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Who Borrows from the Lender of Last Resort?

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ABSTRACT

We analyze lender of last resort (LOLR) lending during the European sovereign debt crisis. Using a novel data set on all central bank lending and collateral, we show that weakly capitalized banks took out more LOLR loans and used riskier collateral than strongly capitalized banks. We also find that weakly capitalized banks used LOLR loans to buy risky assets such as distressed sovereign debt. This resulted in a reallocation of risky assets from strongly to weakly capitalized banks. Our findings cannot be explained by classical LOLR theory. Rather, they point to risk taking by banks, both independently and with the encouragement of governments, and highlight the benefit of unifying LOLR lending and bank supervision.

LENDER OF LAST RESORT (LOLR) actions represent one of the most dramatic interventions by governments in financial markets, particularly during financial crises. Such interventions have long been an important part of economic policy, even providing the motivation behind the establishment of central banks such as the Federal Reserve. Given their central role in policy as well as their

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magnitude, it is important to understand how these interventions impact the financial system and, ultimately, the economy.

In this paper, we ask which banks borrow from the LOLR and why they do so. The answers to these questions are important for understanding the costs and benefits of LOLR interventions. If banks borrow from the LOLR to stop a banking panic, then LOLR interventions will help alleviate a contraction in bank lending (i.e., "credit crunch") and reduce the impact of financial crises on the real economy. This is the scenario envisaged by classical LOLR theory. However, if banks borrow from the LOLR for other reasons, for instance, to increase risk-taking or in response to regulatory pressure, then LOLR interventions will do little to mitigate financial crises and may harm financial stability.

We analyze the take-up of LOLR lending during the European sovereign debt crisis. The European crisis is an almost ideal setting for our study because LOLR lending was a central tool of the European Central Bank's (ECB) strategy for addressing the sovereign debt crisis, and the intervention was arguably the largest and longest lasting LOLR program ever conducted. Moreover, the ECB's implementation largely followed the recommendations of LOLR theory. That is, the ECB provided unlimited lending to a large set of banks, but only against collateral that was good prior to the crisis.[1]

We use a novel, proprietary data set that contains weekly bank-level records of all banks' ECB borrowing for the period August 2007 to December 2011, as well as precise, security-level information on the collateral each bank pledges. We match these data to publicly available data on bank characteristics, bank asset holdings, and security characteristics. The sample covers the universe of banks in Europe.

Our analysis yields three main findings. First, following the onset of the European sovereign debt crisis in May 2010, weakly capitalized banks took out more LOLR loans and pledged riskier collateral against their loans than did strongly capitalized banks. Using banks' precrisis credit ratings as a measure of bank capital, we find that a one-standard-deviation decrease in a bank's credit rating leads to a 11.2 percentage point increase in the likelihood of LOLR borrowing and a 14.6% increase in the amount of LOLR borrowing after May 2010.[2] It also leads to a reduction in a bank's value-weighted average collateral rating of 0.3 notches and a 36 bps increase in its pledging of distressed-sovereign debt (Cyprus, Greece, Italy, Ireland, Malta, Portugal, and Spain) relative to bank assets.[3] The results are economically significant, accounting

[1] Our focus is on LOLR lending undertaken as part of the ECB's normal credit operations, which represents the bulk of its lending during the sample period. The ECB has referred to this lending as the "monetary approach" to LOLR (Praet (2016)). We do not analyze lending under the Emergency Liquidity Assistance program, which focused on banks that had insufficient eligible collateral and was administered by national central banks.

[2] We use precrisis credit ratings (August 2007) to avoid capturing the direct impact of the crisis on ratings.

[3] Throughout the paper, we define distressed countries as those that were downgraded below AA after the onset of the sovereign debt crisis, namely, Cyprus, Greece, Ireland, Italy, Malta, Portugal, and Spain. We refer to their debt as distressed-sovereign debt.

for 23%, 18%, 22%, and 21% of a standard deviation of the respective outcome measures.

Second, weakly capitalized banks borrowed at least in part to buy *risky* assets such as distressed-sovereign debt. Using panel data from the European bank stress tests, we analyze whether banks that pledged more distressed-sovereign debt with the LOLR also actively purchased this debt. Indeed, we find that a 10% increase in a bank's pledging of distressed-sovereign debt is associated with a 4.5% increase in its holdings. This relationship is driven entirely by weakly capitalized banks and is stronger for distressed-sovereign debt originated in the bank's home country.

Third, we show that, in aggregate, risky assets pledged with the LOLR moved from strongly to weakly capitalized banks. Following the start of the European sovereign debt crisis, about a third of total distressed-sovereign debt pledged with the LOLR moved from strongly to weakly capitalized banks. Similarly, we find that for the pool of all distressed-country-originated debt, which includes mortgage-backed securities, covered bonds, and other debt instruments, approximately one quarter of the total moved from strongly to weakly capitalized banks.

Taken together, our findings do not support classical LOLR theory. Classical LOLR theory predicts that LOLR lending stops bank runs by allowing banks to continue financing their existing assets. This removes the need for banks to sell assets at fire-sale discounts and enables them to continue lending to firms and households, averting a credit crunch. Hence, classical LOLR theory says that banks borrow because they suffer runs, not necessarily because they have low capital, which is what we find. Indeed, our results hold when we exclude the likely sources of runs, when we limit attention to banks located in the nondistressed countries (which did not suffer runs), when we control for country-specific factors (which were the likely source of runs), and when we measure capital before the start of the financial crisis (to avoid runs causing low capital). Moreover, whereas classical LOLR theory says that banks use LOLR borrowing to finance existing asset holdings, we find that weakly capitalized banks used LOLR funding to actively buy risky assets.

Our findings thus point toward alternative LOLR theories that emphasize banks' incentives to increase risk-taking. Specifically, weakly capitalized banks have an incentive to borrow from the LOLR because they are close to default and hence their equity holders do not internalize losses conditional on default. Consequently, they want to buy risky assets, particularly those whose downside is realized when the bank defaults. This theory explains the relationship we find between a bank's capital, a proxy for its proximity to default, and its LOLR borrowing and collateral risk. It further explains why weakly capitalized banks invested in distressed-sovereign debt.

Banks may also borrow from the LOLR because of political economy pressures. In particular, regulators and politicians in the distressed countries may have encouraged banks to buy their home country's sovereign debt to help fund their governments. Weakly capitalized banks are the most susceptible to such pressure because they are the most reliant on regulatory approval. This can explain why we find that the effect of bank capital on LOLR borrowing is larger in the distressed countries and stronger for purchases of home country distressed-sovereign debt.

We find no evidence that differences in banks' valuations of risky assets can explain our results, as our findings are remarkably robust to controlling for proxies of banks' business models, their level of "optimism," and their expertise in certain asset classes. Given that all our results hold for distressed-sovereign debt, a type of asset not usually associated with particular banking expertise (in contrast to certain types of firm or household lending), it is unlikely that differences in banks' expertise can explain our findings.

Our findings have undesirable implications from the viewpoint of classical LOLR theory, including an increase in the risk of a systemic crisis due to a run on weak banks, and an increase in the cost of resolving weak banks should they fail.[4] However, from the viewpoint of distressed governments, or even the Euro area more generally, this risk may be viewed as the necessary cost of avoiding an even more costly sovereign default and the breakup of the Eurozone. Therefore, our results do not say that LOLR lending reduces social welfare.

Our findings imply that LOLR interventions need to address banks' risk-taking incentives and the resulting reallocation of assets within the banking system. A direct way of reducing risk-taking incentives is by restructuring weakly capitalized banks. However, the ECB faced institutional impediments to restructuring banks because this is linked to bank supervision, which was carried out by national bank regulators. Our analysis therefore suggests that it is beneficial to unify bank supervision and LOLR lending in a single entity.

Our work relates to the literature on LOLR lending, which goes back to the seminal contributions of Thornton (1802) and Bagehot (1873), who were the first to formulate the role of central banks in the provision of LOLR financing during financial crises. Friedman and Schwartz (1963) argued that an LOLR could have prevented the series of bank failures during the Great Depression that resulted in an unprecedented decline in the stock of money. Meltzer (1986) argues similarly, and suggests that the worst financial panics arose because central banks did not follow Bagehotian principles. Bernanke (2013) argues that LOLR lending by the Federal Reserve during the 2008 financial crisis prevented a credit crunch. We contribute to this literature by analyzing LOLR lending in a setting that closely follows Bagehotian principles.

Our work also relates to the literature on the interaction between bank risk-taking and regulation. It is widely recognized that government guarantees,

[4] The failure of Cyprus's banking system in March 2013 provides an example of such losses. At the time of failure, the value of bank assets was so low that losses on deposits above €100,000 were estimated to be at least 60%. A forensic accountant's report on Cyprus's largest bank, Bank of Cyprus, shows that banks invested in risky assets with ECB funding prior to default. Specifically, large losses arose because "Bank of Cyprus was speculating on Greek debt with money borrowed from the ECB" (*The New York Times*, "Cyprus bailout revisited," May 7, 2013). Cyprus's second-largest bank, Cyprus Popular Bank, engaged in a similar strategy of buying Greek debt with ECB money prior to its default (Reuters, "Insight: Laiki—Countdown to catastrophe," April 2, 2013).

including deposit insurance and LOLR lending, create the need for bank regulation (Dewatripoint and Tirole (1994), Hellmann, Murdock, and Stiglitz (2000)). Regulation sometimes fails because regulators are reluctant to close insolvent banks ("regulatory forbearance"), which can lead to gambling for resurrection (e.g., Savings and Loan crisis in the United States, Kane (1989)), zombie lending (e.g., Japan's lost decade, Caballero, Hoshi, and Kashyap (2008)), or excessive risk-taking (e.g., U.S. 2008 financial crisis, French et al. (2010)).

Our paper also connects to the growing literature on the European sovereign debt crisis.[5] Recent work analyzes the effect of the crisis on banks' credit risk, banks' lending, and the real economy (e.g., Acharya, Drechsler, and Schnabl (2014), Becker and Ivashina (2014), Boissel et al. (2014), Chernenko and Sunderam (2014), Farhi and Tirole (2014), Ivashina, Scharfstein, and Stein (2015), Uhlig (2013)). Other work examines ECB policies such as sovereign debt purchases, optimal collateral standards, and swap lines with other central banks (e.g., Obstfeld, Shambaugh, and Taylor (2009), Eser and Schwaab (2013), Krishnamurthy, Nagel, and Vissing-Jorgenson (2013), Cassola and Koulischer (2014)). Our paper focuses on the role of LOLR lending during the European sovereign debt crisis.

The paper is structured as follows. Section I describes the institutional background and provides summary statistics. Section II discusses LOLR theories. Section III presents our empirical strategy and reports the results. Section IV analyzes the aggregate impact of our findings. Section V concludes.

I. Setting and Data

A. Institutional Background

We first describe how the ECB lends to banks during regular times, we then explain how the ECB acted as LOLR during the European financial crisis. The ECB provides loans to banks via a lending arrangement that mirrors private repurchase agreements (repos). In a repo, the lender provides funds to the borrower against collateral. The amount of funding provided equals the market price of the collateral multiplied by one minus the "haircut." For example, if a \$100 market value bond is used as collateral and the haircut is 15%, then the borrower can borrow up to \$85.

The haircut depends on the type of collateral used. Collateral must satisfy eligibility criteria regarding the type of assets, credit standards, place of issue, type of issuer, currency, asset marketability, and other characteristics. Broadly speaking, ECB-eligible collateral is Euro-denominated investment-grade debt, such as sovereign debt, mortgage-backed bonds, covered bonds, bank bonds,

[5] This work builds on earlier research on the European currency union and the optimal conduct of monetary policy (De Grauwe (2000)), its interaction with fiscal policy (Sims (1999), Farhi and Werning (2013)), financial regulation (Goodhart and Schoenmaker (1995), Enriques and Volpin (2007), Kalemli-Ozcan, Papaioannou, and Peydro, (2012)), and the role of the LOLR (Goodhart and Albert (2000), De Grauwe (2012), Buiter and Rahbari (2012)).

and corporate bonds. Riskier collateral is penalized with a higher haircut, as collateral is meant to protect the lender from default risk on the loan. However, as in private markets, the haircut on an ECB loan does *not* depend on the specific borrowing bank.[6]

All collateral pledged with the ECB is marked to market. The ECB generally uses publicly available price data to value assets. If there is no price data, the ECB uses proprietary models to value assets. If the total value of a bank's collateral pledged with the ECB falls below its amount of borrowing, the bank must pledge additional collateral or reduce borrowing. If the bank cannot provide additional collateral, then it is considered to be in default. The ECB then has the right to seize and liquidate the collateral.

The ECB lends to banks with full recourse. Hence, if a bank defaults and the liquidation value of collateral is not sufficient to cover the outstanding loan, then the ECB becomes an unsecured creditor in general bankruptcy. The ECB has the same priority in bankruptcy as other unsecured creditors. The ECB may therefore suffer losses if the liquidation value of collateral is too low and the remaining bank assets are insufficient to pay off the total loan amount.

The ECB stands ready to provide repos to all European banks against a broad range of collateral if they satisfy eligibility criteria regarding their reserves within the Eurosystem and their financial soundness. Prior to 2013, financial soundness was determined by the national bank supervisor in the country in which the bank is headquartered.[7]

Prior to the financial crisis, the ECB had a cap on total bank lending and distributed funds via auctions as part of its regular monetary policy implementation.[8] However, after the Lehman bankruptcy in September 2008, the ECB decided to provide unlimited funding to banks. This means that banks could borrow an unlimited amount at the given interest rate (i.e., they faced a completely elastic supply curve) as long as they provided sufficient collateral. The interest rate (sometimes referred to as the policy rate) was the same for all loans. The change in the ECB's policy was intended to increase bank funding during times of crisis and marked the start of unlimited LOLR lending in the Eurozone area.[9]

As part of LOLR lending, the ECB also changed its haircut policy. Before September 2008, the haircuts on ECB loans were similar to private-market haircuts on repo loans. However, after September 2008 the ECB started offering haircuts that were below private-market haircuts on risky securities, such as asset-backed securities, mortgage-backed securities, covered bonds, and distressed-sovereign debt. In contrast, the ECB's haircuts on safe securities were equal to, or slightly larger than, market haircuts. These differences

[6] The ECB publishes the haircut schedule on its website. The schedule is available at https://www.ecb.europa.eu/paym/coll/html/index.en.html.

[7] The ECB maintains a list of eligible banks on its website. The list is available at https://www.ecb.europa.eu/stats/money/mfi/general/html/elegass.en.html.

[8] For an analysis of the auction system, see Cassola, Hortacsu, and Kastl (2013).

[9] The ECB refers to unlimited lending as full allotment under its regular credit operations. This lending represents the fulfillment of its LOLR role (Constancio (2014) and Praet (2016)).

between the haircuts required by the ECB and the private market reflected the fact that the ECB's haircuts varied less with asset quality than did those in the private market.

For example, at the end of 2010 the ECB's haircut on risky five-year Portuguese government bonds was 4%, while the haircut applied to these bonds by LCH Clearnet, an important private repo exchange, was 10%. In contrast, the ECB's haircut on safe five-year German government bonds was 3%, while LCH Clearnet's haircut was 2%.[10]

We refer to the difference between a security's ECB haircut and its private-market haircut as its "haircut subsidy." To summarize, risky securities carried high haircut subsidies, while safe assets carried little or no subsidy.[11]

The presence of haircut subsidies creates an incentive for banks to pledge risky assets with the ECB. A stark example of such pledging is the case of Greek sovereign bonds. Panel A of Figure 1 plots the average haircut charged by the ECB on a representative Greek bond over the sample period, together with a plot of the credit default swap (CDS) rate on Greek government debt. The plot shows that the average ECB haircut was below 8% throughout the sample period, even as the Greek CDS rate increased dramatically. In February 2010, the main repo exchange announced that it stopped accepting Greek sovereign bonds as collateral. This means that the private-market haircut on Greek sovereign bonds was 100%, which implied a haircut subsidy of 92%. Panel B shows that, consequently, Greek sovereign bond collateral largely migrated from private markets to the ECB.[12]

In contrast to its below-market haircuts, the ECB charged a *higher* interest rate than the one charged on private repo loans. This higher interest rate represented a "penalty" for borrowing from the LOLR and imposed a cost on banks for taking up haircut subsidies. For example, the interest rate on private market repos secured with Italian sovereign debt was the same as the ECB rate until October 2008. However, after the start of LOLR lending, the ECB's rate exceeded the private market repo rate, with the spread between

[10] The ECB also modified the collateral framework to widen the pool of risky assets eligible as collateral. It is generally understood that these changes only affected a small share of the potential collateral pool. To the extent that the changes were significant for some individual banks, they increased the set of risky assets with below-market haircuts. Eberl and Weber (2014) provide an overview of collateral changes from 2001 to 2013.

[11] The ECB maintained that the valuations of risky assets were in line with those of other market participants. Some outside observers raised concerns that ECB valuations of illiquid assets were too high (*Der Spiegel*, "Europe's central bad bank: Junk bonds weigh heavy on ECB," June 6, 2011). To the extent that ECB prices exceed market valuations, effective haircut subsidies were even larger.

[12] In the event of a sovereign default, if the ECB's collateral is insufficient to pay its loans, then its residual claim is parri passu with other bank creditors. However, some observers have argued that the ECB may claim superseniority ex post (i.e., after a sovereign default occurs). Although the ECB has explicitly stated that it will not do so, one cannot completely rule out this possibility. If the ECB does claim superseniority, the counterparty risk of ECB loans will be partially borne by other creditors. This does not affect the size of the ECB's haircut subsidy because the size of the subsidy depends on the expected losses borne by creditors, not how these losses are divided among them.

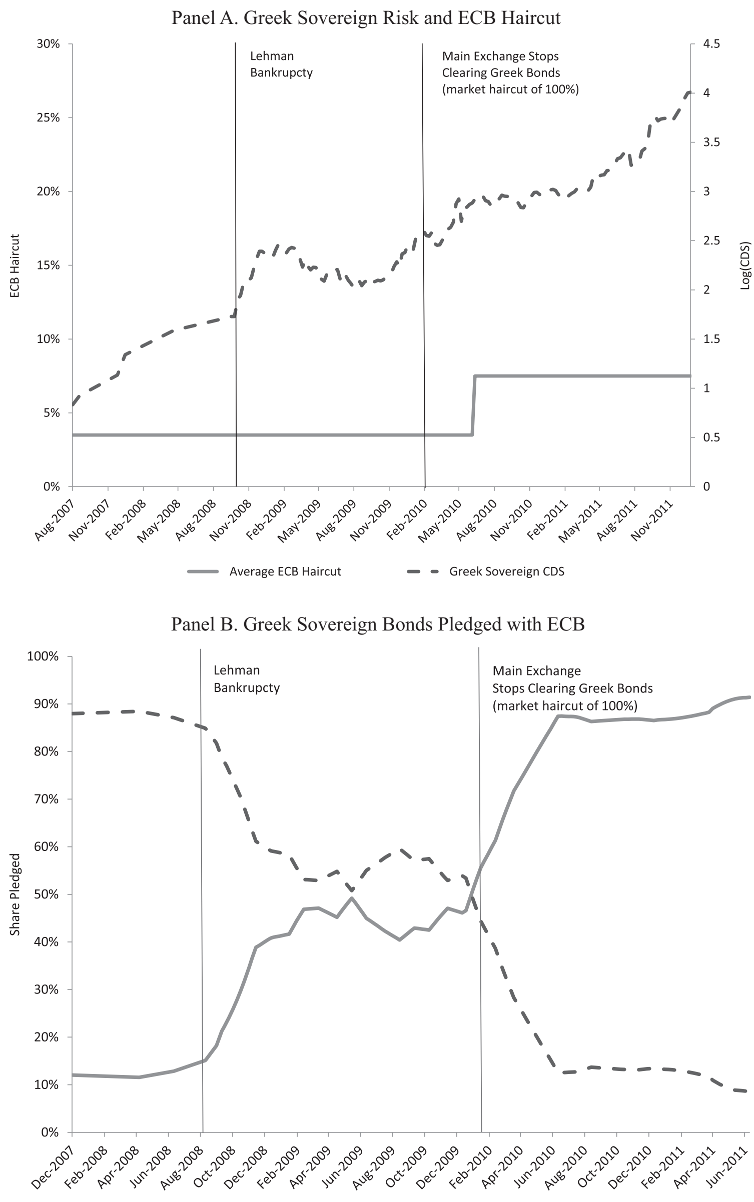


Figure 1. Greek sovereign debt as ECB collateral. Panel A of the figure plots the time series of the natural logarithm of the Greek CDS rate (dashed line, right axis) and the average ECB haircut on a representative Greek sovereign bond pledged with the ECB in percentage points (solid line, left axis). Panel B shows the time series of the share of total market value of Greek sovereign bonds pledged as collateral in private markets (dashed line) versus the share pledged with the ECB (solid line). Private market collateral data are collected from repo market surveys that are conducted every six months. Greek sovereign debt pledged is estimated using total ECB borrowing by Greek banks assuming that 50% of borrowing is collateralized with Greek sovereign debt. Data on Greek bank borrowing is taken from the Bruegel database developed in Merler and Pisani-Ferry (2012).

the two rates averaging 49 bps over the period October 2008 to December 2011.[13]

The combination of below-market collateral requirements (haircut subsidies) and an above-market interest rate adheres to the prescriptions of LOLR theory. In particular, it follows Bagehot's famous dictum that "to avert crisis, central banks should lend early and freely (i.e., without limit) to solvent firms, against good collateral, at high rates" (Tucker (2009)). Good collateral is understood to be "everything that in common times is a good banking security." It also follows the LOLR principle that lending must be subsidized in some way relative to private markets to affect bank lending. This is precisely the role of haircut subsidies. In the absence of any subsidy, LOLR lending would offer no benefit over the private market, banks would not borrow from the LOLR, and the intervention would have no effect.

B. Data and Summary Statistics

We use bank-level data on ECB borrowing and security-level data on collateral pledged with the ECB. These data are collected by the ECB in the process of their lending operations. The data set covers the period from August 2007 to December 2011. From October 2008 to December 2011 the data set contains the full set of weekly observations. Prior to that time the data are recorded intermittently. We do not have earlier data because these data were not collected at the aggregate ECB level prior to 2007. To the best of our knowledge, this is the first paper to use such detailed bank- and security-level data on an LOLR intervention.[14]

The ECB assigns each bank a unique identifier and consolidates all data at the bank headquarters level. The data set reports total ECB borrowing by type of operation.[15] The data set further provides security-level information by bank on all collateral pledged with the ECB. Collateral is identified through a unique ISIN code, and the entries record nominal values as well as pre- and post-haircut market values. The post-haircut market value of a bank's collateral gives its total borrowing capacity with the ECB.

[13] The date on private market repo rates is available at http://www.repofundsrate.com/. The data is collected from banks participating in the private repo market and may not apply to banks that do not participate.

[14] The data are not shared with the public and can only be accessed by researchers who are physically at ECB headquarters in Frankfurt, Germany.

[15] The ECB lends through its main refinancing operations (MRO) and its longer-term refinancing operations (LTRO). MRO lending is offered at a weekly frequency, normally with a maturity of one week. LTRO lending is offered every other week, normally with maturities of one to three months. During our sample period, the ECB also once offered an LTRO with a maturity of one year (July 2009 to June 2010). In addition, the ECB engaged in fine-tuning operations, which were quantitatively very small. The ECB also offered lending under the marginal lending facility, which charged a high interest and had a negligible take-up (European Central Bank (2011)). The complete history of open market operations is available at http://www.ecb.int/mopo/implement/omo/html/index.en.html.

We match the ECB data to four other publicly available data sets. First, we use the ECB's bank credit ratings data to identify all banks that are headquartered in Europe and have at least one rating by the main rating agencies (Moody's, S&P, Fitch). We define a bank's credit rating as the median of its long-term unsecured credit ratings as of August 2007. We assign a numerical value to each rating: 1 for AAA, 2 for AA+, and so on. The resulting data set contains 284 banks with at least one credit rating as of August 2007. These banks represent more than 95% of bank assets in the Euro area.

Second, we match all banks to the banking database Bankscope. Bankscope provides data on bank characteristics, such as as total assets, equity, Tier-1 ratio, total loans, and deposit funding. We cross-check these characteristics with those provided in the SNL European Financials data set (which has a smaller coverage) and find an almost perfect overlap for the banks that are reported in both data sets.

Third, we use Datastream and the SNL European Financials to identify all publicly listed banks and banks with CDS rates. We then match the ECB data to equity returns and CDS rates from Datastream. Our match yields 58 banks with equity returns and 29 banks with CDS rates.

Fourth, we collect data from the three rounds of European bank stress tests conducted in March 2010, December 2010, and September 2011. These data are available on the websites of national bank supervisors. We use these data to construct a balanced panel of bank-level holdings of distressed-country sovereign debt. We match these data to our main data set, which yields 54 banks.

We conduct several tests to ensure the accuracy of our data set. First, we aggregate total borrowing by week. We match our data with publicly available information on weekly aggregate ECB borrowing and find a perfect overlap. Second, we aggregate collateral by loan type and year. We check accuracy using information from ECB Annual Financial Statements and find an almost perfect overlap. Third, we aggregate total borrowing by country and check the releases on total borrowing by national central banks. Again, we find a perfect overlap. We thus find consistent evidence that our data are highly accurate and complete.[16]

Panel A of Figure 2 plots total lending by the ECB in the period from October 2008 to December 2011. In October 2008, total borrowing from the ECB was about €736 billion. In July 2009, the ECB offered one-year loans leading to additional borrowing of €61 billion. Total borrowing peaked at €880 billion prior to the expiration of the one-year loans in June 2010. After July 2010, total borrowing dropped by €253 billion and continued to decline gradually. This trend reversed in June 2011, as ECB borrowing increased again. Panel B

[16] Our data do not include lending under the Emergency Liquidity Assistance (ELA) program. The ELA is administered by national central banks and there is almost no public information on lending under the ELA. However, anecdotal reports in the financial press indicate that ELA is restricted to banks in serious financial distress, with most of the lending directed to Cypriot, Greek, and Irish banks.

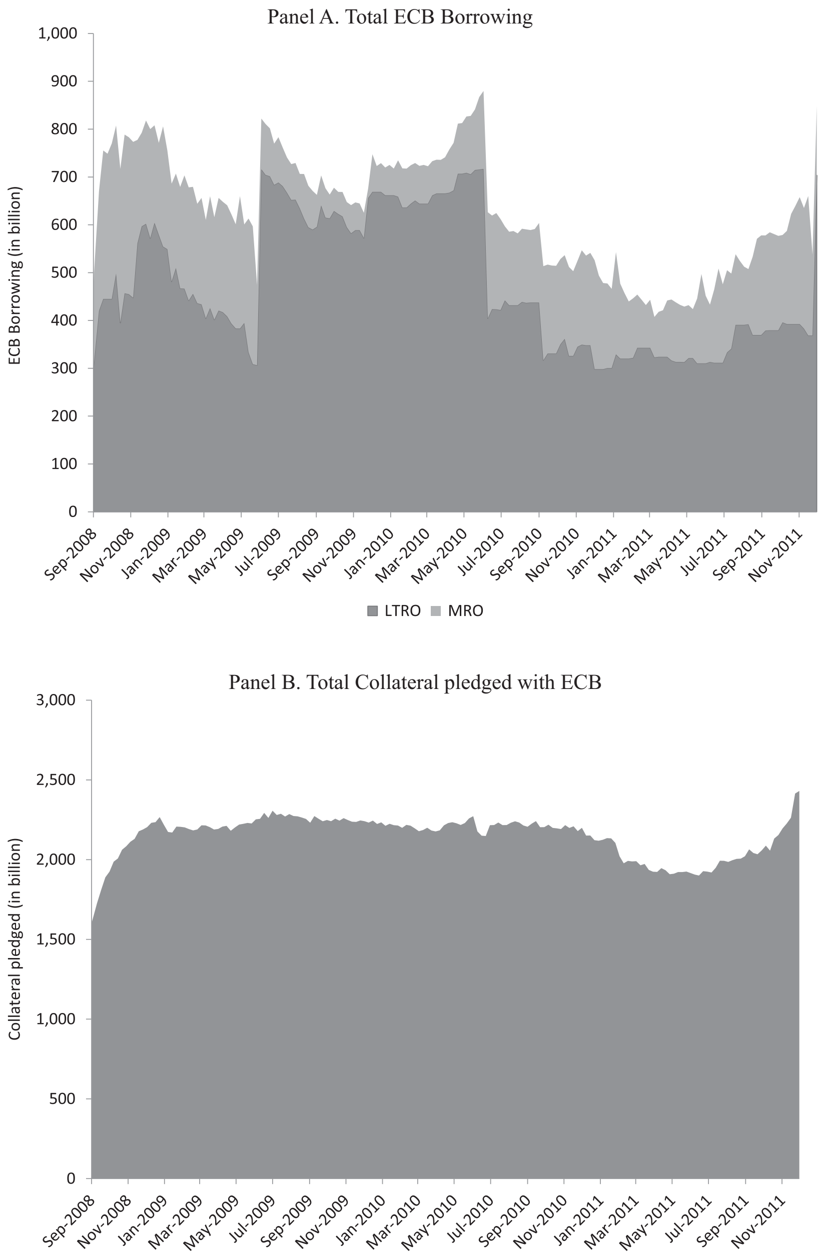


Figure 2. ECB borrowing and collateral. Panel A of the figure plots the time series of borrowing from the ECB under long-term refinancing operations (LTRO) and main refinancing operations (MRO) in €billion. Panel B plots the time series of total collateral (market value) pledged to the ECB in €billion.

Table I

Summary Statistics

This table provides bank-level summary statistics from August 2007 to December 2011. The sample comprises all rated European banks. The variables are for the entire sample except CDS rates and market leverage, which are only available for banks with a traded CDS and publicly listed banks, respectively. Variable definitions and data sources are described in the Appendix.

	All (284 Banks)		Nondistressed Countries (228 Banks)		Distressed Countries (56 Banks)	
	Mean (1)	Std. Dev. (2)	Mean (3)	Std. Dev. (4)	Mean (5)	Std. Dev. (6)
Bank characteristics						
Total assets (Euro bil)	120.9	322.6	122.2	342.9	115.3	219.7
Book equity (Euro bil)	5.5	14.8	5.0	14.7	7.8	14.9
Bank rating	5.5	2.1	5.2	1.9	7.0	2.5
Bank rating (2007)	5.1	1.9	4.9	1.9	5.8	1.5
Market leverage	45.6	57.2	50.0	57.5	41.4	56.6
CDS rate	242.3	296.3	161.9	114.1	391.7	438.8
Loan share	56.9%	17.6%	54.6%	16.9%	66.2%	17.0%
Deposit share	65.9%	23.3%	68.8%	24.3%	53.8%	13.0%
Book equity/assets	6.0%	3.4%	5.8%	2.7%	6.6%	5.4%
Tier 1 ratio	11.2%	6.8%	12.0%	7.9%	9.3%	2.4%
Located in distressed country	19.7%	39.8%	0.0%	0.0%	100.0%	0.0%
Central bank borrowing						
Any borrowing (yes = 1)	57.4%	49.5%	52.8%	49.9%	75.9%	42.7%
Total borrowing (Euro bil)	1.8	6.0	1.4	5.9	3.5	6.0
Log(Borrowing)	0.4	0.8	0.3	0.7	0.9	1.0
Borrowing/book equity	61.0%	145.3%	52.8%	137.9%	94.8%	168.4%
Borrowing/collateral	32.0%	34.1%	27.7%	32.5%	49.6%	34.8%
Central bank collateral						
Any collateral (yes = 1)	90.8%	28.9%	90.9%	28.8%	90.7%	29.1%
Collateral pledged (Euro bil)	5.5	12.9	5.2	13.5	6.7	10.3
Collateral/book equity	166.2%	205.5%	160.2%	199.4%	173.2%	212.0%
Haircut	7.2%	4.1%	6.8%	3.9%	8.6%	4.4%
Rated share (%)	79.7%	25.4%	79.77%	25.5%	79.4%	24.9%
Average rating	2.7	1.5	2.6	1.2	3.1	2.1
Distressed-sovereign debt/assets	0.5%	1.8%	0.1%	0.7%	1.8%	3.6%
Observations						
N	50,268		40,356		9,912	

of Figure 2 shows the market value of total collateral pledged with the ECB. The figure shows that total collateral pledged was fairly stable at about €1.9 trillion. The average ECB haircut was 8.5% throughout the financial crisis.

Table I provides summary statistics for our main sample. The sample contains 284 unique banks and 50,268 bank-week observations over the August 2007 to December 2011 period. Average bank size is €121 billion and average book equity is €5.5 billion. The banks are relatively highly levered, with an average ratio of book equity to total assets of 6.0% and an average Tier-1 ratio of 11.2%. About 57% of assets are loans and about 66% of liabilities are financed with deposits. The average credit rating is 5.5, or equivalently, a rating between A+ and A. About 20% of banks are headquartered in the distressed countries (Cyprus, Greece, Ireland, Italy, Malta, Portugal, and Spain).

On average, about 57% of banks borrow from the ECB in a given week. The average total borrowing per bank (including observations with zero borrowing) is €1.8 billion, which represents about 61% of book equity. About 91% of banks have collateral pledged with the ECB in a given week. About 80% of collateral is rated by at least one of the three rating agencies. The average rating is 2.7, or equivalently, a rating between AA+ and AA. Assets without credit ratings are nonmarketable assets or assets that were not matched to ratings by the ECB.[17]

Some of our empirical analysis separately considers banks located in distressed versus nondistressed countries. We therefore provide all summary statistics by subsample. We note that banks in the nondistressed and distressed countries are roughly of similar size, with average total bank assets of €122 billion and €115 billion, respectively. Banks in nondistressed countries have slightly higher ratings, A+ versus A−, and higher Tier-1 ratios, 12.0% versus 9.8%.

II. LOLR Theories

The classical motivation for establishing an LOLR is to stop bank runs. The canonical model of bank runs is Diamond and Dybvig (1983), which shows that depositors have an incentive to run if they expect other depositors to run, *even if* the bank would survive if all depositors decide not to run. Such runs are called "panic-based runs" because depositors are jointly better off if they can coordinate on not running. The early LOLR literature described banks subject to panic-based runs as illiquid but solvent banks and asserted that an LOLR could stop panic-based runs by lending directly to banks (Bagehot (1873)). The intuition is that the LOLR acts as a coordination device to avoid the run equilibrium.[18]

[17] We note that the average bank pledges collateral in excess of ECB borrowing. This average masks significant cross-sectional heterogeneity at the bank level. While some banks pledge significant excess collateral to ensure that they have access to ECB funding at short notice, other banks pledge little or no excess collateral. Our empirical analysis exploits these cross-sectional differences by analyzing the heterogeneity in excess collateral as an outcome variable.

[18] Historically, runs occurred because short-term deposits were backed by illiquid loans. If a sufficiently large share of depositors requested payment at once, banks were forced to rediscount loans. If the proceeds from rediscounting loans were too small, then banks had to suspend convertibility, which could lead to default (Bordo, 1990). In a modern financial system, bank runs are less likely because a large share of deposits is covered by deposit insurance and most banks hold a significant buffer of liquid securities. However, bank runs are not completely eliminated because banks also borrow from non-insured short-term creditors (e.g., money market funds (Kacperczyk and Schnabl (2013)) and banks may suffer fire-sale discounts if they have to sell securities quickly.

A shortcoming of the classical model is that it lacks an explanation for why runs occur in the first place. The empirical literature shows that runs occur at times when depositors become worried about economic fundamentals (e.g, Gorton (1988), Kaminsky and Reinhart (1999)). A new generation of theoretical work explicitly models the interaction between economic fundamentals and runs using global games methods (Morris and Shin (2002)). This literature shows that panic-based bank runs occur if fundamentals are low, but not too low. If fundamentals are very low, then runs are "fundamentals-based runs" because it is rational for depositors to withdraw funds regardless of what others do. If fundamentals are high, then depositors never run.[19]

The common message of this literature is that an LOLR can be highly beneficial if runs are panic-driven. An idealized version of this theory implies that the mere announcement of an LOLR policy is sufficient to eliminate any need for LOLR borrowing. In that case, banks are certain to have access to financing and hence there is no need for depositors to run.[20] This theory suggests that an LOLR has large benefits to society because it prevents a credit crunch. It also limits contagion to other banks and the negative externalities from banks' fire-sales.

However, the literature recognizes that an LOLR may come at the cost of both ex ante and ex post moral hazard. The ex ante moral hazard cost is that banks may not take sufficient precautions to prevent bank panics. Some authors argue that bank runs act as a disciplining device on banks' risk-taking, and that this device is weakened by the LOLR (e.g., Kaufman (1988), Calomiris and Kahn (1991), Diamond and Rajan (2000)). Others argue that banks grow too large ("too-big-to-fail problem") to ensure access to government support during times of crisis (Stern and Feldman (2004)).

The ex post moral hazard cost is that banks may borrow from the LOLR for reasons other than stopping a run (Bordo (1990)). In particular, insolvent banks, those whose assets are worth less than their liabilities, have an incentive to borrow excessively. The reason is that these banks are close to default. As a result, their equity holders do not bear the full downside risk of their investments but do receive all the upside. This asymmetric payoff creates a strong motive to borrow and invest in risky assets, particularly those whose downside is realized when the bank defaults, a behavior often called "risk-shifting" or "gambling for resurrection."[21] We therefore refer to this motivation for LOLR borrowing as the risk-taking theory.

[19] Goldstein and Pauzner (2005) examine the likelihood of panic-based runs as a function of economic fundamentals. Rochet and Vives (2004) show that this setup justifies lending to individual banks instead of limiting the LOLR to open market operations as proposed by Goodfriend and King (1988). Freixas, Parigi, and Rochet (2004) examine optimal LOLR policy in a similar setting. Flannery (1996) analyzes the need for LOLR lending to individual banks. Allen and Gale (1998) develop an alternative model that links bank runs and fundamentals.

[20] This idealization is unlikely to hold in practice because LOLR borrowing is constrained by the need to post collateral in order to alleviate moral hazard concerns. This creates uncertainty for depositors, so that banks may need to borrow from the LOLR when they face a panic-based run.

[21] The risk-shifting (or asset substitution) problem is quite general and applies to all firms that face significant default risk (Jensen and Meckling (1976)). The issue is particularly relevant in

Under the risk-taking theory, haircut subsidies offered by the LOLR give banks an opportunity to risk shift because they make LOLR loans undercollateralized. The value of exploiting this undercollaterlization depends on a bank's default risk. For strongly capitalized banks the value is small, and is more than offset by the LOLR's penalty interest rate. In contrast, weakly capitalized banks can extract large value from undercollateralization, especially by buying risky assets, whose haircut subsidies are the largest. Thus, the risk-taking theory predicts that it is weakly capitalized banks that borrow from the LOLR, in order to buy risky assets.

Several authors emphasize that LOLR borrowing may be encouraged by regulators and politicians. One reason may be that regulators are in charge of supervising banks, and therefore have an incentive to disguise losses by providing them with public funding. Alternatively, regulators may be pressured by politicians to keep insolvent banks alive. Although such regulatory forbearance reduces social welfare, it may be in the interest of regulators and politicians, who want to maintain their reputation and avoid the political costs of bank defaults (Boot and Thakor (1993), Mishkin (2001)).[22]

Alternatively, regulators may also face institutional constraints that prevent them from bailing out insolvent banks through direct recapitalization, even though there may be large welfare gains to doing so. In this case, regulators may use LOLR funding to attempt to recapitalize banks, though more efficient mechanisms may exist (Philippon and Schnabl (2013)).[23] Regulators may also encourage borrowing in order to use the banking system to support the sovereign debt issuance of distressed countries (Buiter and Rahbari (2012)). In these cases, regulators may in fact be acting in the public interest rather than their own.

We refer to regulatory pressure to borrow from the LOLR as the political economy theory. It is important to note that, independent of the regulator's motivation, banks with high default risk, that is, those with the strongest incentives to increase risk-taking, will be most responsive to regulatory pressure to borrow from the LOLR. In other words, regulatory pressure and internal

banking because banks benefit from explicit and implicit guarantees, which allow them to raise funding even if they are close to default. Risk-shifting incentives may also lead to a credit freeze, which impairs trade across banks (Diamond and Rajan (2011)).

[22] Benston and Kaufman (1996) argue that the historical motivation for bank regulation was rent extraction by government officials. Kane (1989) shows that career concerns of regulators and regulatory forbearance played an important role in the Savings and Loan (S&L) crisis in the United States. Barth, Brumbaugh, and Sauerhaft (1986) document that most of the cost absorbed by the insurance fund occurred after S&Ls became insolvent based on Generally Accepted Accounting Principles. Barth, Caprio, and Levine (2006) analyze bank regulation in over 150 countries and find that politicians and bank supervisors often do not act in the public interest.

[23] In the United States, the Federal Deposit Insurance Fund (FDIC) can provide open bank assistance to a failing bank if the bank is "essential to the community" and the cost of providing assistance is smaller than the cost of liquidation. The FDIC's authority to provide open bank assistance was severely curtailed after its use during the S&L crisis raised concerns about providing hidden subsidies to banks (Federal Deposit Insurance Fund (1998)).

risk-taking motives reinforce each other, making the political economy theory a compliment, or amplifier, of the risk-taking theory.

III. Empirical Analysis

A. Identification Strategy

Our identification strategy aims to identify the motivation for banks' borrowing from the LOLR. The risk-taking theory emphasizes the role of banks' default risk in driving their incentives to take risk. Under this theory, banks with a high default risk use LOLR funding to invest in risky assets whose losses are likely to occur when the bank defaults. We test the risk-taking theory by examining the effect of a bank's default risk on the likelihood and extent of LOLR borrowing and the risk of assets pledged against LOLR borrowing.

The main challenge in implementing this test is that measures of a bank's default risk may be correlated with other (omitted) variables that also affect LOLR borrowing and collateral. For example, measures of a bank's default risk during a crisis may also reflect concerns about the bank's exposure to fire sales, which may directly affect whether the bank borrows from the LOLR. More generally, any omitted variable that is correlated with measures of banks' default risk and that also affects LOLR borrowing and collateral directly may confound the empirical analysis.

To address this problem, we proxy for a bank's default risk during the financial crisis using default risk *before* the crisis began. Specifically, we measure a bank's default risk using bank capital as of August 2007. The idea underlying this identification strategy is that banks entering the crisis with lower capital levels were more likely to end up with risk-taking incentives during the crisis. In other words, one can interpret precrisis capital levels as an instrument for whether a bank has risk-taking incentives *during* the financial crisis. The identifying assumption is that precrisis bank capital affects a bank's LOLR borrowing and collateral risk *only* through its incentive to take risk.

We measure a bank's capital using the median of its long-term unsecured credit ratings as of August 2007. We assign numerical values to bank credit ratings such that bank risk is increasing in our credit rating measure (AAA = 1, AA + 2, etc.). We choose credit ratings as our preferred measure because they are available for a broad cross-section of banks. Moreover, relative to accounting-based measures, credit ratings have the advantage that they are based on market participants' assessments.[24]

We exploit the start of the European sovereign debt crisis in early 2010 as a substantial shock to banks' default risk and hence risk-taking incentives. At this time, the first Greek debt crisis occurred and serious concerns about the creditworthiness of several European sovereigns emerged. We mark the start of the crisis as of May 2, 2010, the date when the European Union and

[24] Acharya, Schnabl, and Suarez (2013) show that banks engaged in regulatory arbitrage to circumvent accounting-based measures. Other market-based measures such as CDS rates are only available for smaller samples. We examine CDS rates in one of our robustness tests.

the International Monetary Fund agreed on the first Greek bailout totaling € 110 billion.[25] The crisis subsequently affected Ireland, Cyprus, Portugal, Spain, Malta, and Italy.

Bank and sovereign CDS rates provide direct support for the emergence of risk-taking incentives in May 2010. As shown in Panel A of Figure 3, before May 2010 the difference in CDS rates between weakly and strongly capitalized banks was at most 70 bps. This difference doubled after the announcement of the Greek bailout on May 2, 2010 and increased to more than 500 bps thereafter. Sovereign CDS rates display a similar pattern. As shown in Panel B of Figure 3, the difference between CDS rates of distressed and nondistressed sovereign bonds almost doubled in May 2010 and gradually increased to more than 2,000 bps. These results indicate that the onset of the sovereign debt crisis may well have triggered incentives for weakly capitalized banks to take risk, and substantially increased the pool of risky, high-yielding assets that banks can use to do so.

We note that it is unlikely that banks adjusted their August 2007 capital levels in anticipation of this major financial crisis. Although some market participants were concerned about European banks prior to August 2007, all conventional measures of bank risk at that time indicated a low likelihood of a large-scale financial crisis (Acharya, Drechsler, and Schnabl (2014)).

B. Do Weakly Capitalized Banks Borrow More?

The risk-taking theory predicts that banks with high default risk borrow more from the LOLR. To test this prediction, we capture LOLR borrowing using two measures: (1) an indicator variable for whether a bank borrows from the ECB, and (2) the natural logarithm of total borrowing in billion Euros plus one. These variables capture the extensive and intensive margins of LOLR borrowing.[26]

The risk-taking theory also predicts that banks with high default risk pledge riskier assets with the LOLR because they carry the largest haircut subsidies and hence the loans are undercollateralized. We measure a bank's collateral risk using two measures: (1) the average collateral credit rating (weighted by market values) of *all* the securities pledged with the LOLR, and (2) total distressed-sovereign debt scaled by 2007 bank assets. We use bank assets as of December 2007 to avoid endogeneity with respect to the scaling variable. The second measure focuses on distressed-sovereign debt (relative to other types of

[25] On May 2, 2010, the European Union and the International Monetary Fund agreed to a €110 billion bailout of Greece (Reuters, "EU, IMF agree $147 billion bailout for Greece," May 2, 2010). Some observers mark the start of the sovereign crisis two months earlier, when it became increasingly likely that Greece would need a bailout. All our results are robust to using March 2010 as the start date of the sovereign crisis.

[26] We find qualitatively similar results if we drop observations with zero borrowing and estimate the main regressions using only variation on the intensive margin. We also find qualitatively similar results if we measure LOLR borrowing as borrowing scaled by bank assets.

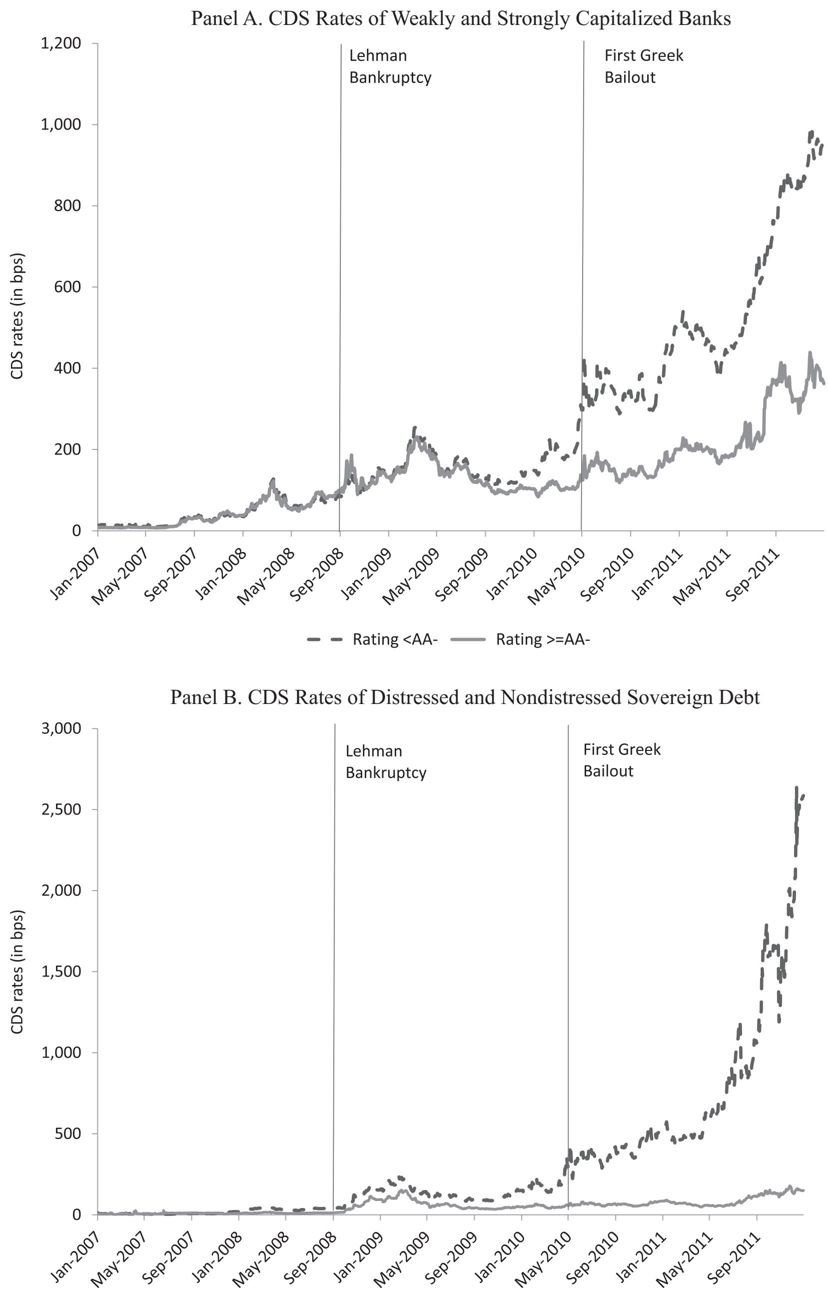


Figure 3. CDS rates of banks and sovereigns. Panel A of the figure plots the average CDS rates of weakly capitalized banks (credit rating below AA− as of August 2007, dashed line) and strongly capitalized banks (credit rating of AA− or higher as of August 2007, solid line). Panel B plots average CDS rates of distressed country sovereign debt (Greece, Ireland, Italy, Portugal, and Spain, dashed line) relative to nondistressed country sovereign debt (Austria, Belgium, Denmark, France, Germany, Netherlands, Sweden, and United Kingdom, solid line).

debt) because it was considered a capital-efficient way to take on risk due to its low regulatory risk weights.[27]

We implement our test of the risk-taking theory using a difference-in-differences regression framework. The estimation controls for time fixed effects to capture time-series variation that is common to all banks. We also control for bank fixed effects to capture any time-invariant characteristics that affect LOLR borrowing and collateral risk. Some of our robustness tests also control for additional time-varying bank characteristics.

Specifically, we estimate the following OLS regression:

$$y_{it} = \alpha_i + \delta_t + \beta BankRating_{i,07} \times Post_t + \varepsilon_{it} \ , \tag{1}$$

where y_{it} is the LOLR borrowing or collateral risk of bank i at time t, $BankRating_{i,07}$ is bank i's credit rating as of August 2007, $Post_t$ is a vector of year-month indicator variables, α_i are bank fixed effects, and δ_t are time fixed effects. We double-cluster standard errors at the bank and time levels to allow for correlation of error terms across banks and over time.

We present the results in a series of figures. Panel A of Figure 4 shows the results when the outcome variable is LOLR borrowing. The figure plots the coefficients (solid line) and 95% confidence interval (dashed lines) for the year-month interactions with precrisis credit rating in equation (1). We indicate the month of the Lehman bankruptcy (September 2008) and the month of the first Greek bailout (May 2010) with vertical lines.

The figure shows that, beginning in early 2010, weakly capitalized banks increased borrowing relative to strongly capitalized banks. Specifically, a one-standard-deviation decrease in a bank's precrisis credit rating (about two notches) leads to an 11.2 percentage point increase in the likelihood of borrowing. Panel B plots the coefficients when the natural logarithm of borrowing is the outcome variable. The results are similar: a one-standard-deviation decrease in a bank's precrisis credit rating leads to a 14.6% increase in borrowing after May 2010.[28]

Weakly capitalized banks also pledge riskier collateral than strongly capitalized banks. Panel C of Figure 4 plots the coefficients when the outcome variable is the average collateral credit rating. Starting in early 2010, a one-standard-deviation decrease in a bank's precrisis credit rating is associated with a decrease in average collateral rating of 22% of a standard deviation. As shown in Panel D, it is also associated with a 21% of a standard deviation increase in the pledging of distressed-sovereign debt relative to assets. These findings are statistically significant as indicated by the 95% confidence interval.

Table II presents the results of estimating the regressions using indicator variables for the period after the Lehman bankruptcy (October 2008 to

[27] Acharya and Steffen (2014) argue that some Eurozone banks engaged in a "carry trade" by investing in distressed-sovereign bonds because of low regulatory weights.

[28] The start of the sovereign debt crisis was around the same time as the end of the one-year LTRO. The sharp change around this time picks up higher repayment of LTRO borrowing by banks with a high precrisis credit rating relative to banks with a low precrisis credit rating.

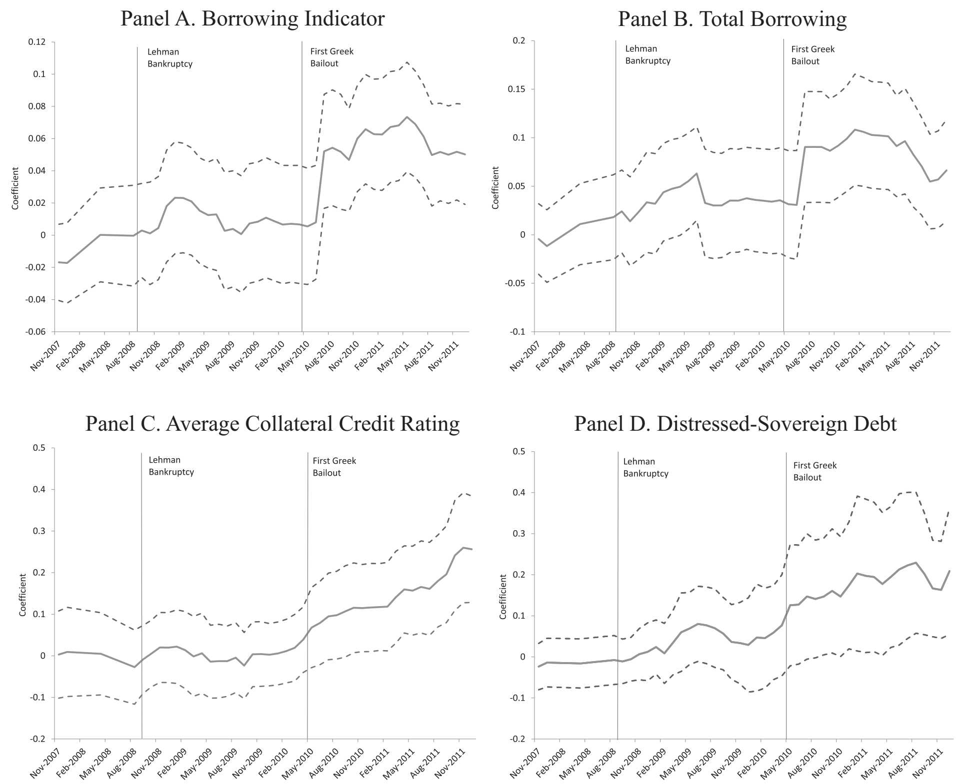


Figure 4. Effect of precrisis bank rating on ECB borrowing. This figure plots the coefficients (solid line) and 95% confidence interval (dashed lines) on the year-month indicator variables interacted with the precrisis bank credit rating when the outcome variable is the borrowing indicator (Panel A), the natural logarithm of total borrowing in €billions plus one (Panel B), the market value-weighted collateral credit rating (Panel C), and distressed-sovereign debt relative to assets (Panel D).

May 2010) and after the first Greek bailout (June 2010 to December 2011). Consistent with the figures above, we find that weakly capitalized banks increased their LOLR borrowing and collateral risk relative to strongly capitalized banks starting in May 2010. All results are statistically significant at the 1% level.[29]

We note that we find no effect of weak bank capitalization on LOLR borrowing and collateral risk during the first half of the financial crisis (October 2008 to May 2010). This shows that the strong relationship between LOLR borrowing and collateral risk is neither obvious nor a given in a financial crisis. The financial crisis has to be severe enough that weakly capitalized banks have

[29] The number of observations in columns (1) and (2) (borrowing measures) is slightly larger than the number of observations in columns (3) and (4) (collateral measures). The reason is that not all banks pledge collateral all the time. All results are robust to restricting the sample to observations with nonzero collateral.

Table II

Bank Rating and LOLR Borrowing

This table examines the effect of bank ratings on ECB borrowing and collateral pledged with the ECB. The unit of observation is at the bank-week level and the sample covers the period from August 2007 to December 2011. *Bank Rating* is a bank's credit rating (AAA = 1, AA+ = 2, AA = 3, etc.) as of August 2007. *Borrowing Indicator* is an indicator variable for whether a bank borrows from the ECB. Log(*Borrowing*) is the natural logarithm of total borrowing in billions plus one. *Collateral Rating* is the value-weighted average credit rating of collateral. *Distressed-Sovereign Debt/Assets* is total sovereign debt issued by distressed countries (Cyprus, Greece, Ireland, Italy, Malta, Portugal, and Spain) relative to 2007 bank assets. *Post-Lehman* and *Post-Greek Bailout* are indicator variables for the periods from October 2008 to May 2010 and June 2010 to December 2011, respectively. All columns include week and bank fixed effects. Standard errors in parentheses are double-clustered at the bank and time levels. ***Significant at the 1% level, **significant at the 5% level, and *significant at the 10% level.

Dependent Variable	Borrowing Indicator_{it} (1)	Log $(\text{Borrowing})_{it}$ (2)	Collateral Rating_{it} (3)	Distressed-Sovereign $\text{Debt}_{it}/\text{Assets}_{i,07}$ (4)
$\text{Bank Rating}_{i,07} \times$ Post-Greek Bailout_t	0.059***	0.077***	0.153***	0.190***
	(0.011)	(0.020)	(0.041)	(0.063)
$\text{Bank Rating}_{i,07} \times$ Post-Lehman_t	0.013	0.029**	0.014	0.058**
	(0.012)	(0.014)	(0.020)	(0.029)
Time fixed effects	Y	Y	Y	Y
Bank fixed effects	Y	Y	Y	Y
Banks	284	284	277	272
Observations	50,268	50,268	44,783	48,144
Within R^2	0.167	0.059	0.078	0.042
Overall R^2	0.471	0.782	0.681	0.672

stronger risk-taking incentives than strongly capitalized banks. This also suggests that the risk-taking theory is unlikely to explain LOLR borrowing during the early part of the financial crisis.

C. Risk-Taking versus Panic-Based Runs

C.1. Do Banks Actively Invest in Risky Assets?

A unique prediction of the classical LOLR theory is that banks increase their pledging of risky collateral but *not* their corresponding asset holdings. Under this theory, banks borrow from the LOLR to substitute for a loss of their funding due to panic-based runs, *not* to increase their risk-taking.[30] In contrast, the risk-taking theory says that banks use LOLR funding to increase their holdings of risky assets. To distinguish between the two theories, we examine the relationship between *changes* in a bank's pledging of risky assets

[30] Note that the risk-taking theory also predicts that banks lose funding. Therefore, a decline in a bank's market funding is consistent with both panic-based and fundamentals-based runs. Hence, adding controls for a bank's access to funding markets (e.g., deposit rates) does not distinguish between the classical LOLR theory and the risk-taking theory.

and *changes* in its holdings of these assets. The classical LOLR theory predicts no relationship, whereas the risk-taking theory predicts a positive relationship.

A challenge in implementing this test is that banks provide little information on their asset holdings. However, as part of the European bank stress tests, bank regulators published information on bank holdings of sovereign debt by country. European banks conducted three separate rounds of bank stress tests during our sample period (March 2010, December 2010, September 2011), allowing us to analyze a panel of bank holdings of distressed-sovereign debt. The bank stress tests were designed to include the largest banks in Europe. Participation was mandatory and regulators ensured that the largest banks were present in all rounds. We therefore focus our analysis on the sample of 54 banks that participated in all three rounds. These banks were the largest banks in Europe and represented more than 50% of total European bank assets.

We analyze the relationship between banks' pledging of distressed-sovereign debt collateral and their corresponding holdings using the following OLS regression:

$$\Delta Holdings_{it} = \alpha + \delta_t + \beta \Delta Pledged_{it} + \varepsilon_{it}, \tag{2}$$

where $\Delta Holdings_{it}$ is the change in bank i's holdings of distressed-sovereign debt from time t to $t+1$, $\Delta Pledged_{it}$ is bank i's change in distressed-sovereign debt pledged as collateral from time t to $t+1$, and δ_t are time fixed effects. We normalize both the holdings and collateral amounts by bank assets as of December 2007. We measure holdings and collateral using face values to avoid a mechanical relationship due to price changes. We double-cluster standard errors at the bank and time levels to account for the correlation of error terms across banks and over time.

We estimate this relationship in *changes* to control for pre-existing heterogeneity in distressed-sovereign debt holdings.[31] We focus on the LOLR's perspective and use changes in pledged collateral on the right-hand side. This specification provides an estimate of the share of pledged collateral that was actively purchased during the analysis period. A coefficient of one indicates that pledging was driven exclusively by active investments in risky assets, whereas a coefficient of zero indicates that pledging reflects financing of existing asset holdings.

Table III presents the results. As shown in column (1), a 10% increase in distressed-sovereign debt pledged (relative to assets) is associated with a 4.5% increase in distressed-sovereign debt holdings (relative to assets). As shown in column (2), the coefficient is unchanged if we control for time fixed effects. These results show that, for each additional dollar of distressed-sovereign debt pledged with the ECB, $0.45 reflects an increase in a bank's active investment in distressed-sovereign debt. This result is inconsistent with the classical LOLR theory.

[31] We can also add a bank's precrisis holdings of distressed-sovereign debt as an additional control variable. The results are unchanged if we do so.

Table III

Distressed-Sovereign Debt Pledged and Distressed-Sovereign Debt Holdings

This table examines the correlation between collateral pledged and holdings of distressed-sovereign debt. The sample is all banks that participated in the European bank stress tests in March 2010, December 2010, and September 2011. *Distressed-Sovereign Debt Pledged / Assets* and *Distressed-Sovereign Debt Holdings / Assets* are collateral pledged and holdings of distressed-sovereign debt (Cyprus, Greece, Ireland, Italy, Malta, Portugal, and Spain) divided by banks assets as of December 2007, respectively. *Bank Rating* is a bank's credit rating (AAA = 1, AA+ = 2, AA = 3, etc . . .) as of August 2007. Δ denotes the change in bank *i*'s variable from time *t* to *t+1*. Columns (2), (4), and (6) include time fixed effects. Standard errors in parentheses are double-clustered at the bank and time levels. ***Significant at the 1% level, **significant at the 5% level, and *significant at the 10% level.

Dependent Variable	$\Delta_{t+1,i}$ Distressed-Sovereign Debt Holdings$_{it}$/Assets$_{i,07}$					
Sample	All		Bank Rating$_{i,07}$ $<$AA–		Bank Rating$_{i,07}$ $>=$ AA–	
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta_{t+1,i}$ Distressed Sovereign	0.453***	0.450***	0.550**	0.534**	0.064	0.085
Debt Pledged$_t$/Assets$_{i,07}$	(0.154)	(0.153)	(0.257)	(0.262)	(0.114)	(0.121)
Time fixed effects	N	Y	N	Y	N	Y
Banks	54	54	26	26	28	28
Observations	108	108	52	52	56	56
R^2	0.172	0.197	0.236	0.256	0.005	0.035

To directly test the risk-taking theory, we also analyze the association between distressed-sovereign debt holdings and pledging as a function of a bank's default risk. We implement this test by dividing our sample into two subsamples: the subsample of weakly capitalized banks, with a precrisis credit rating of less than AA− (26 banks), and the subsample of strongly capitalized banks, with a precrisis credit rating of AA− or higher (28 banks).

Columns (3) and (4) present the results for the sample of weakly capitalized banks. We find that the strength of the association between changes in distressed-sovereign debt and changes in holdings of distressed-sovereign debt increases: a 10% increase in distressed-sovereign debt pledged with the ECB is associated with a 5.5% increase in distressed-sovereign debt holdings. Columns (5) and (6) examine the sample of strongly capitalized banks. We find that the effect drops to 0.6% and is not statistically significant. The difference between weakly and strongly capitalized banks is statistically significant at the 5% level. These results support the risk-taking theory.

C.2. Are the Results Driven by Cross-Country Differences?

As an alternative test of classical LOLR theory, we further control for country-level variation in exposure to panic-based bank runs. The most likely source of bank runs was the ongoing decline in the macroeconomic health of distressed countries. Specifically, some experts argued that banks suffered a "quiet" bank run, in which depositors slowly moved deposits to other countries (Ferguson and Roubini (2012)). This would imply that country-level changes in the supply of bank funding can potentially explain the need to borrow from the LOLR. We test this explanation by including a complete set of time dummies for each country in our main regression equation (1). This is a nonparametric way to control for any variation in borrowing or collateral risk that affects all banks within a country.

Table IV presents the results. As shown in columns (1) and (2), we find that the results are qualitatively similar to the ones in Table II. A one-standard-deviation decrease in a bank's precrisis credit rating raises the likelihood of borrowing by 7.6 percentage points and the amount of borrowing by 6.9%, respectively. As shown in Columns (3) and (4), a one-standard-deviation decrease in a bank's precrisis credit rating reduces the average collateral rating by 11% of a standard deviation and increases the pledging of distressed-sovereign debt relative to assets by 5% of a standard deviation.

Compared to Table II, the coefficients are at least a third smaller than the corresponding coefficients in specifications without country-time fixed effects but all results remain statistically significant at the 10% level or at a higher level. Given that explanations relying on panic-based runs emphasize the importance of cross-country differences, these findings provide further support for the risk-taking theory. Moreover, these estimates provide a lower bound on the effect of risk-taking under the conservative assumption that all cross-country variation is driven by panic-based runs.

Table IV

Bank Rating and LOLR Borrowing (Country-Time Fixed Effects)

This table examines the effect of bank ratings on ECB borrowing and collateral pledged with the ECB. The unit of observation is at the bank-week level and the sample covers the period from August 2007 to December 2011. All columns include country-time fixed effects and bank fixed effects. All variables are defined in Table II. Standard errors in parentheses are double-clustered at the bank and time levels. ***Significant at the 1% level, **significant at the 5% level, and *significant at the 10% level.

	Borrowing Indicator$_{it}$ (1)	Log (Borrowing)$_{it}$ (2)	Collateral Rating$_{it}$ (3)	Distressed-Sovereign Debt$_{it}$/Assets$_{i,07}$ (4)
Bank Rating$_{i,07}$ ×	0.040***	0.036**	0.082***	0.043*
Post-Greek Bailout$_t$	(0.011)	(0.015)	(0.031)	(0.024)
Bank Rating $_{i,07}$ ×	0.016	0.022	0.021	−0.022
Post-Lehman$_t$	(0.011)	(0.014)	(0.016)	(0.032)
Country-time fixed effects	Y	Y	Y	Y
Bank fixed effects	Y	Y	Y	Y
Banks	284	284	277	272
Observations	50,268	50,268	44,731	48,144
Within R^2	0.404	0.744	0.678	0.423
Overall R^2	0.538	0.836	0.827	0.805

C.3. Are the Results Driven by the Distressed Countries?

There is no evidence that nondistressed countries suffered panic-based bank runs. Classical LOLR theory therefore predicts that there should be no differences in LOLR borrowing and collateral across banks in the nondistressed countries. To test this prediction, we estimate the main specification only for banks located outside the distressed countries. Similar to the estimation in Table IV, we include country-time fixed effects to control for any country-specific trends.[32]

Table V presents the results. As shown in columns (1) and (2), a bank's credit rating continues to predict LOLR borrowing. A one-standard-deviation decrease in a bank's credit rating increases the likelihood of borrowing by 8.0 percentage points and the amount of borrowing by 10.5%, respectively. We find similar results for collateral risk. As shown in columns (3) and (4), a one-standard-deviation decrease in a bank's precrisis credit rating reduces the average collateral rating by 11% of a standard deviation and increases the pledging of distressed-sovereign debt relative to assets by 5% of a standard deviation. All results are statistically significant at the 10% level or at a higher level.

We note that the coefficients in Table V are similar in magnitude to the ones in Table IV. This result shows that the effect of credit ratings on LOLR borrowing and collateral is similar *within* distressed countries and in nondistressed

[32] The results are similar if we do not control for country-time fixed effects.

Table V

Bank Rating and LOLR Borrowing (Nondistressed Countries)

This table examines the effect of bank ratings on ECB borrowing and collateral pledged with the ECB. The unit of observation is at the bank-week level and the sample covers banks headquartered in the nondistressed countries from August 2007 to December 2011. All variables are defined in Table II. All columns include country-time fixed effects and bank fixed effects. Standard errors in parentheses are double-clustered at the bank and time levels. ***Significant at the 1% level, **significant at the 5% level, and *significant at the 10% level.

Sample	Nondistressed Sovereigns			
Dependent Variable	Borrowing Indicator_{it} (1)	Log $(\text{Borrowing})_{it}$ (2)	Collateral Rating_{it} (3)	Distressed Sovereign $\text{Debt}_{it}/\text{Assets}_{i,07}$ (4)
$\text{Bank Rating}_{i,07}$ ×	0.042***	0.044***	0.075**	0.043*
$\text{Post-Greek Bailout}_t$	(0.012)	(0.015)	(0.034)	(0.022)
$\text{Bank Rating}_{i,07}$ ×	0.014	0.022	0.032**	−0.018
Post-Lehman_t	(0.013)	(0.015)	(0.015)	(0.035)
Country-time fixed effects	Y	Y	Y	Y
Bank fixed effects	Y	Y	Y	Y
Banks	227	227	222	218
Observations	40,356	40,356	35,940	38,763
Within R^2	0.396	0.769	0.744	0.656
Overall R^2	0.518	0.809	0.797	0.681

countries. In other words, comparing strongly and weakly capitalized banks within distressed countries (e.g., within Italy) gives the same results as comparing strongly and weakly capitalized banks within nondistressed countries (e.g., within Germany). This suggests that risk-taking incentives operate both across and within countries. It also suggests that the effect of rating has no country-specific component in nondistressed countries, while country-level factors can partially explain the difference between distressed and nondistressed countries.

D. What Is the Role of Regulators?

The political economy theory says that banks increase LOLR borrowing because they are encouraged (or pressured) to do so by their regulators. This could be the case because governments in distressed countries experience high sovereign borrowing costs and want banks to buy their debt. In this way, distressed countries may circumvent rules that restrict the ECB from directly lending to them. For the same reason, the ECB may view this arrangement as a way to avoid sovereign defaults and the breakup of the Eurozone.[33]

[33] Consistent with this interpretation, the French President, Nicolas Sarkozy, explicitly pointed out that banks may want to use ECB funding to buy distressed-sovereign bonds (*The Financial Times*, "Sarkozy plan to prop up sovereigns is worrying," December 14, 2011).

It is important to note that, under the political economy theory, banks use LOLR funding to buy risky assets. Hence, the political economy theory is inconsistent with the classical LOLR theory. Instead, it interacts with and amplifies the risk-taking theory as regulators harness banks' existing risk-taking incentives.[34] To explain our findings, the theory further requires that political economy forces disproportionately affected weakly capitalized banks. This is plausible because weakly capitalized banks have the strongest risk-taking incentives, which makes them more responsive to encouragements to take risk. Weakly capitalized banks are also more likely to respond to regulators because they are more dependent on regulatory approval.

Several of our results provide support for the political economy theory. As described above, country-time fixed effects reduce the effect of credit ratings on LOLR borrowing and collateral. This reduction is consistent with differences in banks' borrowing and collateral risk being driven by regulatory pressure in the distressed countries. Regulatory pressure is also consistent with our finding that credit ratings have a smaller effect on collateral risk in the nondistressed countries since regulators in these countries are, if anything, more likely to pressure banks to reduce risky asset investments. Hence, our results are consistent with a positive interaction between political economy pressures and risk-taking.[35]

To further test the role of political economy considerations, we analyze whether banks invested in domestic or foreign distressed-sovereign debt. While it is plausible that national regulators in the distressed countries encouraged banks to invest in their own sovereign debt, they were unlikely to have encouraged them to buy foreign sovereign debt. We therefore focus our analysis on the sample of banks located in the distressed countries and analyze their holdings of domestic and foreign distressed-sovereign debt. We start by computing the share of domestic and foreign distressed-sovereign debt. Panel A of Table VI shows that domestic sovereign debt accounts for 83% of these banks' distressed-sovereign debt holdings. Hence, banks invested primarily in domestic distressed-sovereign debt.

Next, we decompose holdings and collateral into domestic and foreign distressed-sovereign debt and estimate equation (2) for banks located in distressed countries. As a benchmark, we first estimate the effect for all distressed-sovereign debt. As shown in columns (1) and (2) of Panel B, the coefficients are similar to those estimated in Table III. The effect is larger after restricting

[34] Our empirical methodology does not allow us to determine whether regulators encouraged risk-taking to increase welfare or for other reasons. Consistent with an interpretation based on regulatory career concerns, our main results are stronger in the distressed countries, where the central bank is also the bank supervisor. However, given the limited number of distressed countries in our study, we are hesitant to draw conclusions from this finding.

[35] The political economy theory can also explain why the LOLR does not restrict banks' risk-shifting. In the standard risk-shifting theory, the principal cannot restrict risk-shifting because he cannot observe the agent's actions. However, under the political economy explanation, the principal (LOLR) can observe the agent's (bank's) actions but encourages costly risk-shifting in the pursuit of political economy objectives.

Table VI

Distressed-Sovereign Debt Holdings and Collateral Pledged in Distressed Countries

Panel A examines the country of origin of holdings of distressed-sovereign debt. The sample is all banks located in the distressed countries that participated in the European bank stress tests. Column (1) reports total distressed-sovereign debt holdings. Column (2) reports total domestic distressed-sovereign debt holdings. Column (3) reports total foreign distressed-sovereign debt holdings. Column (4) reports domestic distressed-sovereign debt holdings as a share of total distressed-sovereign debt holdings. Standard errors are in parentheses. Panel B examines the correlation between collateral pledged and holdings of distressed-sovereign debt. The sample is all banks that participated in the European bank stress tests in March 2010, December 2010, and September 2011 and are located in distressed countries. The variables are defined in Table III. Columns (1) and (2) include all distressed-sovereign debt. Columns (3) and (4) only include distressed-sovereign debt issued by the bank's home country. Columns (5) and (6) only include distressed-sovereign debt issued by countries other than the bank's home country. Columns (2), (4), and (6) include time fixed effects. Standard errors in parentheses are double-clustered at the bank and time levels. ***Significant at the 1% level, **significant at the 5% level, and *significant at the 10% level.

Panel A: Holdings of Domestic and Foreign Distressed-Sovereign Debt

Sample	Total (1)	Domestic (2)	Foreign (3)	Domestic Share (in %) (4)
Distressed-sovereign debt holdings (in million Euro)	19,017	17,472	1,545	82.7
	(21,859)	(20,826)	(1,703)	(26.2)

Panel B: Holdings and Collateral Pledged of Distressed-Sovereign Debt

Dependent Variable	$\Delta_{t+1,i}$ Distressed-Sovereign Debt Holdings$_{it}$/Assets$_{i,07}$					
Sample	All		Domestic		Foreign	
	(1)	(2)	(3)	(4)	(5)	(6)
$\Delta_{t+1,i}$ Domestic Distressed Sovereign Debt Pledged$_t$/Assets$_{i,07}$	0.440***	0.416***	0.514***	0.502***	0.226	0.213
	(0.120)	(0.114)	(0.080)	(0.070)	(0.257)	(0.261)
Time fixed effects	N	Y	N	Y	N	Y
Banks	17	17	17	17	17	17
Observations	34	34	34	34	34	34
R^2	0.181	0.253	0.183	0.231	0.168	0.240

holdings and collateral to domestic debt. As shown in columns (3) and (4), a 10% increase in domestic distressed-sovereign debt pledged (relative to assets) is associated with a 5.1% increase in domestic distressed-sovereign debt holdings (relative to assets). In contrast, as shown in columns (5) and (6), the effect is small and statistically insignificant for foreign distressed-sovereign debt. These findings are consistent with distressed-country regulators pressuring their banks to purchase domestic debt.[36]

[36] We note that this result in no way contradicts the risk-taking theory. Domestic bonds are an efficient vehicle for distressed-country banks to risk shift, since the downside risk of these bonds is

Finally, we note that political economy alone cannot explain all our results. As shown in Table V, we find that precrisis bank ratings predict LOLR borrowing and collateral risk even *outside* the distressed countries. Furthermore, this relationship also holds for collateral besides distressed-sovereign debt, which was not the focus of regulators. Hence, there is evidence of bank risk-taking independent of regulatory pressure.

E. Are the Results Robust to Alternative Specifications?

E.1. What Is the Role of Bank-Specific Asset Valuations?

A potential concern with our findings is that banks may value assets differently for reasons other than differences in risk-taking incentives. Due to such differences in bank-specific valuations of assets, some banks may borrow more from the LOLR to invest in risky assets. For instance, these banks may be specialists in managing or investing in certain types of risky assets, or they may be more "optimistic" about these assets' payoffs. Under this explanation, differences in banks' LOLR borrowing are not driven by bank capital, but rather by bank characteristics such as business models, expertise, or optimism. Like the risk-taking theory, this explanation emphasizes active risk-taking by banks and is therefore incompatible with classical LOLR theory.

We note that, in order to explain our findings, the bank-specific valuation theory requires that differences in bank-specific valuations be correlated with banks' credit ratings as of August 2007. It also requires that banks have different valuations of sovereign debt, an asset class for which differences in banking expertise are less plausible, even more so in nondistressed countries. Hence, our results so far do not point to the importance of differences in bank-specific valuations.

To further examine this issue, we control for bank characteristics that proxy for differences in business model, expertise, and access to sovereign debt markets. Specifically, we estimate the main regression equation (1) after adding the natural logarithm of bank size, deposits as a share of liabilities, and loans as a share of assets as control variables. We control for these variables by including interactions between their values as of December 2007 and indicator variables for the main time periods. We use this specification because it follows the setup in our benchmark specification in Table II. Panel A of Table VII presents the results. We find that all coefficients are almost unchanged relative to Table II and remain statistically significant at the 1% level.[37]

We also analyze whether banks' exposure to distressed-sovereign debt *before* the start of the financial crisis predicts LOLR borrowing and collateral. We interpret such exposure as a proxy for whether a bank is specialized in or "optimistic" about distressed-sovereign debt. Due to data constraints, we cannot

likely to occur when the bank would default anyway (e.g., Italian bonds are likely to default when Italian banks default). While foreign bonds may have a higher yield than domestic bonds (e.g., Greek bonds for Italian banks), they are less likely to default at the same time as the bank.

[37] All our results are robust to including time-varying variables instead of the interactions.

Table VII

Bank Rating and LOLR Borrowing (after Controls)

This table examines the effect of bank ratings on ECB borrowing and collateral pledged with the ECB. The unit of observation is at the bank-week level and the sample covers the period from August 2007 to December 2011. All variables are defined in Table II. Panel A includes control variables for bank size, deposit share, and loan share and interactions of these variables with *Post-Greek Bailout*$_t$ and *Post-Lehman*$_t$ (coefficients not shown). Panel B includes two control variables for precrisis exposure to distressed-sovereign debt relative to assets and interactions of these variables with *Post-Greek Bailout*$_t$ and *Post-Lehman*$_t$ (coefficients not shown). All columns include week fixed effects and bank fixed effects. Standard errors in parentheses are double-clustered at the bank and time levels. ***Significant at the 1% level, **significant at the 5% level, and *significant at the 10% level.

Panel A: Controlling for Time-Varying Bank Characteristics

Dependent Variable	Borrowing Indicator$_{it}$ (1)	Log (Borrowing)$_{it}$ (2)	Collateral Rating$_{it}$ (3)	Distressed-Sovereign Debt$_{it}$/Assets$_{i,07}$ (4)
Bank Rating$_{i,07}$ ×	0.039***	0.055***	0.172***	0.219***
Post-Greek Bailout$_t$	(0.012)	(0.021)	(0.046)	(0.071)
Bank Rating $_{i,07}$ ×	−0.013	0.042***	0.015	0.081***
Post-Lehman$_t$	(0.010)	(0.016)	(0.020)	(0.029)
Time fixed effects	Y	Y	Y	Y
Bank fixed effects	Y	Y	Y	Y
Banks	272	272	266	272
Observations	48,144	48,144	43,145	48,144
Within R^2	0.198	0.139	0.106	0.064
Overall R^2	0.484	0.802	0.691	0.679

Panel B: Controlling for Pre-Crisis Distressed-Sovereign Holdings

Dependent Variable	Borrowing Indicator$_{it}$ (1)	Log (Borrowing)$_{it}$ (2)	Collateral Rating$_{it}$ (3)	Distressed-Sovereign Debt$_{it}$/Assets$_{i,07}$ (4)
Bank Rating$_{i,07}$ ×	0.056***	0.064***	0.133***	0.143***
Post-Greek Bailout$_t$	(0.011)	(0.018)	(0.037)	(0.050)
Bank Rating $_{i,07}$ ×	0.012	0.023	0.016	0.035*
Post-Lehman$_t$	(0.013)	(0.015)	(0.018)	(0.021)
Time fixed effects	Y	Y	Y	Y
Bank fixed effects	Y	Y	Y	Y
Banks	269	269	263	269
Observations	47,613	47,613	42,833	47,613
Within R^2	0.189	0.120	0.174	0.141
Overall R^2	0.477	0.798	0.717	0.703

measure precrisis distressed-sovereign debt holdings directly and hence we construct two indirect measures of distressed-sovereign debt exposure. The first measure is based on total holdings of sovereign debt as of December 2007 (relative to total assets) from Bankscope. We assume that a constant fraction of sovereign debt is held in domestic debt.[38] The second measure is total distressed-sovereign debt pledged with the ECB as of August 2007 (scaled by 2007 bank assets). We assume that precrisis distressed-sovereign debt pledged with the ECB is proportional to precrisis holdings of distressed-sovereign debt. We estimate the main regression equation (1) after adding both measures as control variables. As shown in Panel B of Table VII, we find that all coefficients are almost unchanged relative to Table II and remain statistically significant at the 1% level.[39]

In short, we find no evidence that controlling for differences in bank-specific valuations can explain our main findings on LOLR borrowing and collateral.

E.2. Do the Results Hold for Large Banks?

Our benchmark specification uses the sample of banks that have at least one credit rating (284 banks). We also examine whether our results hold for the subsample of publicly listed banks (58 banks). These banks are important for assessing the impact of risk-taking at the aggregate level because they represent approximately 54% of total bank assets. Moreover, they may have had better market access and therefore more opportunities to take risk. We thus estimate the main regression equation (1) for the sample of publicly listed banks.

We present the results in Table VIII. We find that the effect of credit ratings on LOLR borrowing and collateral risk is at least twice as large as for the main sample. As shown in columns (1) and (2), a one-standard-deviation decrease in a bank's precrisis credit rating raises the likelihood of borrowing by 18.1 percentage points and the amount of borrowing by 65%, respectively. As shown in columns (3) and (4), it also reduces the average collateral rating by 58% of a standard deviation and raises the pledging of distressed-sovereign debt relative to assets by 94% of a standard deviation.

E.3. Do the Results Hold for CDS Rates?

Our main measure of a bank's default risk is its credit rating. We use this measure because it is available for a broad cross-section of banks. Alternatively, one can also use a bank's CDS rate to estimate the impact of default risk on risk-taking. We note, however, that CDS rates are only available for large banks (29 banks) and most of these banks were considered safe before the financial

[38] Even though we cannot verify this assumption independently, related work suggests that this assumption is plausible (Gennaioli, Martin, and Rossi (2014)).

[39] In addition to LOLR lending, the ECB also engaged in purchases of distressed-sovereign debt under the Securities Market Program (SMP). The results are robust to controlling for these purchases. Using data on the timing of SMP purchases, we find that the effect of bank ratings on LOLR borrowing and collateral is independent of SMP purchases.

Table VIII

Bank Rating and LOLR Borrowing (Sample of Publicly Listed Banks)

This table examines the effect of bank ratings on ECB borrowing and collateral pledged with the ECB. The unit of observation is at the bank-week level and the sample is publicly listed banks (58 banks) over the period August 2007 to December 2011. All variables are defined in Table II. All columns include week fixed effects and bank fixed effects. Standard errors in parentheses are double-clustered at the bank and time levels. ***Significant at the 1% level, **significant at the 5% level, and *significant at the 10% level.

Dependent Variable	Borrowing Indicator_{it} (1)	Log $(\text{Borrowing})_{it}$ (2)	Collateral Rating_{it} (3)	Distressed Sovereign $\text{Debt}_{it}/\text{Assets}_{i,07}$ (4)
$\text{Bank Rating}_{i,07}$ ×	0.095***	0.342***	0.443***	0.886***
$\text{Post-Greek Bailout}_t$	(0.027)	(0.068)	(0.130)	(0.286)
$\text{Bank Rating}_{i,07}$ ×	0.037**	0.146***	−0.032	0.387***
Post-Lehman_t	(0.018)	(0.041)	(0.036)	(0.126)
Time fixed effects	Y	Y	Y	Y
Bank fixed effects	Y	Y	Y	Y
Banks	58	58	58	58
Observations	10,262	10,262	10,071	10,262
Within R^2	0.107	0.153	0.264	0.190
Overall R^2	0.472	0.652	0.685	0.765

crisis. Hence, there is little variation in CDS rates before the crisis, making it difficult to estimate the effect of precrisis default risk on LOLR borrowing and collateral.

However, over the course of the financial crisis even large banks became risky. Our previous results establish that banks increased risk-taking after the start of the sovereign debt crisis in early 2010. Hence, we can measure bank risk using CDS rates as of January 2010 (rather than August 2007). This approach assumes that bank risk as of January 2010 is a good proxy for risk-taking incentives after January 2010. We estimate the main regression equation (1) for the sample of banks with traded CDS rates and measure bank financial strength using the natural logarithm of CDS rates as of January 2010.

We present the results in Table IX. We find that the effect of bank CDS rates on LOLR borrowing and collateral is similar to the effect of bank credit ratings for publicly listed companies. As shown in columns (1) and (2), a one-standard-deviation decrease in a bank's precrisis CDS rate raises the likelihood of borrowing by 9.2 percentage points and the amount of borrowing by 69%, respectively. As shown in columns (3) and (4), it also reduces the average collateral rating by 84% of a standard deviation and raises the pledging of distressed-sovereign debt relative to assets by 79% of a standard deviation.

E.4. Do the Results Hold for Excess LOLR Collateral?

A number of banks pledged collateral in excess of their borrowing. The benefit of doing so was that it gave banks access to ECB borrowing on short notice.

Table IX

CDS Prices and LOLR Borrowing

This table examines the effect of CDS prices on ECB borrowing and collateral pledged with the ECB. The unit of observation is at the bank-week level and the sample is publicly listed banks with CDS rates (30 banks) for the period August 2007 to December 2011. Log(*CDS*) is the natural logarithm of the CDS rate as of January 4, 2010. All other variables are defined in Table II. All columns include week fixed effects and bank fixed effects. Standard errors in parentheses are double-clustered at the bank and time levels. ***Significant at the 1% level, **significant at the 5% level, and *significant at the 10% level.

Dependent Variable	Borrowing Indicator$_{it}$ (1)	Log (Borrowing)$_{it}$ (2)	Collateral Rating$_{it}$ (3)	Distressed Sovereign Debt$_{it}$/Assets$_{i,07}$ (4)
Log(CDS)$_{i,10}$ ×	0.233**	1.527***	2.501***	2.955***
Post-Greek Bailout$_t$	(0.116)	(0.391)	(0.717)	(0.992)
Log(CDS)$_{i,10}$ ×	0.086	1.000***	–0.169	1.883***
Post-Lehman$_t$	(0.096)	(0.204)	(0.267)	(0.728)
Time fixed effects	Y	Y	Y	Y
Bank fixed effects	Y	Y	Y	Y
Banks	30	30	30	30
Observations	5,310	5,310	5,234	5,310
Within R^2	0.158	0.139	0.407	0.216
Overall R^2	0.497	0.589	0.721	0.816

However, there was also a cost because collateral pledged with the ECB could not be pledged elsewhere. The risk-taking theory implies that banks engaged in risk-taking decrease such excess collateral in order to maximize risk-taking.[40] In contrast, classical LOLR theory makes no clear prediction regarding excess LOLR collateral. We therefore analyze the effect of bank credit ratings on excess collateral using our main regression equation (1). We measure excess collateral as the natural logarithm of borrowing relative to collateral.

Table X presents the results. We find that weakly capitalized banks pledged less excess collateral. Column (1) shows that a one-standard-deviation decrease in a bank's precrisis credit rating reduces excess collateral by 36%. This result is robust to controlling for time-country fixed effects (column (2)) and restricting the sample to banks located in nondistressed countries (column (3)). These results supports the risk-taking theory.

IV. Aggregate Implications

Since our sample captures the universe of banks in Europe, we are able to examine how the distribution of risky collateral changes within the overall banking system during the financial crisis. Following our earlier analysis, we measure risky collateral using distressed-sovereign debt. We also look at all

[40] Dynamic considerations may still make some buffer desirable.

Table X

Bank Rating and Excess LOLR Collateral

This table examines the effect of bank ratings on excess collateral pledged with the ECB. The unit of observation is at the bank-week level and the sample covers the period from August 2007 to December 2011. The outcome variable *Borrowing/Collateral* is the natural logarithm of total borrowing relative to collateral. All other variables are defined in Table II. All columns include bank and week fixed effects. Column (2) also includes country-time fixed effects (similar to Table IV). Column (3) restricts the sample to banks headquartered in nondistressed countries (similar to Table V). Standard errors in parentheses are double-clustered at the bank and time levels. ***Significant at the 1% level, **significant at the 5% level, and *significant at the 10% level.

Dependent Variable	$\text{Borrowing/Collateral}_{it}$	$\text{Borrowing/Collateral}_{it}$	$\text{Borrowing/Collateral}_{it}$
Sample	All	All	Nondistressed
	(1)	(2)	(3)
$\text{Bank Rating}_{i,07}$ ×	0.188***	0.141***	0.168***
$\text{Post-Greek Bailout}_t$	(0.058)	(0.054)	(0.062)
$\text{Bank Rating}_{i,07}$ ×	0.103**	0.092*	0.090**
Post-Lehman_t	(0.041)	(0.048)	(0.045)
Time fixed effects	Y	Y	Y
Bank fixed effects	Y	Y	Y
Country-time fixed effects	N	Y	N
Banks	281	281	213
Observations	28,830	28,830	21,306
Within R^2	0.096	0.064	0.185
Overall R^2	0.551	0.632	0.606

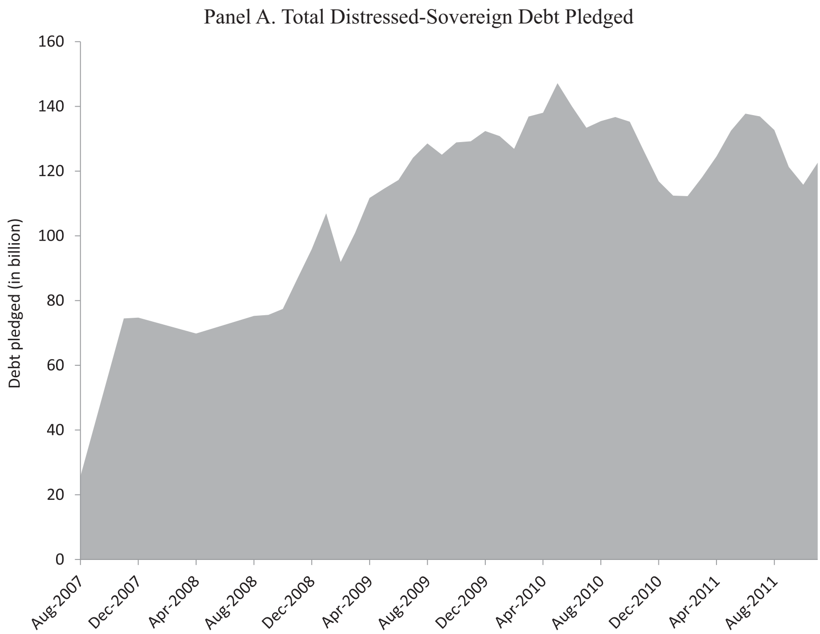
debt originated in the distressed countries to get a broader measure of risky collateral.

To analyze the distribution of risky collateral within the banking system, we split the sample of banks into two groups based on their credit rating. We choose the credit rating threshold for this split so that each group pledges about 50% of total distressed-country sovereign debt collateral as of the beginning of 2010. This corresponds to a credit rating cutoff of AA−.

Panel A of Figure 5 plots total distressed-sovereign debt pledged as collateral over the sample period by all banks that have a credit rating.[41] As the figure shows, the total distressed-sovereign debt collateral pledged by the banking system started at around €74 billion in October 2008, reached €119 billion by July 2009, and then fluctuated around this value over the remainder of the sample. Hence, viewed at the level of the aggregate banking system, there was little variation in the exposure of the LOLR to total distressed-sovereign debt.

A different picture emerges when we look at the breakdown across the two groups of banks, as revealed by Panel B of Figure 5. As of the end of 2009, weakly capitalized banks pledged €59 billion, while strongly capitalized banks pledged €73 billion. However, starting in early 2010, there was a steady migration of distressed-sovereign debt from strongly capitalized to weakly capitalized banks. By the end of 2011, the weakly capitalized banks increased their

[41] Collateral pledged by rated banks is about 80% of the total for the entire banking system.



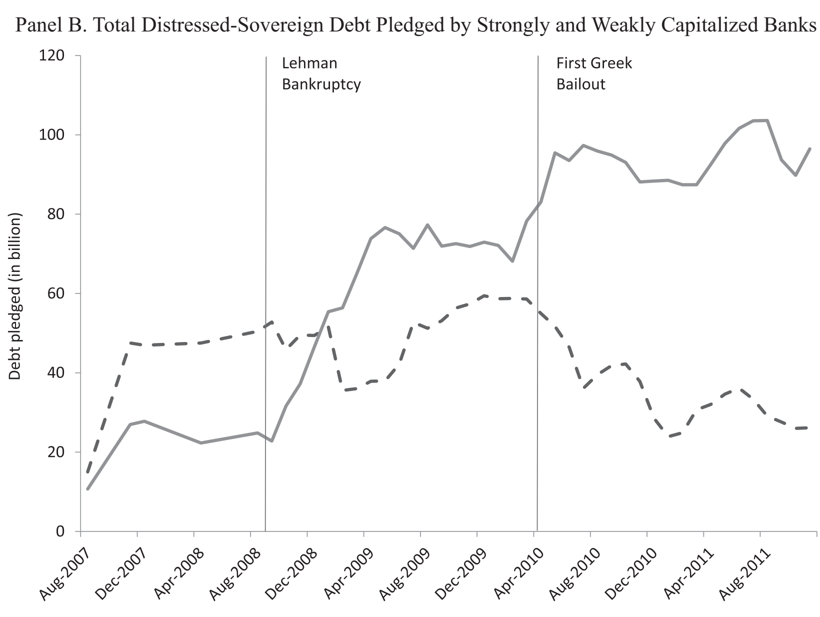


Figure 5. Reallocation of distressed-sovereign debt. Panel A of the figure plots total distressed-sovereign debt pledged with the ECB during the sample period. Panel B plots total distressed-sovereign debt pledged with the ECB by banks with credit ratings of AA– or higher (strongly capitalized banks, dashed line) and banks with credit ratings lower than AA– (weakly capitalized banks, solid line) as of August 2007.

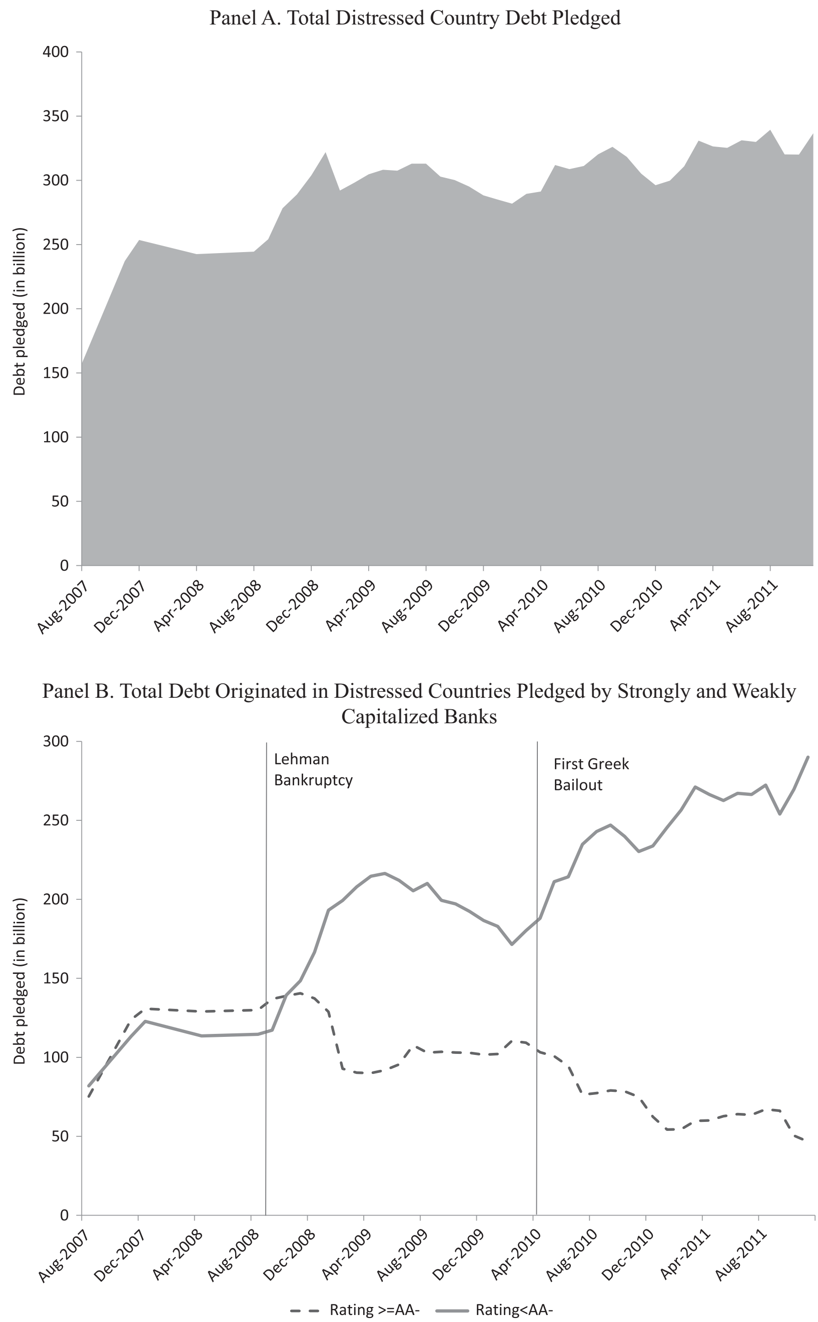


Figure 6. Reallocation of distressed-country originated debt. Panel A of the figure plots total debt originated in distressed countries and pledged with the ECB during the sample period. Panel B plots total debt originated in distressed countries and pledged with the ECB by banks with credit ratings of AA− or higher (strongly capitalized banks, dashed line) and banks with credit ratings lower than AA− (weakly capitalized banks, solid line) as of August 2007.

pledging to €86 billion, while the strongly capitalized banks decreased their pledging to around €33 billion.

Panels A and B of Figure 6 show a similar pattern for all debt originated in the distressed countries, which includes covered bonds, mortgage-backed securities, and asset-backed securities. Aggregate distressed-country debt collateral was on average at €324 billion, but again there was a strong reallocation from strongly capitalized banks to weakly capitalized banks. Over the sample period pledging by weakly capitalized banks increased from about €164 to €255 billion, while pledging by strongly capitalized banks decreased from €124 billion to €77 billion.

These findings indicate that the LOLR intervention facilitated a redistribution of risk within the banking system from strongly to weakly capitalized banks. From the point of view of LOLR theory this result is alarming. One would have hoped instead that the opposite occurs, that over time the strongest banks would buy up risky assets from the weaker ones. Concentrating risky assets in the weakest banks poses several hazards. It raises the likelihood of individual bank failures and increases the risk of a systemic crisis. It also makes resolving weak banks costlier should they end up failing. Finally, it redistributes risky assets toward distressed countries, further increasing their sovereign risk.

V. Conclusions

An important mandate of central banks is to act as an LOLR during financial crises. This role is motivated by the idea that providing direct lending to banks can stop panic-based bank runs and prevent a costly credit crunch. However, a troubling concern for an LOLR is that banks may borrow for other reasons, which may lead to an inefficient allocation of capital.

We examine the LOLR intervention undertaken by the ECB during the European financial crisis. We show that, starting in May 2010, weakly capitalized banks borrowed more from the ECB and used riskier collateral than strongly capitalized banks. We also find that weakly capitalized banks used LOLR loans to actively invest in risky assets, leading to an aggregate reallocation of risky assets to weak banks. Our findings cannot be explained by classical LOLR theory based on panic-based runs. Instead, they point toward risk taking by banks, both independently and with the encouragement of regulators.

Our results have several implications for the theory and practice of the LOLR. First, they imply that following the prescriptions of standard LOLR theory can entail significant costs. These costs come from an inefficient allocation of capital as weak banks use LOLR funding to make risky investments. The resulting accumulation of risky assets at weak banks increases the likelihood of a systemic crisis and the subsequent cost of resolving it. If these costs are sufficiently large, an LOLR intervention might actually end up exacerbating a financial crisis.

Second, our results raise the question of whether LOLR practice can be modified to diminish the costs while retaining the benefits. A natural implication of our results is that the LOLR can reduce the costs by directly addressing the risk-taking incentives. This can be done by restructuring or recapitalizing banks. Our results further indicate that both observable measures of market risk and the dynamics of banks' behavior during a crisis can be used to help identify banks with risk-taking incentives.[42]

Third, our findings raise the question of what is the optimal LOLR policy in the presence of risk-shifting incentives. Our results suggest that LOLR interventions facilitate the reallocation of risky securities to weak banks. This effect is missing from most theories of LOLR, which typically focus on an aggregate financial sector with a single representative bank. Hence, our results point to a need for further work on the theory of optimal LOLR design.

Fourth, our results raise questions about the optimal design of an LOLR intervention in a currency union. While the theory of LOLR focuses on banks, governments may also face a liquidity shortage and require an LOLR intervention. This can occur if there are inefficient equilibria in which investors' expectations of government default are self-fulfilling. The political economy explanation suggests that this type of concern may have motivated the central bank's intervention during the crisis.[43] Hence, there is a need for theoretical work on the optimal design of LOLR intervention in this setting.

Fifth, it is possible that the recommendations of LOLR theory were not properly implemented. In Europe, access to the LOLR was determined by national bank regulators and not the ECB. This is in contrast to the United States, where the Federal Reserve is both the LOLR and the main bank supervisor. Since losses on LOLR lending are shared across countries, national bank regulators have an incentive to provide access to the LOLR even for banks with risk-shifting incentives. At the same time, the benefits of extending help to these banks accrue mostly at the national level. This interpretation of our results indicates that bank supervision and LOLR lending should reside within a single entity.[44]

Finally, we emphasize that our results do not imply that LOLR interventions are welfare reducing. The reason is that the interventions' benefits, such as avoiding inefficient bank runs and a credit crunch, are likely to be large. Therefore, a central question is what are the *net* benefits of the intervention. The literature has not answered this question. We view our work as a first step in this direction.

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[42] We recognize that following a policy of monitoring would itself change the equilibrium as risk-taking banks would respond by attempting to avoid detection.

[43] However, this response is very unlikely to have been an efficient way to deal with the problem in light of the resulting reallocation of risky securities into weak banks. Yet, it is possible that institutional constraints prevented the ECB from implementing more efficient policies.

[44] Agarwal et al. (2013) document a similar dynamic in the United States, where state bank supervisors provide more favorable assessments than federal bank supervisors for the *same* bank. Kashyap (2010) discusses this issue in the context of bank regulation in the United States.

Appendix: Variables Definition and Data Sources

Variable	Definition	Source
Bank Characteristics		
Total Assets	Total book assets	Bankscope, SNL Financial
Book Equity (Euro bil)	Total book equity	Bankscope, SNL Financial
Book Leverage	(Book assets − book equity)/book equity	Bankscope, SNL Financial
Market Leverage	(Book assets − market equity)/market equity	Bankscope, Datastream
CDS Price	Credit default swap price	Datastream
Bank Rating	Median bank rating based on Moody's, S&P, and Fitch Ratings	ECB
Loan Share; Deposit Share	Loans/assets; Deposits/assets	Bankscope, SNL Financial
Equity/Assets	Book equity/assets	Bankscope, SNL Financial
Tier-1 Ratio	Tier-1 capital/risk-weighted assets	Bankscope, SNL Financial
Located in Distressed Sovereign	Bank headquartered in distressed country (Cyprus, Greece, Ireland, Italy, Malta, Portugal, and Spain)	ECB
Central Bank Borrowing		
Any Borrowing (Yes = 1)	Indicator variable for whether a bank borrows from the ECB	ECB
Total Borrowing (Euro bil)	Total borrowing from the ECB	ECB
Log(Borrowing)	Natural logarithm of (1+Total borrowing)	ECB
Borrowing/Book Equity	Total borrowing/book equity	ECB, Bankscope
Borrowing/Collateral	Total borrowing/collateral	ECB
Collateral		
Any Collateral (Yes = 1)	Indicator variable whether a bank pledges collateral with ECB	ECB
Collateral Pledged (Euro bil)	Collateral pledged with ECB	ECB
Collateral/Book Equity	Collateral/book equity	ECB, Bankscope
Haircut	Value-weighted haircut on collateral	ECB
Rated Share (%)	Share of collateral this is rated	ECB
Average Rating	Market value-weighted rating of collateral (AAA = 1, AA+ = 2, etc. . . .)	ECB
Distressed Sovereign Debt	Sovereign debt issued by distressed countries	ECB

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