optimal, resulting in a discontinuity in the plot. The model is parameterized as follows: $\tilde{R}_V \sim U[0.6, 1.4]$, $\tilde{A}_1 \sim U[0, 1]$, $\alpha = 1$, $\vartheta = 0.3$, $\gamma = 0.2$, $\beta = 0.5$, $m = 1.3$, $D = 0.06$, $k_A = 0$ and $N_D = 0.25$.

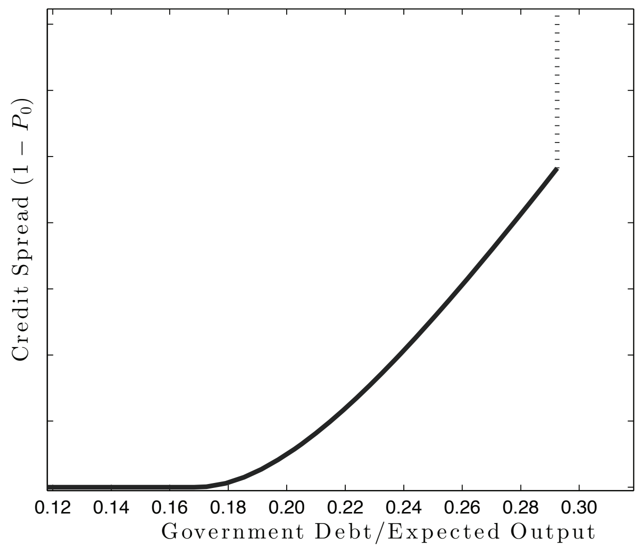


Figure 5. Sovereign credit spread and debt-to-output ratio. This figure plots the equilibrium credit spread on government bonds $(1-P_0)$ versus the ratio of total government debt to expected future output $([N_T + N_D]/V(K_1))$. The points correspond to the different values of debt overhang (L_1) shown in Figure 4. For low levels of government debt (to output), the sovereign credit spread remains zero even as government debt rises. This region corresponds to low levels of debt overhang. As debt overhang becomes more severe, the government chooses to dilute existing debt, leading to an increase in both government debt to output and the credit spread. The dotted line in the plot represents the point at which total default $(H \to \infty)$ is optimal. The model parameters are the same as in Figure 4.

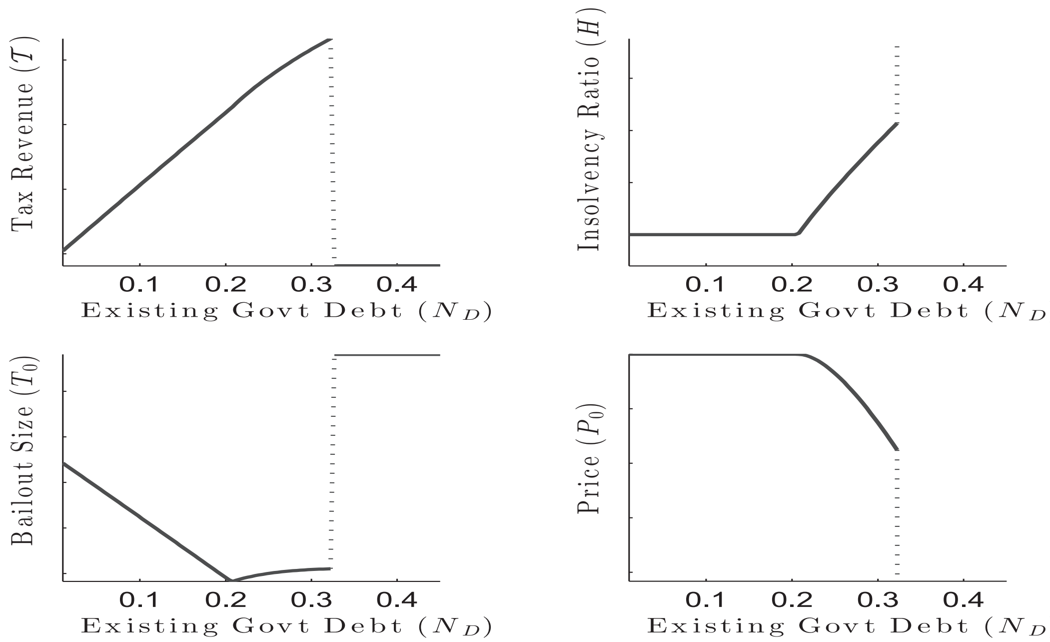


Figure 6. Comparative statics for existing government debt. This figure plots the equilibrium values for the expected tax revenue $\mathcal{T}$, the insolvency ratio H, the transfer T_0, and the sovereign bond price P_0 as the level of pre-bailout government debt N_D (bottom panel) varies. The dotted line in the plots represents the point at which total default ($H \to \infty$) is optimal, resulting in a discontinuity in the plot. The model is parameterized as follows: $\tilde{R}_V \sim U[0.6, 1.4]$, $\tilde{A}_1 \sim U[0, 1]$, $L_1 = 0.5$, $\alpha = 1$, $\vartheta = 0.3$, $\gamma = 0.2$, $\beta = 0.5$, $m = 1.3$, $D = 0.06$, and $k_A = 0$.

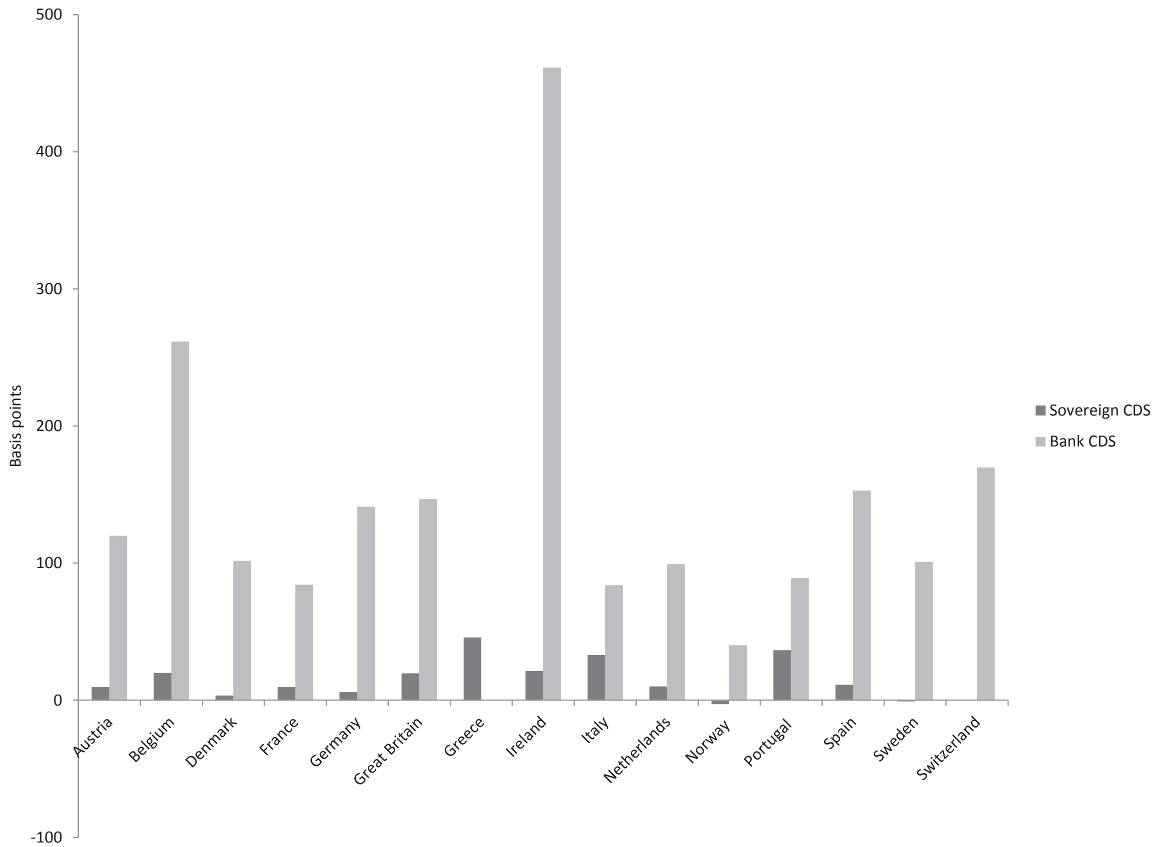


Figure 7. Change in sovereign and bank CDS before bank bailouts. This figure plots the change in average bank CDS and sovereign CDS for Eurozone countries plus Denmark, Norway, Sweden, Switzerland, and the U.K. for the period 1/1/2007 to 9/25/2008. The bank CDS is computed as the equal-weighted average of bank CDS for banks headquartered in that country. The data are from Datastream (U.K. sovereign CDS data start in November 2007; Norwegian bank CDS data start in May 2008; there are no data for Swiss sovereign CDS and Greek bank CDS during this period).

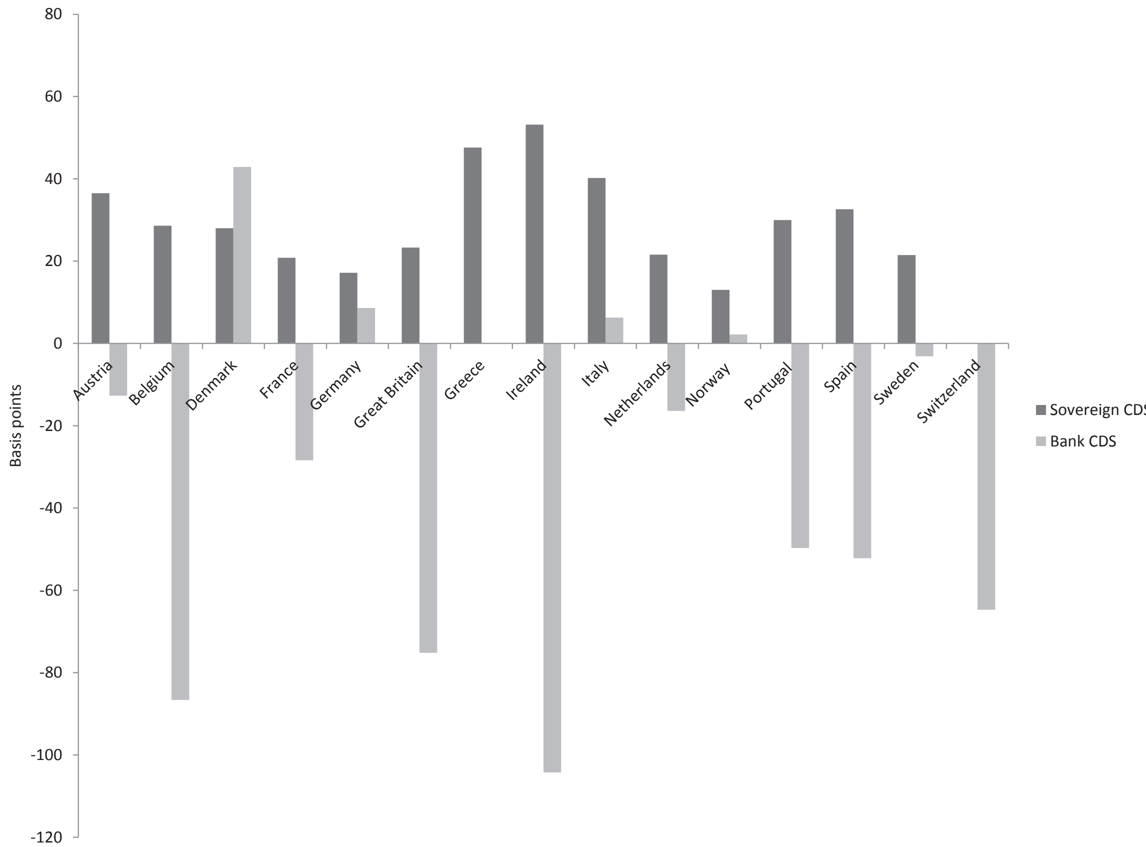


Figure 8. Change in sovereign and bank CDS during bank bailouts. This figure plots the change in average bank CDS and sovereign CDS for Eurozone countries plus Denmark, Norway, Sweden, Switzerland, and the U.K. for the period 9/26/2008 to 10/21/2008. The bank CDS is computed as the equal-weighted average of bank CDS for banks headquartered in that country. The data are from Datastream (there are no data for Swiss sovereign CDS and Greek bank CDS during this period).

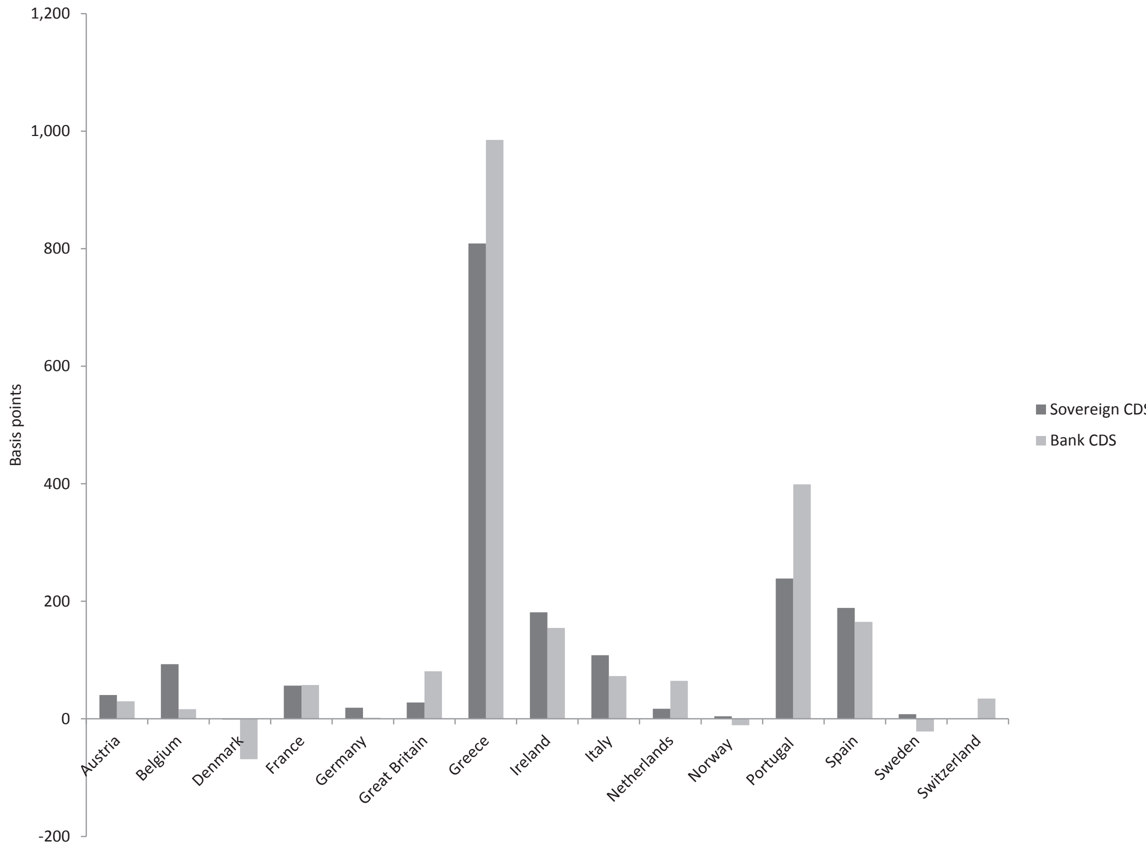


Figure 9. Change in sovereign and bank CDS after bank bailouts. This figure plots the change in average bank CDS and sovereign CDS for Eurozone countries plus Denmark, Norway, Sweden, Switzerland, and the U.K. for the period 10/22/2008 to 6/30/2010. The bank CDS is computed as the equal-weighted average of bank CDS for banks headquartered in that country. The data are from Datastream.

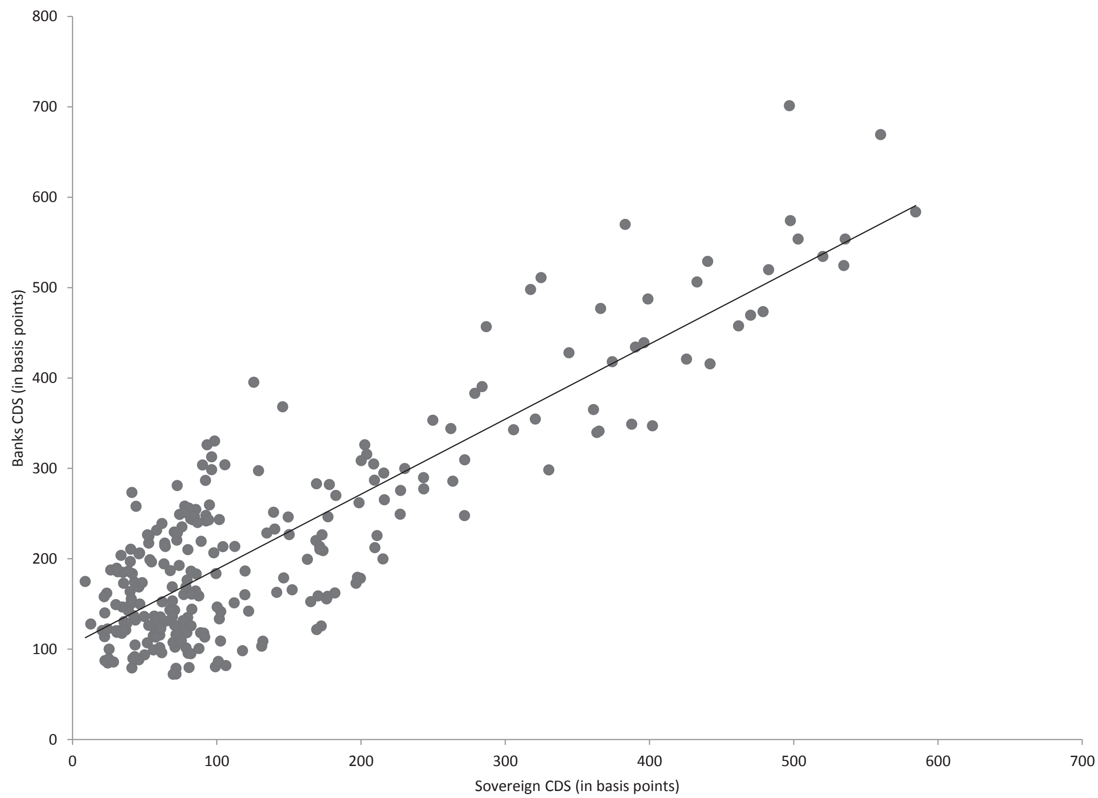


Figure 10. Comovement of sovereign and Bank CDS after bank bailouts. This figure shows a scatterplot of average bank CDS and sovereign CDS by month and country. The sample is the five largest European countries (France, Germany, Italy, Spain, and the U.K.) in the period from October 2008 to December 2012. Sovereign CDS is the average CDS by month and country. Bank CDS is the equal-weighted average bank CDS by country and month. The data are from Datastream.

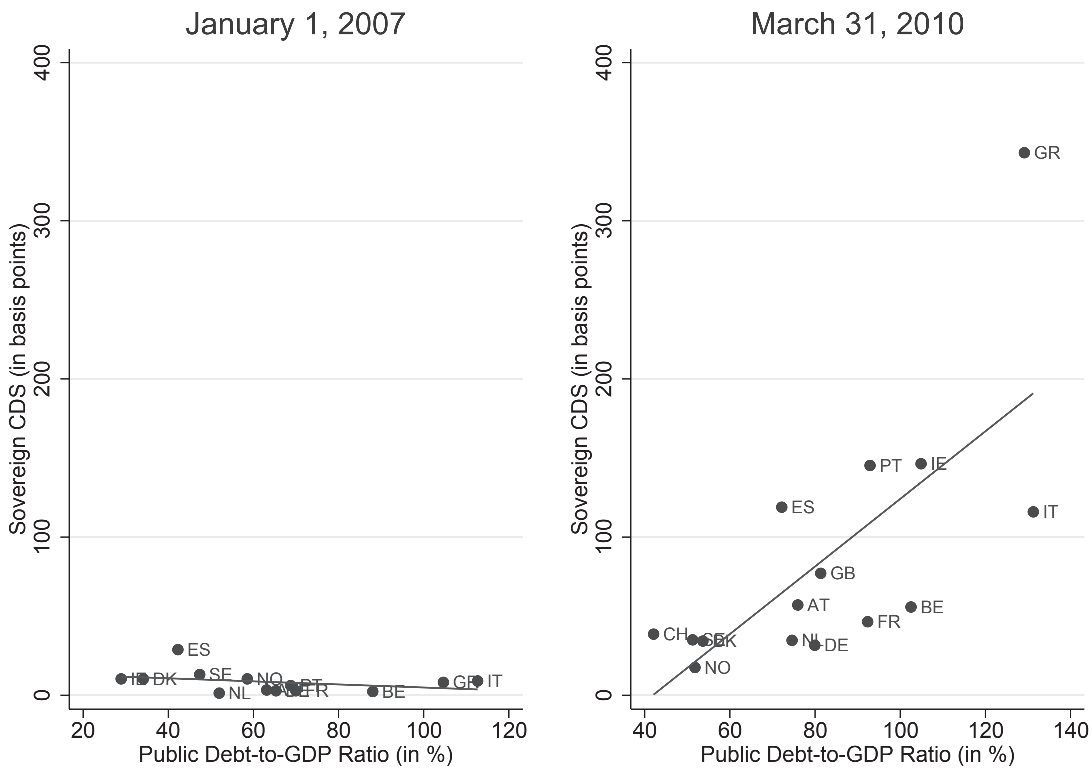


Figure 11. Correlation between sovereign CDS and public debt before and after bank bailouts. This figure shows the correlation between sovereign CDS (in basis points) and public liabilities (as a percentage of GDP) for Western European countries before and after the bank bailouts. The left figure shows no correlation before the bailouts (as of 1/1/2007). The right figure shows a strong correlation after the bank bailouts (as of 3/31/2010). The CDS data are from Datastream and the public liabilities data are from the OECD Economic Outlook database.

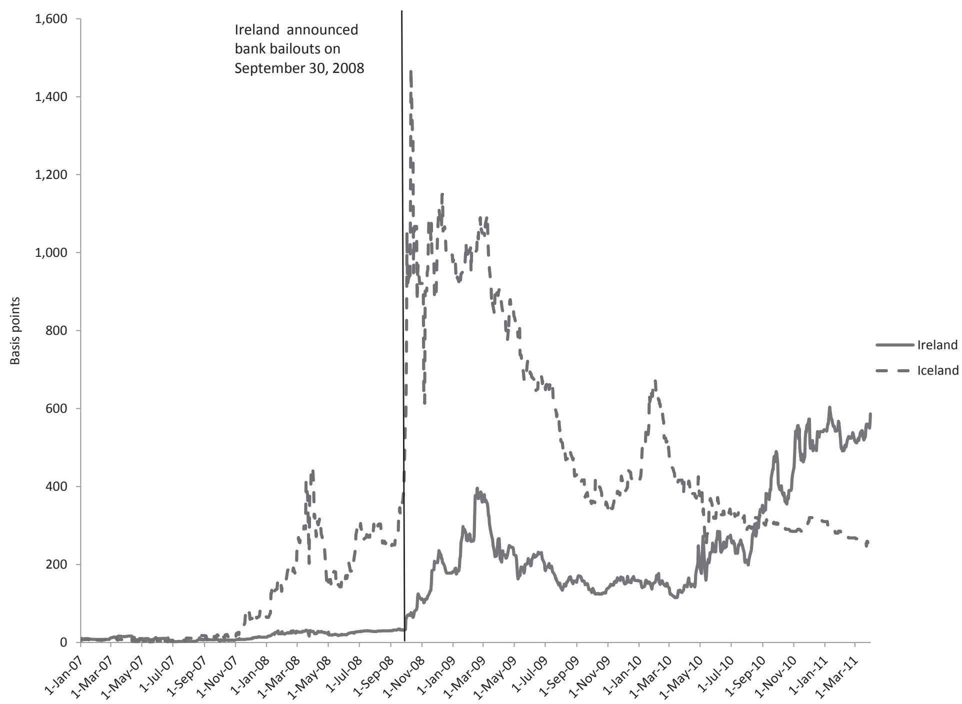


Figure 12. Sovereign CDS of Iceland and Ireland. This figure plots the sovereign CDS of Iceland and Ireland in the period from 3/1/2007 to 4/30/2011. The data are from Datastream.

Table I
Summary Statistics

This table provides summary statistics on bank characteristics and bank credit risk. The sample covers all banks with publicly traded credit default swaps (CDS) in Eurozone countries and Denmark, Norway, Sweden, Switzerland and the U.K. Panel A shows bank characteristics as of January 1, 2008. *Assets* is total bank assets, *Equity* is total bank equity, *Equity Ratio* is the ratio of equity to assets, *Short-term Debt Share* is short-term debt as a share of assets, *Long-term Debt Share* is long-term debt as a share of assets, *Deposit Share* is deposits as a share of assets, and *Credit Rating* is Moody's credit rating (AAA=1, AA+=2, etc.). Panel B shows summary statistics for the periods before, during, and after the bank bailouts at the daily level. *Bank CDS* is the average bank CDS in basis points (bp), *Sovereign CDS* is the average sovereign CDS, Δ*Log(Bank CDS)* is the daily log change in bank CDS, Δ *Log(Sovereign CDS)* is the daily log change in sovereign CDS, *Bank Equity Return* is the average equity return, and Δ *Log(Foreign Exposure CDS*) is the daily change in foreign exposure CDS. Panel C presents data on the holdings of European sovereign debt as of March 31, 2010. *Risk-Weighted Assets* are total risk-weighted assets, *European Sovereign Bond Holdings* are total holdings of European sovereign bonds, *Home Sovereign Bond Holdings* are total holdings of Home sovereign bonds, *Home Share* is home sovereign bonds as a share of total European sovereign bonds, and *Share Banking Book* is the share held in the bank's banking book.

Panel A: Cross Section (1/1/2008)

	Obs	Mean	Std.Dev	50th percentile	5th percentile	95th percentile
Assets (Euro billion)	36	498.6	462.2	333.2	58.6	1,427.80
Equity (Euro billion)	36	19.7	16.2	14.1	2.3	56.5
Equity Ratio (%)	36	4.7%	2.0%	4.2%	2.5%	10.0%
Short-term Debt Share (%)	36	12.6%	11.0%	9.8%	0.3%	33.8%
Long-term Debt Share (%)	36	33.1%	12.2%	31.5%	11.7%	57.7%
Deposit Share (%)	36	49.5%	11.1%	49.2%	30.8%	70.7%
Credit Rating	33	3.1	1.3	3	2	6

Panel B: Time Series

Pre-Bailout (1/1/2007-9/25/2008)

	Obs	Mean	Std.Dev	50th percentile	5th percentile	95th percentile
Bank CDS (bp)	11,352	64.0	58.1	54.5	7.0	166.0
Sovereign CDS (bp)	11,352	13.8	12.3	9.5	1.7	39.8
Δ Log(Bank CDS)	11,352	0.7%	20.7%	0.0%	-11.6%	11.9%
Δ Log(Sovereign CDS)	11,352	0.4%	25.2%	0.0%	-14.0%	17.6%
Bank Equity Return	11,352	-0.2%	2.7%	-0.1%	-4.2%	4.0%
Δ Log(Foreign Exposure CDS)	11,352	0.5%	23.5%	0.1%	-15.0%	17.5%

Bailout (9/26/2008-10/21/2008)						
Bank CDS (bp)	561	147.0	87.6	123.5	65.0	325.0
Sovereign CDS (bp)	561	45.7	20.6	42.5	13.7	79.2
Δ Log(Bank CDS)	561	-2.1%	15.9%	-0.4%	-26.2%	20.8%
Δ Log(Sovereign CDS)	561	5.0%	10.7%	3.3%	-9.7%	22.9%
Bank Equity Return	561	-2.4%	11.9%	-0.9%	-18.1%	11.2%
Δ Log(Foreign Exposure CDS)	561	4.6%	10.3%	3.1%	-8.0%	27.0%
Post-Bailout (10/22/2008 - 30/4/2011)						
Bank CDS (bp)	22,291	183.5	200.1	131.4	63.9	467.7
Sovereign CDS (bp)	22,291	111.7	98.8	78.6	24.4	300.6
Δ Log(Bank CDS)	22,291	0.1%	4.8%	0.0%	-6.6%	7.1%
Δ Log(Sovereign CDS)	22,291	0.1%	4.8%	0.0%	-7.3%	7.8%
Bank Equity Return	22,291	0.0%	4.4%	0.0%	-5.9%	5.8%
Δ Log(Foreign Exposure CDS)	22,291	0.1%	5.4%	0.0%	-7.1%	7.6%

Panel C: European Bank Stress Tests (3/31/2010)

	Obs	Mean	Std.Dev	50^{th} percentile	5^{th} percentile	95^{th} percentile
Risk-Weighted Assets (Euro billion)	91	126.3	179.1	63.4	3.3	493.3
European Sovereign Bond Holdings (Euro billion)	91	20.6	27.9	7.9	0.1	81.7
Home Sovereign Bond Holdings (Euro billion)	91	11.5	14.4	5.7	0.2	42.8
Home Share (%)	91	69.4%	30.0%	81.6%	18.9%	100.0%
Share Banking Book (%)	91	84.9%	19.9%	92.2%	35.4%	100.0%

Table II
Emergence of Sovereign Credit Risk

This table analyzes the risk transfer of financial sector distress onto government balance sheets. The sample covers the Eurozone countries and Denmark, Norway, Sweden, Switzerland, and the U.K. *Financial Distress* is the natural logarithm of the average bank CDS as of 9/22/2008 (prior to bailouts). *Debt/GDP Ratio* is the ratio of government liabilities to GDP as of June 2008 (collected from the OECD Economic Outlook). *Log (Sovereign CDS)* is the log of the sovereign CDS. Δ *Debt/GDP Ratio* is the increase in the public debt to GDP ratio from June 2008 to June 2010. *Bank Recapitalization Cost/GDP* is the ratio of total expenditure for bank recapitalization relative to GDP. We report robust standard errors. ***, **, and * indicates statistical significance at the 1%, 5%, and 10% level, respectively.

	Log (Sovereign CDS, Jan 08)		Log (Sovereign CDS, March 10)		Δ Debt/GDP Ratio, Years 2008-10		Bank Recapitalization Cost/GDP	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Financial $Distress_{08}$	0.101	0.153	1.033**	0.941***	23.598**	24.129**	17.793***	18.000**
	(0.249)	(0.245)	(0.385)	(0.299)	(9.742)	(10.394)	(5.718)	(6.264)
Debt/GDP $Ratio_{08}$		0.009		0.013*		-0.077		-0.030
		(0.006)		(0.007)		(0.187)		(0.106)
Observations	13	13	15	15	15	15	15	15
R^2	0.010	0.184	0.400	0.543	0.365	0.373	0.542	0.546

Table III
Change in Bank and Sovereign Credit Risk

This table shows the effect of sovereign credit risk on bank credit risk during the financial crisis. The sample covers all banks with publicly traded credit default swaps (CDS) headquartered in Eurozone countries and Denmark, Norway, Sweden, Switzerland, and the U.K. Columns (1) to (2) cover the pre-bailout period (1/1/2007 to 9/25/2008), columns (3) to (4) cover the bailout period (9/26/2008 to 10/21/2008), and columns (5) to (6) cover the post-bailout period (10/22/2008 to 04/30/2011). Δ *Log(Bank CDS)* is the daily change in the natural logarithm of bank CDS. Δ*log(Sovereign CDS)* is the daily change in the sovereign CDS of the country in which the bank is headquartered. The variable Δ *Log(Foreign Exposure CDS)* is the change in the sovereign CDS of other countries weighted by cross-country exposure. All columns include time fixed effects. Columns (2), (4), and (6) include bank fixed effects as well as interactions of bank fixed effects with the change in the CDS market index and the change in the volatility index. Standard errors are clustered at the bank level. ***, **, and * indicates statistical significance at the 1%, 5%, and 10% level, respectively.

	Δ Log(Bank CDS)					
	Pre-Bailout		Bailout		Post-Bailout	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Log(Sovereign CDS)	-0.016	-0.016	-0.580***	-0.597***	0.088***	0.074***
	(0.015)	(0.015)	(0.145)	(0.180)	(0.021)	(0.018)
Δ Log(Foreign Exposure CDS)	0.036	0.035	0.181	0.099	0.022**	0.016**
	(0.031)	(0.032)	(0.115)	(0.124)	(0.009)	(0.008)
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	N	Y	N	Y	N	Y
Bank-level betas on market return and volatility	N	Y	N	Y	N	Y
Observations	11,352	11,352	561	561	22,291	22,291
Banks	36	36	36	36	36	36
R^2	0.099	0.106	0.388	0.490	0.459	0.494

Table IV
Change in Bank and Sovereign Credit Risk (controlling for equity returns)

This table shows the effect of sovereign credit risk on bank credit risk during the financial crisis. The sample covers all banks with publicly traded credit default swaps (CDS) headquartered in Eurozone countries and Denmark, Norway, Sweden, Switzerland, and the U.K. Columns (1) to (2) cover the pre-bailout period (1/1/2007 to 9/25/2008), columns (3) to (4) cover the bailout period (9/26/2008 to 10/21/2008), and columns (5) to (6) cover the post-bailout period (10/22/2008 to 04/30/2011). Δ *Log(Bank CDS)* is the daily change in the natural logarithm of bank CDS. Δ*log(Sovereign CDS)* is the daily change in the sovereign CDS of the country in which the bank is headquartered. Δ *Log(Foreign Exposure CDS)* is the change in the sovereign CDS of other countries weighted by cross-country exposure. Δ *Equity Return* is the daily bank equity return. All columns include time fixed effects. Columns (2), (4), and (6) include bank fixed effects as well as interactions of bank fixed effects with the change in the CDS market index, the change in the volatility index, and bank equity returns. Standard errors are clustered at the bank level. ***, **, and * indicates statistical significance at the 1%, 5%, and 10% level, respectively.

	Δ Log(Bank CDS)					
	Pre-Bailout		Bailout		Post-Bailout	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Log(Sovereign CDS)	-0.016	-0.016	-0.567***	-0.538***	0.087***	0.070***
	(0.015)	(0.015)	(0.141)	(0.177)	(0.021)	(0.017)
Δ Log(Foreign Exposure CDS)	0.036	0.035	0.149	0.095	0.022*	0.015*
	(0.031)	(0.032)	(0.113)	(0.130)	(0.009)	(0.008)
Δ Equity Return	-0.135**	-0.171***	-0.177**	-0.180**	-0.026**	-0.032***
	(0.057)	(0.047)	(0.069)	(0.090)	(0.013)	(0.004)
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	N	Y	N	Y	N	Y
Bank-level betas on market return and volatility	N	Y	N	Y	N	Y
Observations	11,352	11,352	561	561	22,291	22,291
Banks	36	36	36	36	36	36
R^2	0.099	0.108	0.400	0.571	0.459	0.499

Table V
Change in Bank and Sovereign Credit Risk (using government bonds)

This table shows the effect of sovereign credit risk on bank credit risk during the financial crisis. The sample covers all banks with publicly traded credit default swaps (CDS) headquartered in Eurozone countries and Denmark, Norway, Sweden, Switzerland, and the U.K. Columns (1) to (2) cover the pre-bailout period (1/1/2007 to 9/26/2008), columns (3) to (4) cover the bailout period (9/27/2008 to 10/22/2008), and columns (5) to (6) cover the post-bailout period (10/23/2008 to 04/30/2011). Δ *Log(Bond Yield)* is the daily log change in the yield of the five-year government bond of the country in which the bank is headquartered. Δ *Log(Foreign Exposure CDS)* is the change in the sovereign CDS of other countries weighted by cross-country exposure. Δ *Equity Return* is the daily bank equity return. All columns include time fixed effects. Column (2), (4), and (6) include bank fixed effects as well as interactions of bank fixed effects with the change in the CDS market index, the change in the volatility index, and bank equity returns. Standard errors are clustered at the bank level. ***, **, and * indicates statistical significance at the 1%, 5%, and 10% level, respectively.

	Δ Log(Bank CDS)					
	Pre-Bailout		Bailout		Post-Bailout	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Log(Bond Yield)	-0.077	0.062	0.478	-0.060	0.093**	0.078***
	(0.160)	(0.175)	(0.602)	(0.877)	(0.042)	(0.025)
Δ Log(Foreign Exposure CDS)	0.036	0.035	0.321*	0.232	0.016	0.010
	(0.031)	(0.032)	(0.171)	(0.190)	(0.010)	(0.008)
Δ Equity Return	-0.144**	-0.178***	-0.187**	-0.145**	-0.026*	-0.011**
	(0.058)	(0.033)	(0.077)	(0.0.65)	(0.013)	(0.004)
Time FE	Y	Y	Y	Y	Y	Y
Bank FE	N	Y	N	Y	N	Y
Bank-level betas on market return and volatility	N	Y	N	Y	N	Y
Observations	12,077	12,077	556	556	21,666	21,666
Banks	35	35	35	35	35	35
R^2	0.0976	0.107	0.383	0.511	0.46	0.498

Table VI
Ratings Uplift

This table shows the effect of sovereign credit risk on bank credit risk during the financial crisis. The sample covers all banks with publicly traded credit default swaps (CDS) and Moody's credit ratings headquartered in Eurozone countries and Denmark, Norway, Sweden, Switzerland, and the U.K. Columns (1) to (2) cover the pre-bailout period (1/1/2007 to 9/25/2008) and columns (3) to (4) cover the post-bailout period (10/22/2008 to 04/30/2011). *Ratings Uplift* is the difference between Moody's long-term issuer credit rating and Moody's bank stand-alone financial strength credit rating. We compute this difference by converting ratings into a numerical scale (AAA=1, AA+=2, etc.). We use the Moody's conversion table to map both ratings into the same numerical scale. *Country Rating* is Moody's country credit rating converted into a numerical scale (AAA=1, AA+=2, etc.). Δ *log(Sovereign CDS)* is the daily change in the sovereign CDS of the country in which the bank is headquartered. Δ *Log(Foreign Exposure CDS*) is the change in the sovereign CDS of other countries weighted by cross-country exposure. All regressions include day fixed effects. Columns (2) and (4) include bank fixed effects. Standard errors are clustered at the bank level. ***, **, and * indicates statistical significance at the 1%, 5%, and 10% level, respectively.

	Ratings Uplift			
	Pre-Bailout		Post-Bailout	
	(1)	(2)	(3)	(4)
Country Rating	-0.083		-0.318***	
	(0.115)		(0.058)	
Log(Sovereign CDS)		-0.071		-0.429***
		(0.153)		(0.141)
Log(Foreign Exposure CDS)	-0.058	0.035	0.625**	0.489***
	(0.134)	(0.096)	(0.255)	(0.145)
Time FE	Y	Y	Y	Y
Bank FE	N	Y	N	Y
Observations	7,535	7,535	18,134	18,134
Banks	27	27	31	31
R^2	0.326	0.593	0.277	0.772

Table VII
Change in Bank and Sovereign Credit Risk (Interactions)

This table shows the effect of sovereign credit risk on bank credit risk during the financial crisis. The sample covers all banks with publicly traded credit default swaps (CDS) headquartered in Eurozone countries and Denmark, Norway, Sweden, Switzerland and the U.K.. *Public/Debt* is the public debt-to-GDP ratio. *Eurozone* is an indicator variable for countries in the Eurozone. The other variables are defined in Tables III and VI. All regressions include the main effects and all controls specified in Table IV. Standard errors are clustered at the bank level. ***, **, and * indicates statistical significance at the 1%, 5%, and 10% level, respectively.

	Δ Log(Bank CDS)							
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Δ Log(Sovereign CDS)*Country Rating	-0.015	0.032**						
	(0.033)	(0.014)						
Δ Log(Sovereign CDS)*Lagged Log(Sov CDS)			0.002	0.049***				
			(0.007)	(0.019)				
Δ Log(Sovereign CDS)*(Public Debt/GDP)					0.031	0.156**		
					(0.038)	(0.069)		
Δ Log(Sovereign CDS)*Eurozone							0.021	0.082**
							(0.015)	(0.031)
Main Effects	Y	Y	Y	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y	Y	Y	Y
Other Controls	Y	Y	Y	Y	Y	Y	Y	Y
Observations	11,352	22,291	11,352	22,291	11,352	22,291	11,352	22,291
Bank	36	36	36	36	36	36	36	36
R^2	0.108	0.499	0.108	0.500	0.108	0.500	0.108	0.499

Table VIII
Robustness

This table examines the robustness of our main results. Panel A estimates the regression from Table IV, Column 5 and 6, for the period from May 2011 to December 2012. Panel B estimates the regressions in Table IV using weekly data (instead of daily data). Panel C estimates the regressions of Table IV after adding a control for bank leverage. Standard errors are clustered at the bank-level. ***, **, and * indicates statistical significance at the 1%, 5%, and 10% level, respectively.

Panel A: Additional Time Period		
	Δ Bank CDS	
	Pre-Bailout	
	(1)	(2)
Δ Log(Sovereign CDS)	0.064***	0.051***
	(0.021)	(0.014)
Controls	Y	Y
Observations	13,121	13,121
Banks	32	32
R^2	0.397	0.471

	Panel B: Weekly Data					
	Δ Log(Bank CDS)					
	Pre-Bailout		Bailout		Post-Bailout	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Log(Sovereign CDS)	-0.003	-0.003	-0.120	-0.572	0.154***	0.146***
	(0.017)	(0.019)	(0.242)	(1.485)	(0.039)	(0.035)
Controls	Y	Y	Y	Y	Y	Y
Observations	2,407	2,407	177	177	4,567	4,567
Banks	36	36	36	36	36	36
R^2	0.288	0.337	0.326	0.832	0.532	0.585

Panel C: Controlling for leverage						
	Δ Bank CDS					
	Pre-Bailout		Bailout		Post-Bailout	
	(1)	(2)	(3)	(4)	(5)	(6)
Δ Sovereign CDS	-0.016	-0.016	-0.565***	-0.539***	0.085**	0.070***
	(0.015)	(0.016)	(0.136)	(0.176)	(0.021)	(0.017)
Δ Leverage	-1.832**	0.034	-2.366	30.592	-0.812***	-0.093
	(0.734)	(0.810)	(4.171)	(43.448)	(0.253)	(0.316)
Controls	Y	Y	Y	Y	Y	Y
Observations	11,352	11,352	561	561	22,291	22,291
Banks	36	36	36	36	36	36
R^2	0.099	0.108	0.402	0.574	0.461	0.499