# Who Borrows from the Lender of Last Resort?*

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**Abstract**

We analyze the Lender of Last Resort (LOLR) intervention undertaken by the European Central Bank from 2007 to 2011. Using a novel dataset on all central bank borrowing and collateral, we show that weakly-capitalized banks (i) borrowed more from the central bank, and (ii) used riskier collateral to do so. These relationships emerged only after beginning of the sovereign debt crisis in early 2010, and strengthened thereafter. They hold both across and within countries, for banks located outside distressed countries, when bank capital is measured pre crisis, and for different types of risky collateral. We further show that weakly-capitalized banks used LOLR loans to actively invest in risky assets, leading to an aggregate reallocation of risky assets in the financial sector. Our findings are at odds with classical LOLR theory, pointing instead to risk taking by banks.

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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 and provided the motivation behind the establishment of central banks such as the Federal Reserve. Given their magnitude and central role in policy, it is important to understand how these interventions impact the financial system and, ultimately, the economy. This question is particularly relevant in recent times, as governments around the world responded to the 2008 financial crisis by engaging in unprecedented large-scale LOLR interventions.

In this paper we examine which types of banks borrow from the LOLR and analyze the forces driving them to do so. The answers to these questions are important for understanding the benefits and costs of LOLR interventions. If banks borrow from the LOLR in order to reduce costly asset liquidations, then LOLR interventions will help alleviate the resulting contraction in bank lending ("credit crunch") and greatly reduce the impact of financial crises. This is the scenario envisaged by classical LOLR theory. However, if banks borrow LOLR funds for other reasons, such as to increase risk taking at the expense of creditors (i.e.,"risk shifting"), or because of regulatory pressure, then LOLR interventions will do little to mitigate financial crises.

Our analysis focuses on the take-up of LOLR lending during the European financial crisis that began in 2008. This setting is almost ideal for our analysis because LOLR lending was the European Central Bank's (ECB) main tool for dealing with the financial crisis in Europe. This LOLR intervention was arguably the largest, and certainly the longest-lasting, LOLR program ever conducted. Moreover, the ECB's implementation of the intervention largely followed the recommendations of LOLR theory. That is, the ECB provided unlimited lending to a large set of banks, but only at penalty rates, and against collateral that was good prior to the crisis.[1] Hence, we think this setting is both important in its own right and well-suited to understanding the impact of LOLR interventions more generally.

[1]This structure follows Bagehot's famous dictum which recommends that, "to avert crisis, central banks should lend early and freely (i.e., without limit) to solvent firms, against good collateral, at high rates." Good collateral is understood to be "everything which in common times is a good 'banking security"' (Bank of England (2009)).

Our analysis is based on a novel, proprietary dataset which contains weekly bank-level records of all banks' ECB borrowing, together with 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. Our sample covers the universe of banks in Europe from August 2007 until December 2011. To the best of our knowledge, this is the first paper to use such detailed bank- and security-level data to analyze a LOLR intervention.

Our analysis yields three main findings. The first finding is that weakly-capitalized banks borrowed more from the LOLR and pledged riskier collateral against LOLR borrowing. This cross-sectional pattern emerged in May 2010 and strengthened steadily thereafter. The starting date is significant because it is the time when the financial crisis that began in September 2008 also turned into a sovereign debt crisis. We therefore interpret the start of the sovereign crisis as a shock that triggered demand for LOLR funding among weakly-capitalized banks.

The effect of bank capital on LOLR borrowing is economically large. We measure a bank's capital using its credit rating before the start of the financial crisis.[2] We find that a one-standard deviation decrease in a bank's pre-crisis credit rating predicts an 11.8 percentage point increase in the likelihood of LOLR borrowing and a 15.1% increase in the amount of LOLR borrowing after May 2010. It also predicts a reduction of a third of a notch in the bank's value-weighted average collateral rating and an increase in its pledging of distressed-sovereign debt (Greece, Italy, Ireland, Portugal, and Spain) of 40 basis points.[3] These results account for 24%, 19%, 22% and 25% of the standard deviation of each respective outcome measure.

These relationships between bank rating, borrowing, and collateral riskiness are robust

[2]We choose banks' credit ratings because they are available for a wide cross-section of banks. We measure the ratings before the start of the financial crisis (as of August 2007) because measures of bank capital during the crisis may also reflect the market's concerns about banks' exposures.

[3]Throughout the paper, we define distressed countries as the ones which were downgraded below 'AA' after the onset of the sovereign crisis in early 2010 (Greece, Ireland, Italy, Portugal, and Spain). We refer to their debt as distressed-sovereign debt.

to controlling for country–specific trends, restricting the sample to only non-distressed countries, and controlling for bank characteristics. Specifically, the effect of credit rating on LOLR borrowing is statistically significant, though 30% smaller, for the sample of banks located outside the distressed countries. Similarly, the coefficient on bank rating remains statistically significant (though it decreases by 32%) if we control for non-parametric country-specific time trends, by including a full set of country-week fixed effects. The results are almost unchanged if we control for observable characteristics such as bank size, funding structure, and pre-crisis distressed-country sovereign debt collateral.

Our second finding is that banks used LOLR funding to invest in *risky* assets. We use panel data from the European bank stress tests to examine if increases in banks' distressed-sovereign debt collateral are associated with increases in their holdings of this debt. We find that a 10% increase in a bank's pledging of this collateral is associated with a statistically significant 4.5% increase in its corresponding holdings. Moreover, we find that this positive relationship is driven entirely by the weakly-capitalized banks. This result shows that weakly-capitalized banks used LOLR funding to increase their asset holdings, not just to finance their existing ones.

Our third finding is that, in aggregate, risky collateral migrated from strongly- to weakly-capitalized banks over the course of the crisis. We find that after May 2010 about a third of the distressed-sovereign debt pledged with the ECB moves from strongly- to weakly-capitalized banks. We find a similar transition for the larger set of distressed-country-originated debt, which also includes mortgage-backed securities, covered bonds, and other debt instruments. These results indicate that LOLR financing facilitated the migration of risky assets within the financial sector, from strongly- to weakly-capitalized banks.

Our main findings are inconsistent with the predictions of classical LOLR theory. Under classical LOLR theory, banks borrow from the LOLR to avoid fire sales of their existing asset holdings. By avoiding such fire sales, banks are able to continue lending to firms and households, which prevents a credit crunch. Under this scenario, LOLR funding goes to finance existing asset holdings, not to making new investments in risky securities. Moreover,

classical LOLR theory does not predict that *pre-crisis* bank capital should predict banks' LOLR borrowing and collateral riskiness, especially if one looks only outside of the distressed countries, or only compares banks within countries.

Instead, our findings suggest that weakly-capitalized banks engaged in risk shifting. This theory predicts that weakly-capitalized banks use LOLR financing to invest in risky assets whose downside is correlated with the banks' own default. This prediction is consistent with banks' use of LOLR funding to invest in distressed-sovereign debt. Moreover, because a bank's capital *before* the crisis proxies for its risk-shifting incentives during the crisis, it should predict the bank's LOLR borrowing and collateral riskiness.

Our findings further suggest that risk shifting may have been encouraged by regulatory and political forces. There is anecdotal evidence that regulators in the distressed countries encouraged their banks to use LOLR lending to purchase their home-country's sovereign debt. Consistent with this interpretation, the effect of bank capital on LOLR borrowing is larger for the distressed countries–where regulators had an incentive to pressure banks–and significant for distressed-sovereign debt, which was the regulator's focus. Moreover, because weakly-capitalized banks rely more on regulator's approval, they are likely to be susceptible to regulatory pressures, consistent with our finding that the relationships to bank capital hold even within countries.

We find no evidence that differences in banks' private valuations of risky assets help to explain our findings, as our results are remarkably robust to controlling for proxies of banks' business models, expertise in certain types of assets, or their level of "optimism" about assets' payoffs. The results on sovereign debt further suggest that differences in expertise are unlikely to explain our findings because sovereign debt is not usually associated with particular banking expertise (in contrast to certain types of firm or household lending).

In summary, our results reflect the effect of banks' risk-taking incentives in combination with regulatory forces. The aggregate result is the migration of risky assets to weakly-capitalized banks. From the point of view of classical LOLR theory, this result is undesirable because it increases the risk of a systemic crisis due to a run on weak banks, and raises the cost

of resolving such banks if they default.[4] However, it could still viewed as a favorable outcome by distressed-country governments, or even the ECB, as a practical means of avoiding a sovereign default or the break-up of the Eurozonek, which may be very costly. Moreover, LOLR lending may have prevented costly bank failures in the meantime and potentially sustained productive lending by strongly-capitalized banks.

We therefore emphasize that our results do *not* imply that LOLR lending is unnecessary. Instead, our results suggest that central banks should directly address banks' risk-shifting incentives when providing LOLR funding, possibly through restructuring or recapitalizing poorly-capitalized banks. We further note that the ECB faces institutional constraints in restructuring and recapitalizing banks because these actions are part of bank supervision, which are carried out by national regulators. Our analysis therefore suggests that these functions should be unified in a single entity such as in the U.S. ("banking union"), where the Federal Reserve is both bank supervisor and LOLR.

The remainder of the paper is organized as follows. Section 1 discusses the literature. Section 2 describes the institutional background and provides summary statistics. Section 3 discusses LOLR theory. Section 4 presents our empirical strategy and reports the results. Section 5 analyzes the aggregate, cumulative impact of our findings. Section 6 discusses the implications of our findings for LOLR theory. Section 7 concludes.

# 1 Relation to the Literature

This paper relates to the theory of the LOLR. This literature goes back to the seminal work by Thornton (1802) and Bagehot (1873), who were the first to formulate a specific role for central banks in the provision of financing in times of financial crisis. The theory posits that central banks can mitigate a market friction or failure, such as information asymmetries

[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 for deposits above €100,000 were estimated to be 60% to 100%. Consistent with the risk-shifting theory, a forensic accountants' report on Cyprus's largest bank, Bank of Cyprus, shows that large losses arose because "Bank of Cyprus was speculating on Greek debt with money borrowed from the ECB."(New York Times, "Cyprus Bailout Revisited", May 7, 2013).

between lenders and borrowers, or an inability of lenders to coordinate, which is particularly acute during financial crises. Bagehot's (1873) advice is often summarized as follows: "to avert panic, central banks should lend early and freely (i.e., without limit) to solvent firms, against good collateral, and at high rates" (Bank of England (2009)). Following this advice, most central banks have adopted a policy to lend freely to solvent but illiquid institutions during financial crises. Indeed, Goodhart (1988) argues that the original motivation for creating central banks in many countries was to contain financial crises.

A large theoretical literature has re-examined the question of whether, and how, central banks should intervene during times of financial crises. Goodfriend and King (1988) argue that in developed economies the efficiency of the money markets implies that solvent banks should always be able to obtain funding liquidity. They therefore suggest that central banks should restrict themselves to regular open market operations. Goodhart (1995) argues that the distinction between illiquidity and risk-shifting is a myth because banks requiring a LOLR intervention have to be under suspicion of being insolvent. However, he argues that the existence of contagion may justify the rescue of a bank during times of crisis. In contrast, Flannery (1996) argues that aggregate liquidity provision is not sufficient, and that a LOLR must provide lending to individual banks. Rochet and Vives (2004) provide a formal model justifying Bagehot's advice of lending only to illiquid banks. In their model, illiquid banks may not have access to funding markets because of bank runs as in Diamand and Dybvig (1983). Allen and Gale (2000) and Diamond and Rajan (2005) argue that, due to interconnectedness in the banking sector, a liquidity shock at one bank could propagate through the financial system. This provides a rationale for LOLR liquidity provision to all banks during a crisis.

Several authors argue that a LOLR can have positive effects. Miron (1986), Bordo (1990), and Eichengreen and Portes (1987) find empirically that the creation of a LOLR helps to prevent bank crises. In a similar spirit, Friedman and Schwartz (1963) argue that a series of bank failures during the Great Depression produced an unprecedented decline in the money stock that could have been prevented by a LOLR. Meltzer (1986) makes a

similar argument and suggests that "the worst cases of financial panics arose because Central Banks did not follow Bagehotian principles." Bernanke (1983) argues that the destruction of informational bank capital due to bank failures deepened the downturn during the Great Depression. Bernanke and Gertler (1989), Bernanke, Gertler, and Gilchrist (1999) and Kiyotaki and Moore (1997) model a "financial accelerator", a self-reinforcing cycle whereby binding collateral constraints limit the supply of credit to firms and thereby amplify the real effects of a negative macroeconomic shock. LOLR intervention can dampen this cycle by relaxing collateral constraints and eliminating the need for fire sales.[5]

Other studies, however, point out that LOLR lending can exacerbate and prolong financial crisis. Caballero, Hoshi, and Kashyap (2008) examine the phenomenon of zombie lending in Japan. They show that the Japanese government allowed insolvent banks to continue to operate, which encouraged them to continue to lend to insolvent firms. In other words, banks did not restructure their portfolios to maximize firm value, which amounts effectively to risk-shifting (or an unwillingness to reduce risk). Similarly, the U.S. government severely magnified the 1980s Savings and Loan crisis because it let insolvent banks continue to operate, which encouraged them to increase their risk exposure. Using data on 104 failing banks across multiple countries, Goodhart and Schoenmaker (1995) find evidence that central banks have a strong tendency to bail out, rather than liquidate, banks in financial distress. Diamond and Rajan (2011) show that impaired banks have an incentive to hoard illiquid assets if the likelihood of a financial crisis is high.

Finally, our paper relates to the literature on the role of a LOLR in sovereign debt crises. The literature on sovereign debt shows that sovereign debt crises can arise from multiple equilibria similar to Diamond and Dybvig (1983), some of which may be inefficient and could be avoided with a LOLR (e.g., Sachs (1984), Calvo (1988)). Fischer (2000) argues that, consequently, a global financial system requires an international LOLR. Jeanne and Wyplosz (2001) suggest that an international LOLR has to be closely involved in the supervision of banks. Bolton and Skeel (2005) discuss how to design an international LOLR that trades off

[5]Shleifer and Vishny (2011) provide an excellent overview of the central role of fire sales in finance and macroeconomics.

bailouts and sovereign debt restructuring.

# 2 Setting and Data

## 2.1 Institutional Background

The ECB acts as the LOLR in Europe. It does so by providing loans to banks. We first describe how the ECB interacts with banks during regular times and then detail its role as a LOLR during the financial crisis that started in 2008.

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 which kind of collateral is 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. The criteria are the same for all banks in the Europe. Broadly speaking, ECB-eligible collateral is euro-denominated investment-grade debt, such as sovereign debt, mortgage-backed bonds, covered bonds, bank bonds, and corporate bonds. Riskier collateral is penalized with a higher haircut because collateral is meant to protect the lender from default risk on the loan.

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 a proprietary model to value assets.[6] 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.

[6]The ECB maintains that the valuations are in line with those of other market participants. Some outside observers have raised concerns that ECB valuations of illiquid assets are too high (Der Spiegel, "Europe's Central Bad Bank: Junk Bonds Weigh Heavy on ECB", June 6, 2011). To the extent that this is the case, it increases the effective benefits provided by the ECB to banks that use such securities.

The ECB then has the right to seize and liquidate the collateral.

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. Financial soundness is determined by the national bank supervisor 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. 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 face a completely elastic supply curve) as long as they provide sufficient collateral. The interest rate (sometimes referred to as the policy rate) is the same for all loans. The change in the ECB's policy was intended to increase bank funding in times of crisis and marks the start of unlimited LOLR lending in the Euro area.

As in private markets, the haircut on an ECB loan depends on the type of collateral used, but *not* on the specific borrowing bank. In regular times, ECB haircuts are similar to market haircuts but during the financial crisis the ECB started offering haircuts that were smaller than those in private markets. In particular, ECB haircuts were smaller than private-market haircuts for relatively risky securities, such as mortgage-backed securities, covered bonds, and distressed-sovereign debt. In contrast, they were equal to, or slightly larger than, market haircuts for very safe securities. This is the case because ECB haircuts vary less with asset quality than do private-market haircuts. For instance, at the end of 2010 the ECB's haircut on (risky) Portugal government bonds was 4.00%, while the haircut applied to these bonds by LCH Clearnet, a private repo exchange, was 10.00%. In contrast, the ECB's haircut on (very safe) 5-year German Bunds was 3.00%, while LCH Clearnet's haircut was 2.00%.

The difference between ECB and private-market haircuts created incentives for banks to

[7]The ECB maintains a complete list of banks that can participate in open market operations on its website. The updated list is available at `https://www.ecb.europa.eu/stats/money/mfi/general/html/elegass.en.html`.

pledge risky assets with the ECB. A stark example of such pledging is the case of Greek sovereign bonds. Panel A of Figure 2 plots the average haircut charged by the ECB on Greek sovereign debt over the sample period, together with a plot of the (log) CDS price on Greek government debt. The plot shows that the average ECB haircut on these bonds was below 8% throughout this period, even as Greek CDS price increased dramatically. Panel B of Figure 2 shows that, consequently, Greek sovereign bond collateral largely migrated from private markets to the ECB.

We call the difference between a security's private-market and ECB haircut its "haircut subsidy". Hence, risky securities carry high haircut subsidies, while safe assets carry little or no subsidy. In contrast, the interest rate charged by the ECB on loans secured with risky assets is *higher* than the interest rate that prevails in private repo markets. This higher interest rate is the *cost* of obtaining the haircut subsidies and represents a penalty rate for borrowing from the LOLR instead of private markets. Hence, the take-up of ECB haircut subsidies is not free and carries a cost in the form of a higher interest rate.

This structure for LOLR lending is considered best practice in central banking. It follows Bagehot's famous dictum which recommends that, "to avert crisis, central banks should lend early and freely (i.e., without limit) to solvent firms, against good collateral, at high rates". It is also in line with the desire of the LOLR to intervene in markets to support bank lending. The reason is that for an intervention to have any impact, it must somewhere provide a subsidy–the below-market haircuts in this case–relative to private markets. Without a subsidy, LOLR lending would have no effect because banks would only use private market funding.

Since October 2008, the ECB modified the collateral framework several times to widen the pool of risky assets eligible as collateral. These assets were usually assigned a low haircut relative to private markets. Our understanding is that these changes were limited and did not affect a significant part of the collateral pool. To the extent that the changes were significant for some banks, they increased the set of risky assets with haircut subsidies.[8]

[8]The list of eligible collateral is available on the ECB website at *https://www.ecb.europa.eu/paym/coll/assets/html/index.en.html*

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.[9]

Some observers have expressed the concern that the ECB may claim superseniority on sovereign debt collateral in case of a sovereign default. Even though the ECB has explicitly stated that it will not do so, one cannot completely rule out this possibility.[10] In this case, the counterparty risk of ECB loans against sovereign debt may be partially borne by other unsecured creditors, such as national deposit insurance funds. This has no effect on our empirical methodology (described below) because we analyze the take-up of LOLR lending independently of how any ultimate losses are divided between the ECB and other unsecured creditors.[11]

## 2.2 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 conducting open market operations. The dataset covers the period August 2007 to December 2011. From October 2008 until December 2011 the dataset contains the full set of weekly observations. Prior to that time the data are recorded intermittently. We do not have earlier data because

[9]The ECB suffered losses on its past lending. For example, Lehman Brothers took out an ECB loan of €8.5 billion before its default in September 2008. The collateral on the loan was insufficient and the ECB suffered a loss of €5.7 billion.

[10]This concern was partly prompted by the restructuring of Greek debt in March 2012. During the restructuring, the ECB did not take losses on its direct holdings of Greek debt. However, there was no superseniority with respect to collateral and collateral was revalued using market prices. In September 2012, the ECB explicitly affirmed its lack of superseniority in the context of its sovereign debt purchase program: "The Eurosystem intends to clarify ... that it accepts the same (pari passu) treatment as private or other creditors with respect to bonds issued by euro area countries ..." (European Central Bank (2012)).

[11]It may, however, affect a welfare analysis of the LOLR intervention that depends on how losses are distributed in case of a sovereign default.

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 a LOLR intervention.[12]

The ECB assigns each bank a unique identifier and consolidates all data at the level of bank headquarters. The dataset reports total ECB borrowing by type of operation.[13] The data set further provides security-level information by bank on all collateral pledged with the ECB. Collateral is identified at the asset level (ISIN code) and the entries record nominal values as well as pre- and post-haircut market values. The aggregate post-haircut market value of a bank's collateral represents its total borrowing capacity with the ECB.

We match the ECB data set to four other publicly available data sets. First, we use the ECB's bank credit ratings data to identify all banks that 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 long-term unsecured credit rating 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 292 banks with at least one credit rating as of August 2007. These banks represent more than 95% of banks 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 the ones provided in the SNL European Financials dataset (which has a smaller coverage) and find an almost perfect overlap for the banks that are reported in both datasets.

Third, we use Datastream and the SNL European Financials to identify all publicly listed

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

[13]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 analysis period, the ECB also once offered a LTRO with a maturity of one year (July 2009 to June 2010). In addition, the ECB engages in fine-tuning operations, which are quantitatively very small. The ECB also offers lending under the marginal lending facility, which charges a very high interest and the take-up is negligible (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`.

banks and banks with CDS prices. We then match the ECB data to equity returns and CDS prices from Datastream. Our match yields 57 banks with equity returns and 36 banks with CDS prices. The main difference between the two samples is that the CDS sample includes a few large, non-traded banks (e.g., German Landesbanken) and excludes smaller listed banks that do not have CDS prices.

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 53 banks.

We conduct several tests to ensure the accuracy of our dataset. First, we aggregate total borrowing by week. We match our data with publicly available information from the ECB on weekly borrowing and find a perfect overlap. Second, we aggregate collateral by loan type and year. We check accuracy using information from the 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 member banks. Again, we find a perfect overlap. Hence, all our tests indicate that our data is highly accurate and complete.[14]

Panel A of Figure 1 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 €500 billion. In July 2009, the ECB offered one-year loans leading to additional borrowing of about €300 billion. Total borrowing peaked at about €900 billion prior to the expiration of the one-year loans in June 2010. After July 2010, total borrowing dropped by €300 billion and continued to decline gradually. This trend reversed in June 2011, as ECB borrowing increased again. Panel B of Figure 1 shows the pre- and post-haircut market value of total collateral pledged with the ECB. As shown in the figure, total collateral pledged is fairly stable at about €2 trillion. The average ECB haircut on collateral is also stable at less than 10%.

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

We note that aggregate collateral pledged with the ECB exceeds bank borrowing. This aggregate number 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 a short notice, other banks pledge little or no excess collateral. Our empirical analysis exploits these cross-sectional differences by analyzing the heterogeneity in borrowing and collateral across banks.

Table 1 provides summary statistics for our main bank sample. Our sample contains 292 unique banks and 51,648 bank-week observations in the period from August 2007 to December 2011. These banks represent more than 95% of bank assets. Average bank size is €113 billion and average book equity is €5.3 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 11.3%. About 57% of assets are loans and about 66% of liabilities are financed with deposits. The average bank credit rating is A. About 20% of banks are headquartered in distressed countries (Greece, Ireland, Italy, Portugal, and Spain).

On average, 58% 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 64% 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 2.8, or equivalently, a rating between AA+ and AA. Assets without credit ratings are non-marketable assets or assets that were not matched to ratings by the ECB.

Some of our empirical analysis focuses on the subsample of banks that are located in distressed versus non-distressed countries. We therefore provide a break-down of all summary statistics by subsample. We note that banks in non-distressed and distressed countries are roughly of similar size, with average total bank assets of €113 billion and €110 billion, respectively. Banks in non-distressed countries have higher bank ratings, A+ versus A-, and higher tier-1 ratios, 12.0% versus 9.8%. Hence, banks in non-distressed countries appear to be financially stronger than banks in distressed countries.

## 2.3 Divergence of Haircut Subsidies

We begin our analysis by examining if there are significant differences in the take-up of haircut subsidies across banks. As described above, the haircut subsidy on a security is increasing in the security's riskiness. Because data on private-market haircuts is sparse, we proxy for the average haircut subsidy on a bank's collateral using measures of the collateral's riskiness. The first measure is the average credit rating of the bank's collateral. We assign a numerical value to each rating: '1' for $AAA$, '2' for $AA+$, and so on, and for each bank in each week compute the value-weighted mean of the individual asset ratings. Hence, a higher value for the average collateral rating indicates riskier collateral. The second measure of a bank's collateral risk is the share of its total collateral in distressed-sovereign debt. We use this second measure since buying distressed-sovereign debt was a well-known, capital-efficient way that banks could accumulate high-yielding assets over the sample period.

The total ECB haircut subsidy received by a bank can be decomposed into the average haircut subsidy on its collateral scaled by its total ECB borrowing. Hence, the largest subsidies are captured by banks that have a high level of borrowing against the riskiest collateral. To determine if there are large differences in the take-up of ECB subsidies across banks, we therefore examine if the highest-borrowing banks also pledged the riskiest collateral. To do so, we sort banks into quintiles based on their normalized ECB borrowing as of July 2010 and examine the average collateral risk of the banks in these quintiles.

Panel A of Figure 3 plots the time series of the average collateral rating measure for the lowest and highest borrowing quintiles. The plot shows that the collateral risk of the banks in the lowest borrowing quintile remains roughly constant throughout the sample period. The collateral risk of the highest borrowing quintile is similar at the beginning of the sample period. However, starting in early 2010 it begins to diverge markedly. By the end of 2011 there is more than a two-notch difference between the average collateral rating of the two quintiles. Panel B of Figure 3 shows that a similar divergence appears for distressed-sovereign debt.

Figure 3 shows that banks with the highest borrowing also used the riskiest collateral.

This pattern starts in early 2010, and widens steadily thereafter, with ECB subsidies becoming increasingly concentrated in the highest borrowing banks. To understand what could be driving these differences across banks, we consider the predictions of LOLR theories for the cross-section of banks' LOLR borrowing, collateral risk, and asset holdings.

# 3 LOLR Theories

In the classical theory of the LOLR banks borrow from the LOLR to finance *existing* asset holdings. The theory assumes that banks' inability to roll over their financing is due to a market failure, such as panic-induced runs on banks' deposits or repo financing. Without a LOLR, banks suffering from such financing shocks are forced to sell assets. The rush to sell assets leads to fire sales, which destroys bank equity and causes a credit crunch. The availability of LOLR financing allows banks to instead gradually reduce leverage and avoid fire sales. Hence, under this theory differences in bank borrowing are explained by differences in banks' need to avoid fire sales.[15]

However, contrary to the classical LOLR theory, banks may borrow from the LOLR to finance investments in *new* asset holdings. The main theory predicting such investments is the *risk shifting* theory. Under this theory, a crisis-induced decline in bank asset values increases the default risk of weakly-capitalized banks, exacerbating their incentives to risk shift. The equityholders of such banks seek to increase risk because they capture most of the expected gains, whereas losses are disproportionately borne by debtholders in a default. Hence, banks that have a high default risk want to accumulate risky assets whose losses are

[15] An idealized version of this theory implies that the mere announcement of a LOLR policy is sufficient to eliminate any need for LOLR borrowing in equilibrium. The reason is that banks are certain to have access to financing, so there is no risk that they will have to engage in fire-sale liquidation. Therefore, depositors (or investors more generally) have no incentive to run on banks. This idealization is likely to be too simplistic to hold in practice. Banks must still obtain non-LOLR financing for the haircut component of their borrowing. Some important asset classes, such as loans, are not eligible as LOLR collateral, probably because they involve a high degree of information asymmetry. Finally, any investor uncertainty about the availability or terms of future LOLR lending creates a risk of future fire sales, which can lead to a withdrawal of current financing. It is therefore unlikely that the mere presence of a LOLR would rule out all fire sales and the need of some banks to use LOLR funding to avoid them.

realized when the bank would default anyway.

Importantly, the haircut subsidies offered by the LOLR allow banks to risk shift onto the LOLR. Banks can risk shift onto the LOLR because the haircuts are too low relative to private markets. This means that LOLR loans are undercollateralized and the LOLR will bear losses if a borrowing bank defaults.[16] The incentive to risk-shift on the LOLR depends on a bank's capitalization and is larger for banks with a high default risk. Hence, a bank's private *value* of the haircut subsidies is increasing in the bank's default risk.

Now, recall that there is a cost to taking the LOLR's haircut subsidy–the penalty interest rate charged by the LOLR on its loans. This cost implies that the net benefit of taking a haircut subsidy is positive for weakly-capitalized, high-default risk banks, but not for strongly-capitalized, low-default risk banks. Consequently, it is weakly-capitalized banks who borrow from the LOLR, in order to buy risky assets that they use as collateral.[17]

In our setting two other theories of banks behavior arise which predict that banks use LOLR funding to actively accumulate new asset holdings (in contradiction to fire-sale avoidance under the classical LOLR theory). The first, which we call the *political economy* theory, is closely linked to the risk-shifting theory. It says that regulators in distressed countries encourage their banks to use LOLR lending to buy their home-country's sovereign debt. In the case of the ECB, this may be done with tacit approval from the ECB because the ECB is restricted from directly lending to governments. Indeed, local governments and the ECB may view this as a way to avoid sovereign defaults and the break-up of the Eurozone, or as a politically expedient means of "recapitalizing" weak banks by allowing them to earn the high yield on these risky securities. We note that this theory represents a refinement of the risk shifting because it implies that regulators harnessed weak banks natural risk-seeking

[16]The theory only requires that haircut subsidies allow banks to shift losses onto creditors as a whole, not necessarily onto the LOLR. The theory is otherwise unchanged even if the LOLR can transfer the losses to other creditors by, for example, granting itself superseniority regarding collateral.

[17]We emphasize that this is the case even though all banks face the same haircut schedule and the same interest rate. This is because weakly-capitalized banks capture the largest *value* from the haircut subsidy due to their greater probability of default. This theory is sometimes summarized as the concern that "insolvent banks use LOLR funding to gamble for resurrection." The market failure underlying risk shifting is the same as in Diamond and Rajan (2011). They formally show that impaired banks have incentives to invest in illiquid assets, and that this can exacerbate financial crises.

incentives.[18]

We refer to the second such theory as the *differences in private valuation* theory. This theory posits that reasons other than risk shifting generate differences in banks' valuations of assets, leading some banks to borrow more LOLR funds to accumulate 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.[19] Hence, this theory predicts that differences in banks' LOLR borrowing are unrelated to their default risk. Instead, differences in LOLR borrowing are driven by other bank differences such as business models, expertise, or optimism. Like the risk shifting theory, this theory is incompatible with the classical LOLR theory because it emphasizes active risk-taking by banks.

Finally, we note that early theoretical work on LOLR often classifies borrowing banks as either illiquid or insolvent. In this work, banks lose financing due to either a coordination failure ("panic-based run") among depositors, or because investors think the bank's fundamentals are weak irrespective of any run ("fundamentals-based run"). The distinction is key for LOLR theory because illiquid banks use LOLR financing to engage in fire-sale avoidance, whereas insolvent banks use this financing to accumulate risky assets to risk shift.

More recent theoretical work uses global games methods (Morris and Shin (2002)) to combine these two mechanisms. In these models, banks fall into one of three groups based on their fundamentals. The first group are strongly-capitalized banks that suffer no financing loss during a crisis. The second group are weakly-capitalized banks–those whose assets are insufficient to cover their debts whether or not there is a coordination failure–that always lose financing during a crisis. The third group are intermediate-capitalized banks that may

[18]We note an important difference between the political economy theory and the standard risk-shifting theory. The standard theory assumes that equityholders take risk at the expense of debtholders, whereas the political economy theory posits that equityholders act with the encouragement of politicians, presumably because the cost of their risk shifting is outweighed by benefits such as the prevention of a sovereign default. From a welfare perspective, the strategy of exploiting risk-shifting incentives to prevent sovereign default is unlikely to be optimal. It is more likely to be the result of regulatory and institutional constraints that prevent the LOLR from conducting other (more efficient) types of interventions, such as direct purchases of distressed sovereign debt.

[19]Note that risk-shifting incentives also lead banks to have a higher valuation of risky assets. Yet we treat risk shifting separately because, in contrast to the other reasons for differences in private valuations, it is incompatible with firm value maximization.

lose funding if there is a run but have sufficiently strong fundamentals to survive otherwise. It is banks in the intermediate-capitalized group, who suffer from inefficient runs, who use LOLR financing to engage in fire sale avoidance, whereas the weakly-capitalized banks use LOLR financing to buy risky assets in order to risk shift.[20]

We further note that because a LOLR intervention is supposed to change an economy's equilibrium (by, for example, changing asset prices) the results of any empirical analysis is necessarily conditional on the size and scope of the LOLR intervention it studies. In principle, one can always ask whether a larger LOLR intervention would have produced a better equilibrium. Given that we study arguably the largest and most far reaching LOLR intervention ever conducted, our setting minimizes this limitation as much as possible.

# 4 Empirical Analysis

## 4.1 Identification Strategy

Our identification strategy aims to identify the motivation for bank's borrowing from the LOLR. We start by examining the risk-shifting explanation. The risk-shifting explanation emphasizes the role of banks' financial strength in driving their incentives to take risk. The main prediction is that weakly-capitalized banks risk shift onto the LOLR. We test the risk-shifting explanation by examining the effect of bank financial strength on LOLR borrowing and collateral risk.

The main challenge in implementing this test is that measures of banks' financial strength may be correlated with other (omitted) variables that also affect LOLR borrowing and collateral. For example, during a financial crisis measures of banks' financial strength may also reflect concerns about their 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' financial strength and which affects LOLR borrowing may confound the

[20]Strongly-capitalized banks do not use LOLR financing because they always have access to private market funding and do not have risk-shifting incentives.

empirical analysis.

We address this identification problem by proxying for banks' financial strength during the financial crisis that started in 2008 using measures taken *before* the crisis began. Specifically, we measure bank financial strength 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-shifting incentives during the crisis. In other words, one can interpret pre-crisis capital levels as an instrument for the likelihood that banks risk-shift onto the LOLR *during* the financial crisis.

The main identifying assumption behind our empirical strategy is that pre-crisis bank capital affects a bank's LOLR borrowing and collateral risk *only* through its incentive to risk shift. We believe this assumption is plausible because the alternative explanations emphasize differential exposures to drivers of the financial crisis as the determinants of bank borrowing and collateral risk. In particular, there were no fire sale discounts prior to the start of the financial crisis. Hence, it is unlikely that bank financial strength measured in August 2007 reflects any concerns about banks' fire sale discounts. Instead, it is more likely that bank capital levels reflect heterogeneity in banks' capital structure that is unrelated to fire sale discounts during the financial crisis.

Concretely, we measure a bank's financial strength using the median long-term unsecured credit ratings as of August 2007. We assign numerical value to bank credit ratings such that bank risk is increasing in our credit rating measure. We choose credit ratings as our preferred measure because they are available for a broad cross-section of banks. Moreover, it has the advantage relative to accounting-based measures that it is based on assessments by market participants.[21]

We believe that risk-shifting incentives emerged after the start of the sovereign crisis in early 2010. It is around the time of the first Greek debt crisis, when Greek debt prices fell, and concerns about the creditworthiness of several European sovereigns increased. We mark

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

the start of the crisis as of May 2, 2010, which is the date when the European Union and the International Monetary Fund agreed on the first Greek bailout totaling €110 billion.[22] The crisis started in Greece but later spread to Portugal and Ireland and eventually to Spain and Italy.

The evidence on bank and sovereign CDS rates provides direct support for the emergence of risk-shifting incentives in May 2010. As shown in Panel A of Figure 4, the difference in CDS rates between pre-crisis weakly- and strongly-capitalized banks is at most 70 basis points until May 2010 and doubles after the announcement of the Greek bailout on May 2, 2010. After May 2010, the difference steadily increases and grows to more than 1,000 basis points. The pattern for sovereign debt is similar. As shown in Panel B of Figure 4, the difference between CDS rates of distressed- and non-distressed sovereign bonds almost doubled in May 2010 and gradually increased thereafter to more than 2,000 basis points. These results indicate that the onset of the sovereign crisis triggered incentives for weakly-capitalized banks to risk shift and also provided them with the opportunity to do so.[23]

We further note that it is unlikely that banks adjusted their capital structures in August 2007 in anticipation of a major financial crisis. Even though some market participants were concerned about European banks prior to the Lehman bankruptcy, all conventional measures of bank risk indicated a low likelihood of a financial crisis. For example, bank CDS prices on the main European banks indicated that the likelihood of bank failure was very low (Acharya, Drechsler, and Schnabl (2012)). Hence, there is no evidence that banks adjusted their capital levels due to concerns about a financial crisis.

In short, we believe that pre-crisis capital level provides a good instrument for identifying the presence of risk-shifting. However, we acknowledge that there could be concerns that pre-crisis capital level correlates with other variables that affect LOLR borrowing and collateral

[22]See Reuters, "EU, IMF agree $147 billion bailout for Greece", May 2 2010" available at `http://www.reuters.com/article/2010/05/02/us-eurozone-idUSTRE6400PJ20100502`. 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.

[23]The rise in sovereign and bank CDS rates are closely related to each other. Acharya, Drechsler, and Schnabl (2012) model this sovereign-bank feedback loop and provide direct empirical evidence on the interaction between sovereign and bank CDS in Europe.

risk. For example, country-level factors may induce a positive relation between bank capital levels and fire sale discounts during the crisis. This may be the case if the banks of the distressed countries entered the crisis with lower capital levels and subsequently suffered greater withdrawals of financing during the crisis. Although it is not a-priori obvious that this should be the case, we address this concern below with a series of empirical tests.

## 4.2 Do Bank Risk-shift onto the LOLR?

We analyze whether weakly-capitalized banks borrow more and pledge riskier collateral. We measure LOLR borrowing in two ways: (1) an indicator variable for whether a bank borrows from the ECB, and (2) the natural logarithm of total borrowing in billion plus one. These variables capture the extensive and intensive margin of LOLR borrowing.[24]

We measure a bank's collateral risk in two ways: (1) the average collateral credit rating (weighted by market values) of the securities pledged with the LOLR, and (2) total distressed-sovereign debt scaled by bank size. We measure bank size as total bank assets in December 2007 to avoid endogeneity with respect to the scaling variable. We focus on distressed-sovereign debt (relative to other types of debt) because it was considered a capital-efficient way to take on risk due to its low regulatory risk weights.

We implement our analysis using a difference-in-differences regression framework. Our 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:

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

[24]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.

where $y_{it}$ is borrowing or collateral 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, $\alpha_i$ are bank fixed effects and $\delta_t$ are time fixed effects. We cluster standard errors at the bank level to allow for correlation of error terms within banks.

Panel A of Figure 5 plots the coefficients (solid line) and 95%-confidence interval (dashed lines) on the year-month interactions with pre-crisis credit rating for borrowing indicator as outcome variable. We indicate the month of the Lehman bankruptcy (September 2008) and the month of the first Greek bailout (May 2010) with vertical lines.

We find that weakly-capitalized banks increase borrowing relative to strongly-capitalized banks starting in early 2010. Specifically, a one-standard deviation decrease in a bank's pre-crisis credit rating (about two notches) leads to a 11.8 percentage point increase in the likelihood of borrowing. Panel B plots the coefficients for the natural logarithm of borrowing as outcome variable. The results are similar: a one-standard deviation decrease in a bank's pre-crisis credit rating leads to a 15.1% increase in borrowing after May 2010.[25]

Next, we analyze the impact of pre-crisis bank capital on collateral risk. The results are similar. Panel C of Figure 5 plots the coefficients on the year-month interactions for the specification with value-weighted collateral credit rating as outcome variable. Starting in early 2010, a one-standard deviation decrease in a bank's pre-crisis credit rating is associated with an increase of 22% of a one-standard deviation in its value-weighted collateral risk. This finding is statistically significant, as indicated by the 95%-confidence interval. Panel D of Figure 5 shows a similar result for distressed-sovereign debt as outcome variable. After May 2010 a one-standard deviation decrease in a bank's pre-crisis capital level is associated with an increase of 25% of a one-standard deviation in the ratio of distressed-sovereign debt collateral to total assets.

Table 2 presents the results of estimating the regressions using indicator variables for the two main periods after the start of the financial crisis. Following the discussion above, we define the financial crisis periods from October 2008 to May 2010 and the sovereign crisis

[25]We compute the size of the effects using the estimates for the post-Greek bailout period from Table 2.

period from June 2010 to December 2011. We find that after the start of the sovereign crisis weakly-capitalized banks increased their LOLR borrowing and collateral risk significantly relative to strongly-capitalized banks. All results are statistically significant at the 1%-level.

## 4.3 Testing Fire-Sale Avoidance versus Risk-shifting

As discussed above, there could be some concern that while pre-crisis bank capital does not directly reflect exposure to fire sales, it may still be positively correlated with the need to sell at fire sale discounts during the crisis. We therefore develop three further tests to distinguish between risk-shifting and fire-sale avoidance.

### 4.3.1 Do bank actively invest in risky assets?

A unique prediction of the classical LOLR theory is that banks increase their pledging of collateral, but *not* their corresponding asset holdings. Under this theory, banks borrow from the LOLR to substitute for a withdrawal of their funding and thereby avoid fire sales, *not* to increase their risk taking. Such a withdrawal in funding could be caused by a coordination failure among depositors that leads to a panic-based bank run.[26]

We test this unique prediction of classical LOLR theory by examining the relationship between changes in a bank's holdings of risky assets and its pledging of risky collateral. In general, there is very limited public information about banks' asset holdings because these data are considered proprietary. 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 analysis period (March 2010, December 2010, September 2011), allowing us to analyze a panel of bank holdings of distressed-country 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

[26]We note that the risk-shifting theory also predicts a decline in a bank's funding. Hence, a decline in a bank's market funding is consistent with either fire-sales avoidance or risk-shifting. This means that adding controls for a bank's access to funding markets (e.g, deposit rates, CD rates) to our regressions does not distinguish between fire-sale avoidance and risk-shifting. Instead, we distinguish between these cases by analyzing how *changes* in a bank's LOLR borrowing are related to *changes* in a bank's actual investments.

were present in all rounds. We therefore focus our analysis on the sample of 53 banks that participated in all three rounds. These banks are the largest banks in Europe and represent about 50% of total European bank assets.

We first analyze the relationship between banks' pledging of distressed-sovereign debt collateral and their corresponding holdings. We estimate this relationship in changes to control for pre-existing heterogeneity in distressed-sovereign debt holdings. We focus on the LOLR's perspective and therefore 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 close to one indicates that pledging was driven by active investments in risky assets. In contrast, a coefficient close to zero indicates that pledging reflects financing of existing asset holdings.[27]

Specifically, we estimate 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 $t+1$ and $\Delta Pledged_{it}$ is bank $i$'s change in distressed-sovereign debt pledged as collateral from time $t$ to $t+1$. Time fixed effects are denoted as $\delta_t$. Similar to our collateral risk measure, 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 cluster standard errors at the bank level to account for the correlation of error terms within banks.

Table 3 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. The result indicates that for each dollar of

[27] Alternatively, one could put the pledged collateral on the left hand side and holdings on the right hand side. In this case, the specification measures the share of holdings that were pledged with the LOLR. This estimate is of independent interest but is less relevant for the LOLR because holdings may vary for reasons unrelated to risk shifting onto the LOLR (e.g., rebalancing, risk shifting onto other creditors).

distressed-sovereign debt pledged with the ECB, \$0.45 reflects banks' active investment in distressed-sovereign debt. This result is inconsistent with the fire-sale avoidance theory.

As a direct test of the risk-shifting explanation, we also analyze the association between distressed-sovereign debt holdings and pledging as a function of a bank's financial strength. We implement this test by dividing our sample into two subsamples: the subsample of weakly-capitalized banks, with a pre-crisis credit rating of less than AA- (25 banks), and the subsample of strongly-capitalized banks, with a pre-crisis credit rating of AA- or higher (28 banks). We then estimate our main specification separately for each sample.

Column (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 5.6% increase in distressed-sovereign debt holdings. The result is robust to including time fixed effects. Columns (5) and (6) examine the sample of strongly-capitalized banks. We find that the coefficient drops to 3% and is not statistically significant. The coefficient is almost unchanged controlling for time fixed effects. The difference between the weakly- and strongly-capitalized banks is statistically significant at the 5%-level. Consistent with risk-shifting, the positive association between holdings and collateral is driven by the weakly-capitalized banks.

In short, we find that banks actively increase their holdings of distressed-sovereign debt by about 45% of the amount of increase in their pledging of distressed-sovereign debt. This finding is inconsistent with the fire-sale avoidance theory. It suggests that risk-shifting may explain about 45% of the cross-sectional variation in the use of distressed-sovereign debt collateral with the ECB.[28] In addition, we find that the positive relationship between pledging and holdings is strongest for the sample of weakly-capitalized banks, providing further support for the risk-shifting explanation.

[28]We use the coefficient rather than the R-squared to assess the importance of risk-shifting. The reason is that holdings may vary for reasons other than risk-shifting onto the LOLR. We therefore cannot ascribe the unexplained variation solely to fire-sale avoidance.

### 4.3.2 Are the Results Driven by Cross-Country Differences?

As an alternative test of the classical LOLR theory, we also directly control for country-level variation that may trigger fire sales discounts. The most likely source of fire sale discounts was the ongoing decline in the macroeconomic health of distressed countries. Specifically, some countries may have suffered a 'quiet' bank run, in which depositors (slowly) moved deposits to other countries. 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 full set of time dummies for each country in our main regression specification (1). This is a non-parametric way to control for any variation in borrowing or collateral risk that affects all banks within a country.

Table 4 presents the results. As shown in Columns (1) and (2), we find that pre-crisis bank ratings continue to predict LOLR borrowing. A one-standard deviation decrease in a bank's pre-crisis credit rating raises the likelihood of borrowing by 10.5 percentage points and the amount of borrowing by 7.8 percent, respectively. We find similar results for collateral risk. As shown in Columns (3) and (4), a one-standard deviation decrease in a bank's pre-crisis credit rating increases collateral risk by 10% of a one-standard deviation in the value-weighted collateral rating and 7% of a one-standard deviation in distressed-sovereign debt relative to assets. Compared to Table 2, the coefficients are about 11-70% smaller than the corresponding coefficients in specifications without country-time fixed effects. These estimates provide a lower bound on the risk-shifting effects given that cross-county differences may also be driven by differences in risk-shifting incentives (as opposed to fire sale discounts). Given that most explanations based on fire sale discounts emphasize the importance of cross-country differences, these findings provide further support for the risk-shifting theory.

### 4.3.3 Are the Results Driven by Distressed Countries?

As an alternative test of the classical LOLR theory, we can also focus on banks in non-distressed countries. Since explanations based on fire sale discounts focus on the distressed countries, we do not expect to find differences across banks in the non-distressed countries.

Hence, we therefore estimate our main specification only for banks located in non-distressed countries.

Table 5 presents the results. As shown in Columns (1) and (2), pre-crisis bank credit rating continues to predict LOLR borrowing. A one-standard deviation decrease in a bank's credit rating increases the likelihood of borrowing by 9.6 percentage points and the amount of borrowing by 10.5 percent, respectively. We find similar results for collateral risk. The coefficients are about 18-72% smaller than the ones in Table 2.

We note that the coefficients in Table 5 are similar in magnitude to the ones in Table 4. This result shows that the predictability of pre-crisis credit ratings for borrowing and collateral risk is the same *within* distressed countries and *across* non-distressed countries. In other words, comparing strongly- and weakly-capitalized banks within distressed countries (e.g., within Italy and Spain) yields similar predictions as comparing strongly- and weakly-capitalized banks across non-distressed countries (e.g., German versus French banks). This suggests that the predictability of pre-crisis rating has no country-specific component in non-distressed countries, while country-level factors can partially explain the predictability in distressed countries. It further suggest that risk-shifting incentives operate both across and within countries.

## 4.4 Are the Results Driven by Regulatory Pressure?

The *political economy* theory posits that banks increase LOLR borrowing because they are encouraged (or forced) to do so by their national regulators. This explanation is closely related to the risk-shifting theory because it emphasizes that risk shifting may be encouraged by regulators. This may be the case because governments in distressed countries experienced high sovereign borrowing costs and, as a result, may have put pressure on banks to buy their debt in order to decrease borrowing rates. This may have been a way for distressed countries to circumvent rules restricting the ECB from directly lending to them. It may also have been in the interest of the ECB as a way to avoid sovereign defaults and the break-up of the Eurozone.

It is important to note that this explanation emphasizes banks using LOLR financing to actively invest in risky assets. Hence, the political economy theory is inconsistent with the classical theory of the LOLR. It is instead a refinement of the risk shifting theory which implies that regulators harnessed banks' existing risk-seeking incentives. To explain our findings, the theory further requires that political economy forces disproportionately affected weakly-capitalized banks. This is consistent with weakly-capitalized banks' risk-shifting incentives making them more responsive to encouragements to take risk. It may also be amplified by weakly-capitalized banks' need to respond to regulators because they rely more on the regulator's approval.

Several of our results provide support for the political economy theory. As described above, country-time fixed effects reduce the coefficient on bank ratings in the regressions. This reduction is consistent with the differences in banks' borrowing and collateral risk being driven by regulatory pressure in the distressed countries. Our finding that the coefficient on bank rating is smallest for the sample of non-distressed-country banks is also consistent with political economy, because regulators in these countries were, if anything, more likely to pressure banks to reduce risky asset investments. Our results can thus be interpreted as the consequence of the interaction of risk-shifting with political economy pressures. This can also explain why the LOLR may have encouraged banks' risk-shifting rather than trying to reduce it.[29]

However, the results in Table 5 suggests that political economy alone cannot explain all our findings. As discussed above, we find that pre-crisis bank rating predicts LOLR borrowing and collateral risk even *outside* the distressed countries. Moreover, this relationship exists even for risky debt other than sovereign debt, which was not the focus of regulators in distressed countries. Hence, there remains evidence of risk shifting by banks that cannot be explained by political economy factors alone.

[29]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 the principal cannot observe the agent's actions. However, under the political economy explanation, the principal (LOLR) can observe the agent's actions (banks) but encourages costly risk-shifting because of the pursuit of other objectives.

## 4.5 Are the Results Driven by Differences in Private Valuation?

The *differences in private valuation* theory suggests that weakly-capitalized banks increase LOLR borrowing and collateral risk for reasons other than risk-shifting. Some possible explanations for such differences in private valuation may be differences in bank size, bank funding structure, business model, or "optimism". Importantly, all these explanation emphasize banks' active risk-taking and are therefore inconsistent with the classical theory of the LOLR.

We note that this theory requires that differences in private valuation are correlated with banks' credit ratings. It further requires that banks have different private valuations of sovereign debt, an asset class for which differences in banking expertise are less relevant, especially outside distressed countries. Hence, our results so far do not point towards the importance of differences in private valuations across banks.

We explicitly test for such explanations by controlling for bank characteristics (other than pre-crisis credit rating) that may proxy for differences in private valuation. We focus on bank characteristics that vary over time (or allow for an interaction between time-invariant characteristics and indicator variables for different time periods) because the effect of time-invariant characteristics are already controlled for via bank fixed effects.

We estimate the main specification (1) and add the following control variables: the natural logarithm of bank size, deposits as share of liabilities, loans as share of assets, and pledged distressed-sovereign debt as a share of bank size. We control for these variables by including interactions between these variables as of December 2007 and indicator variables for the main time periods. We choose this specification because it is follows the setup in our benchmark specification in Table 2.[30]

Table 6 presents the results. We find that all coefficients are almost unchanged relative to Table 2 across the borrowing and collateral measures. Moreover, all results remain statistically significant. Hence, there is no evidence that controlling for private valuation proxies affects the effect of banks' credit rating on LOLR borrowing and collateral. In short, we find

[30] All our results are robust to including time-varying variables instead.

no evidence in support of the private valuations theory.

## 4.6 Are the Results Robust to Alternative Specifications?

### 4.6.1 Do the results hold for large banks?

Our benchmark specification uses the sample of banks that have at least one credit rating (292 banks). We also examine whether our results hold for the subsample of publicly-listed banks (57 banks). These banks are important for assessing the impact of risk-shifting at the macro level because they represent about 50% of total bank assets. Moreover, they may be more willing (or able) to take advantage of opportunities to risk shift. We thus estimate the main specification (1) for the sample of publicly listed banks.

We present the results in Table 7. The format of the table follows the same structure as Table 2. We find that our results strengthen across all specifications. In terms of borrowing, the effect of a one-standard deviation decrease in pre-crisis bank credit rating is 1.7 to 4.9 times larger than for the full sample. In terms of collateral risk, we find that the effect is about 3.1 to 3.9 times larger for both measures of collateral risk.

In short, we find stronger results for the sample of publicly listed banks than for the full sample. The results indicate that the aggregate effects are even larger than the effect for the average bank.

### 4.6.2 Do the results hold for CDS prices?

Our main measure of bank financial strength is a bank's credit rating. We prefer this measure because it is available for a broad swath of banks. Alternatively, one can also use a bank's CDS prices to estimate the impact of bank financial strength on risk-taking. However, we note that CDS prices are only available for large banks (37 banks) and most of these banks were considered safe before the financial crisis. Hence, there is little variation in bank CDS as of August 2007, making it difficult to estimate the effect of pre-crisis bank financial strength on LOLR borrowing.

However, even large banks became risky over the course of the financial crisis. Our previous results established that banks started risk-shifting after the start of the sovereign crisis in early 2010. Hence, we can measure bank risk using CDS spread as of January 2010 (as opposed to August 2007). This approach assumes that bank risk as of January 2010 is a good proxy for risk-shifting incentives after January 2010. We thus estimate the main specification (1) for the sample of banks with traded CDS prices. We measure bank financial strength using the natural logarithm of CDS prices as of January 2010.

We present the results in Table 8. The format of the table follows the same structure as Table 2. We find that the signs of the coefficients are similar to the ones for publicly-listed banks. With the exception of the coefficient on the borrowing indicator, the results are also statistically significant. The lower statistical significance may be due to the small sample size. Overall, these findings provide robustness regarding our main specification.

#### 4.6.3 Do the results hold for excess LOLR collateral?

We note that aggregate collateral pledged with the ECB exceeds bank borrowing. The reason is that many banks pledge excess collateral with the ECB. Banks do so because collateral must be approved by the ECB and this can take some time. A simple interpretation of the risk shifting theory suggests that such pledging is costly for banks engaged in risk shifting because they should maximize borrowing relative to collateral. In contrast, under fire sale avoidance there is no clear prediction regarding excess LOLR collateral.

We therefore analyze the effect of bank credit rating on excess collateral as an outcome variable. We measure excess collateral as the natural logarithm of borrowing relative to collateral. We thus estimate the main specification (1) using excess collateral as an outcome variable.

We present the results in Table 9. We find that weakly-capitalized banks pledge less excess collateral with the ECB. Column (1) shows that a one-standard deviation decrease in a bank's pre-crisis credit rating reduces excess collateral by 40.2 percentage point. The result is robust to controlling for time-country fixed effects (Column (2), similar to Table 4)

and restricting the sample to banks located in non-distressed countries (Column (3), similar to Table 5). These results provide further support for the risk-shifting theory.

# 5 Aggregate Implications

We now analyze how the differences we document across banks accumulate over the course of the crisis, particularly after 2010. 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 over this time period. Following our earlier analysis, we measure risky collateral using distressed-sovereign debt. We further look at all debt originated in the distressed countries in order to get a broader measure of aggregate quantities.

To analyze the redistribution of risky collateral within the banking system, we follow the analysis in Table 3 and split the sample of banks into two groups based on their August 2007 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 6 plots total distressed-sovereign debt pledged as collateral for all banks over the sample period. Since our sample captures the universe of banks in Europe, this represents the aggregate amount for the whole banking system. The figure shows that total distressed-sovereign debt pledged by the banking system was roughly 120 Billion Euros during the crisis. Total collateral starts at around 100 Billion Euros in early 2009, reaches 120 Billion by July 2009 and fluctuates around this value for the remainder of the sample. Hence, viewed at the level of the banking system there appears to be 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 6. As of mid 2009, both groups of banks pledged around 60 Billion Euros of distressed-sovereign debt. However, starting in early 2010, there is a steady migration of distressed-sovereign debt from strongly-capitalized to weakly-

capitalized banks. By the end of 2011, the weakly-capitalized banks increase their pledging to about 84 Billion Euros, while the strongly-capitalized banks' pledging decreases to around 25 Billion Euros.

Panels A and B of Figure 7 show very similar patterns for all debt originated in the distressed countries. Aggregate distressed-country debt collateral is roughly constant at 330 Billion Euros, but again there is a strong reallocation towards the weakly-capitalized banks. Over the sample period pledging by weakly-capitalized banks increases from about 160 to 255 Billion Euros, while pledging by weakly-capitalized banks decreases from roughly 120 Billion to 75 Billion Euros.

These results suggest that the LOLR intervention facilitated a redistribution of risk within the banking system, with risky assets transitioning to weak banks. From the point of view of LOLR theory this result is alarming. One would hope 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 bank failure. In turns this increases the probability of bank runs and the risk of a systemic financial crisis. Moreover, the concentration of risky assets within weak banks makes their resolution costlier should they end up failing.

# 6 What do we learn from the results?

The starting point of our paper is the classical theory of the LOLR. This theory emphasizes the intervention of central banks in markets to lend to banks in order to avoid fire sales and the resulting depletion of bank capital. However, our results show that the classical LOLR theory cannot fully account for the take-up of LOLR assistance during our sample, and that risk-shifting and political economy are also at work. What are the implications of these results?

First, our results imply that following the prescriptions of classical LOLR theory can entail significant costs. These costs can be categorized into two sources: (1) there is inefficient

allocation of capital as weak banks use LOLR funding to make risky investments, and (2) there is a resulting accumulation of risky assets at weak banks, which (all else equal) increases the likelihood of a systemic crisis and the subsequent cost of resolving it. If these costs are sufficiently large, then a (classic) LOLR intervention might actually end up exacerbating a financial crisis.

In spite of these large costs, our result 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, may also be large. Therefore, a central question is what are the *net* benefits of the intervention. The literature has not been able to answer this question. We view our work as a first step in this direction.

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 of intervention by directly addressing the incentives problem that leads to risk shifting. This can be done by restructuring or recapitalizing banks.[31] Our results further indicate that both observable measures of market risk, and the dynamics of banks' behavior during a crisis, can be used to (at least in part) identify banks with risk-shifting incentives.[32]

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

Fourth, our results raise questions about the optimal design of a LOLR intervention in a monetary union. While the theory of LOLR focuses on banks, governments may also face a liquidity shortage and require a LOLR intervention. This could occur if there are inefficient equilibria in which investors' expectations of government default are self-fulfilling.

[31] Philippon and Schnabl (2013) solve for the optimal design of bank recapitalization.

[32] We recognize that following a policy of monitoring such behavior would itself change the equilibrium, as risk-shifting banks would respond by attempting to avoid detection.

The political economy explanations suggests that this type of concern may have motivated the central bank's intervention during the crisis. 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. It seems clear that a more direct approach would be desirable.[33] Hence, there is a need for theoretical work on the optimal design of LOLR intervention in this setting.

Finally, it is possible that LOLR theory was not implemented properly following Bagehot's principle, due perhaps to institutional constraints on the ECB. In Europe, access to the central LOLR facility is determined by national bank regulators and not the ECB. This is in contrast to the US, where the Federal Reserve is both the LOLR and the main bank supervisor. Since losses on LOLR facilities are shared across countries, national bank regulators have an incentive to provide access to LOLR facilities 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.[34] This interpretation of our results indicates that bank supervision and LOLR lending should reside within in a single entity.[35]

# 7 Conclusion

Central banks act as Lender of Last Resort during financial crises. The role of the LOLR is motivated by the idea of providing temporary funding to banks to avoid fire sales and the resulting depletion of bank capital. Such interventions can be highly socially beneficial by containing a financial crisis and avoiding a credit crunch. However, a troubling concern for a LOLR is that there may be other reasons why banks want to take-up LOLR financing, potentially leading to a suboptimal allocation of capital that could, in an extreme case, end up exacerbating a financial crisis.

[33] By law, the ECB can only act as a LOLR to banks, but not governments. It is possible that such institutional constraints prevented the implementation of more efficient policies.

[34] Agarwal, Lucca, Seru, and Trebbi (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.

[35] See Kashyap (2010) for a discussion of this issue in the context of the United States.

We examine the LOLR intervention undertaken by the ECB from 2007 to 2011. We show that weakly-capitalized banks borrowed more from the ECB and used riskier collateral. These relationships emerge only after the start of the sovereign debt crisis in early 2010, and strengthen thereafter. 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 banks' need to avoid fire sales as in classical LOLR theory. Instead, they point to risk shifting by banks, both independently and with the encouragement of governments seeking funding for distressed sovereigns.

A natural implication of our results is that the LOLR can reduce the cost of intervention by directly addressing the incentives problem that leads to risk shifting. This can be done by restructuring or recapitalizing banks. Our results also suggest that the LOLR intervention facilitated the reallocation of risky securities to weak banks. This effect is missing from LOLR theories and our results suggest the need for further work on optimal LOLR design.

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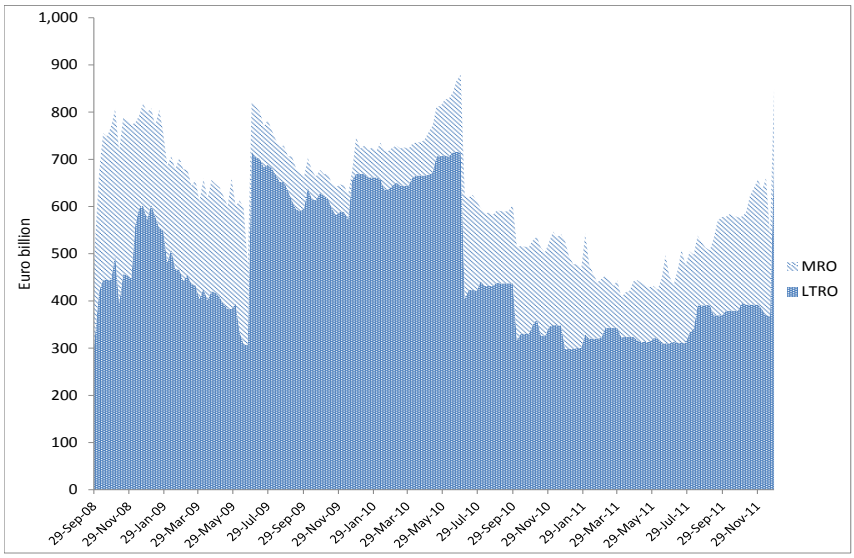
Figure 1

Panel A of Figure 1 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 before and after ECB haircuts in € billion.

(A) Total Borrowing




(B) Total Collateral

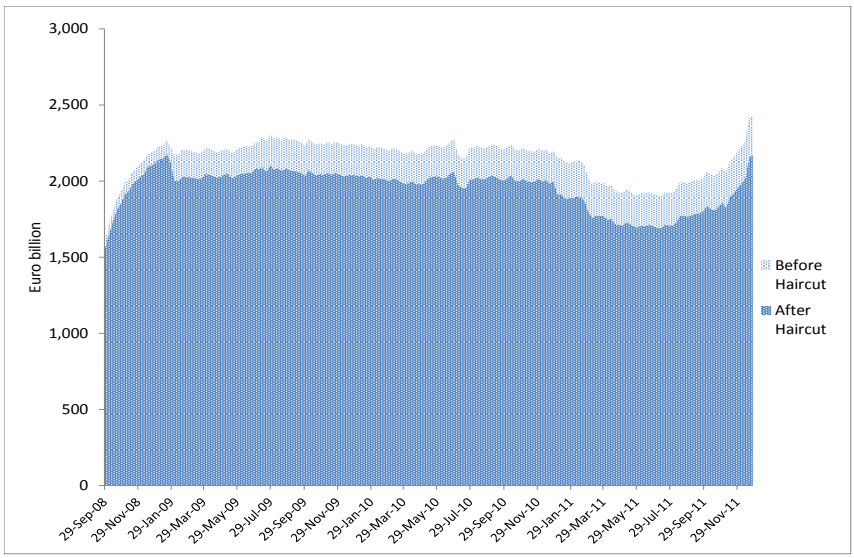
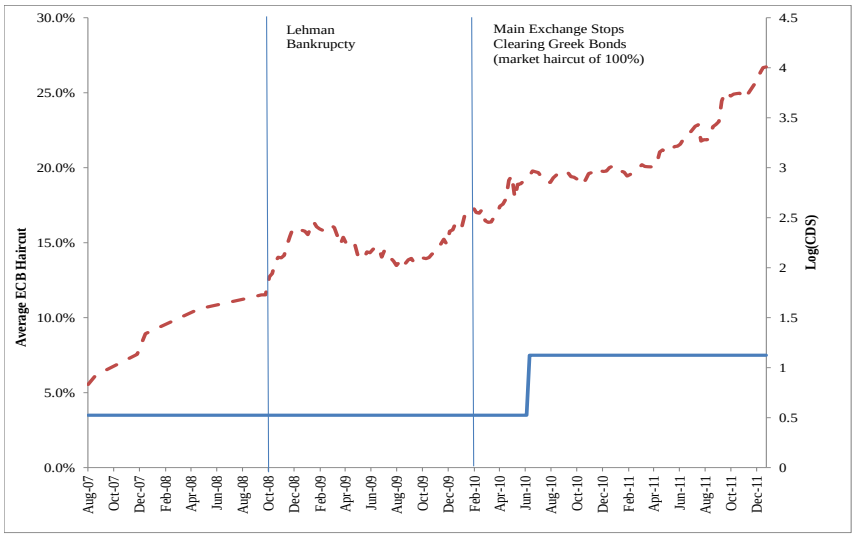


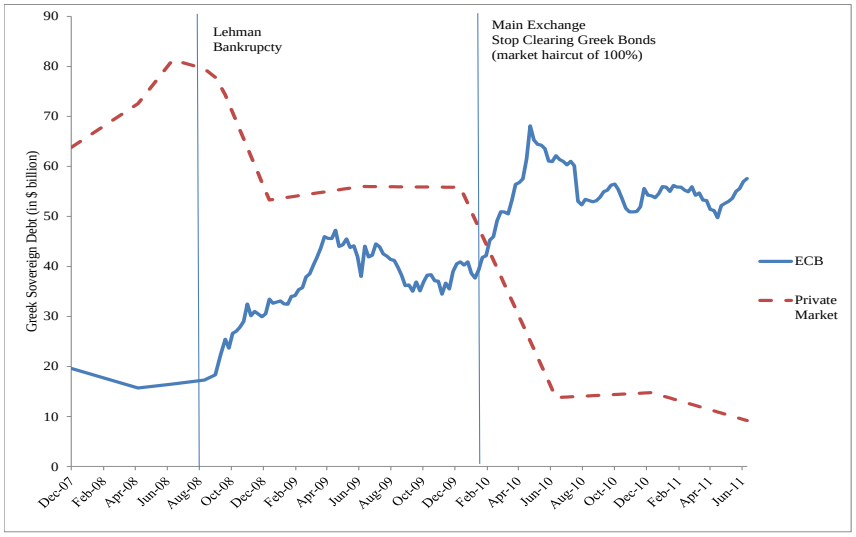
Figure 2

Panel A of Figure 2 plots the time series of the natural logarithm of the Greek credit default swap price (dashed line, right axis) and the average ECB haircut on Greeks sovereign bonds pledged with the ECB in percentage points (solid line, left axis). Panel B shows the time series of total Greek sovereign bonds in market values pledged as collateral in private markets (dashed line) versus the ECB (solid line). The private market collateral data is collected from repo market surveys that are conducted every six months.

(A) Greek Sovereign Risk and ECB Haircut




(B) Collateral Use of Greek Sovereign Bonds

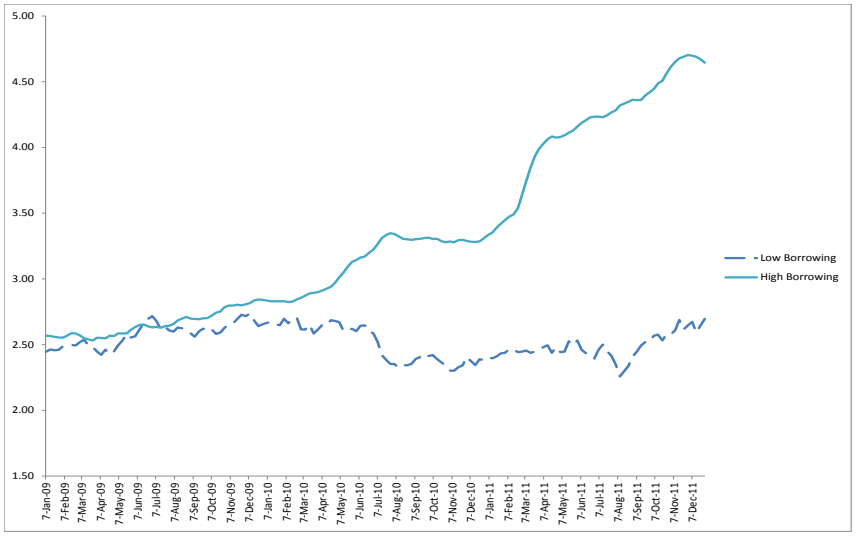



*Source: Goldman Sachs and International Capital Markets Association reports*

Figure 3

Panel A of Figure 3 plots the average collateral credit rating of banks in the highest borrowing quintile (solid line) and banks in the lowest borrowing quintile (dashed line). Panel B plots distressed-sovereign debt as share of total collateral pledged for banks in the highest borrowing quintile (solid line) and in the lowest borrowing quintile (dashed line). The borrowing quintiles are based on the ratio of borrowing to total collateral pledged as of July 2010.

(A) Average Collateral Rating by Borrowing Quintile




(B) Share of Distressed-Sovereign Debt by Borrowing Quintile

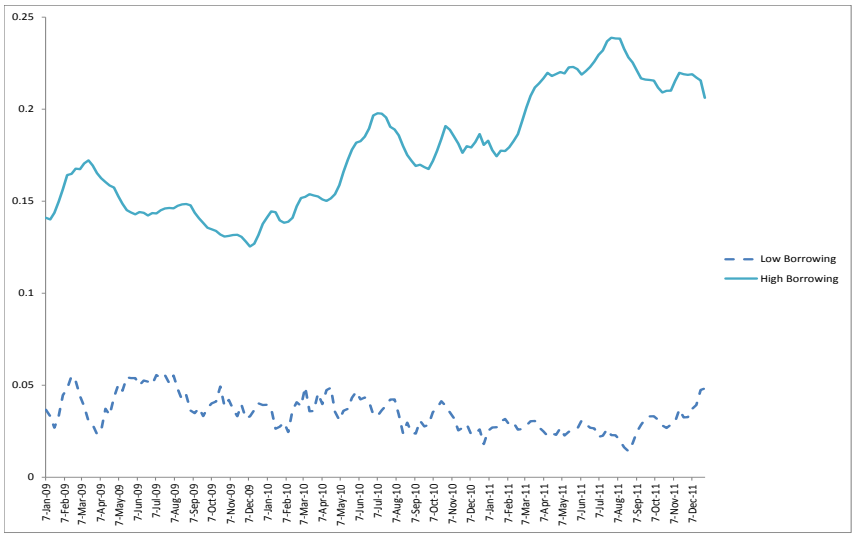
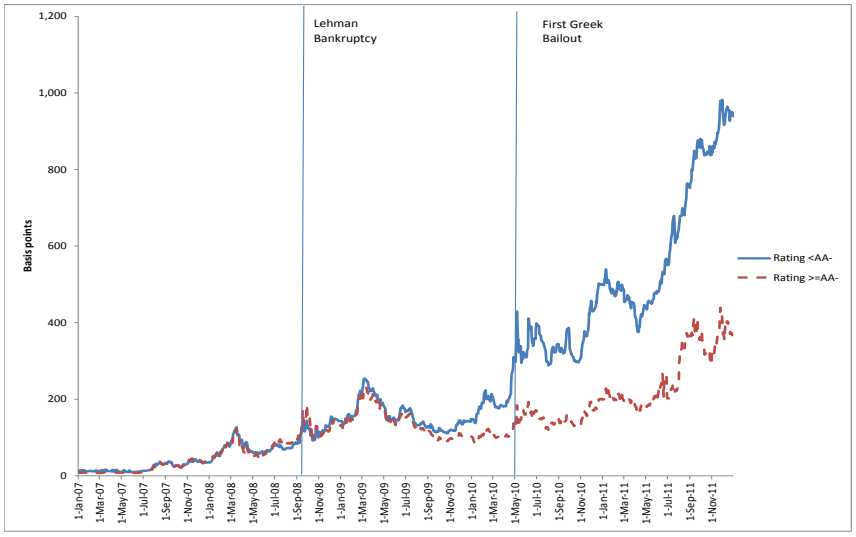


Figure 4

Panel A of Figure 4 plots the average CDS rates of weakly-capitalized banks (credit rating below AA- as of August 2007, sold line) and strongly-capitalized banks (credit rating of AA- or higher as of August 2007, dashed line). Panel B plots average CDS rates of distressed-country (Greece, Ireland, Italy, Portugal, and Spain) sovereign debt (solid line) relative to non-distressed-country (Austria, Belgium, Denmark, France, Germany, Netherlands, Sweden, and United Kingdom) sovereign debt (dashed line).

(A) CDS rates of weakly- and strongly-capitalized banks




(B) CDS rates of distressed and non-distressed sovereign debt

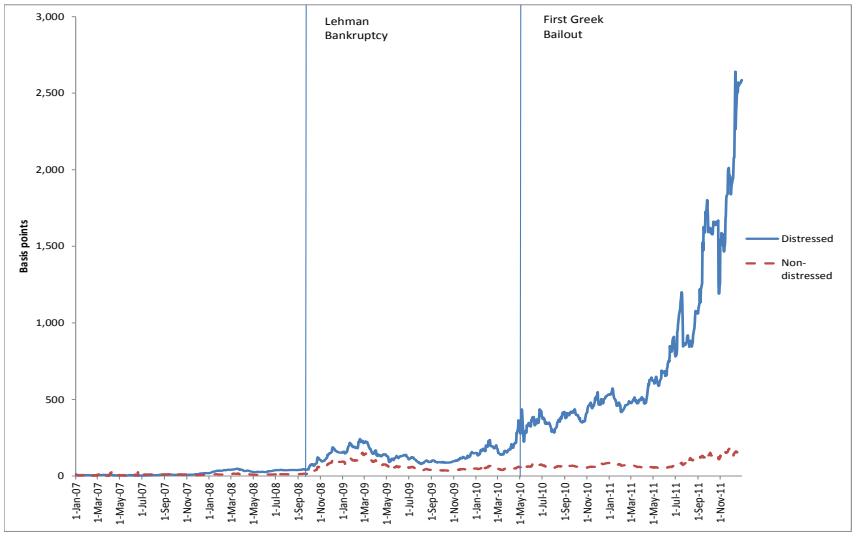
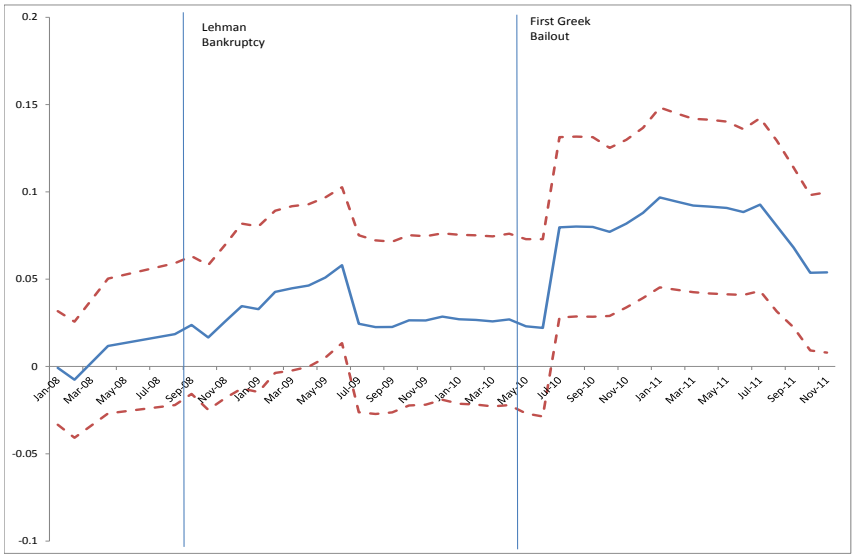


Figure 5

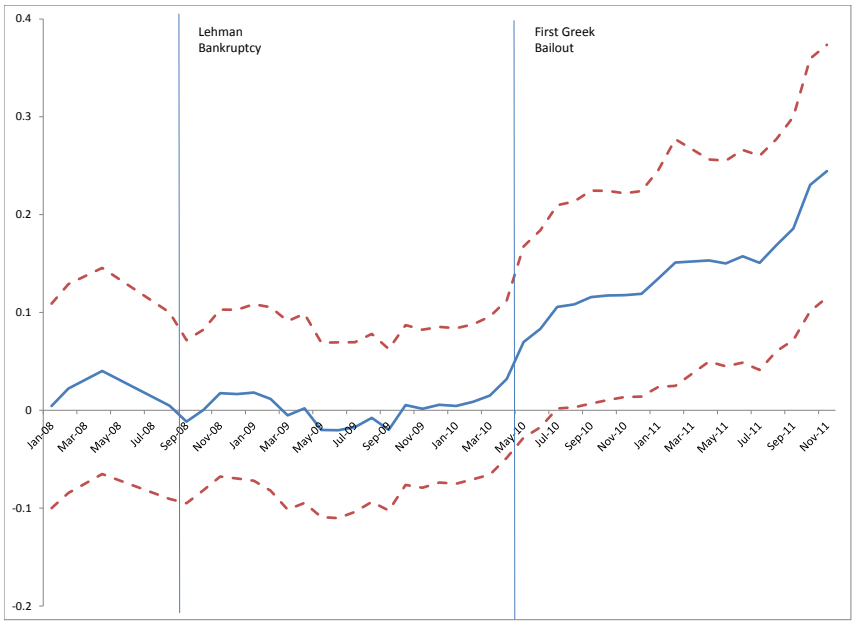
Figure 5 plots the coefficients (solid line) and 95%-confidence interval (dashed lines) on the year-month indicator variables interacted with pre-crisis bank credit rating when the outcome variable is the borrowing indicator (Panel A), the natural logarithm of total borrowing in € billion plus one (Panel B), the market value-weighted collateral credit rating (Panel C), and distressed-sovereign debt (Panel D).

(A) Borrowing Indicator


(B) Log(Borrowing)



(C) Average collateral credit rating




(D) Distressed-sovereign debt

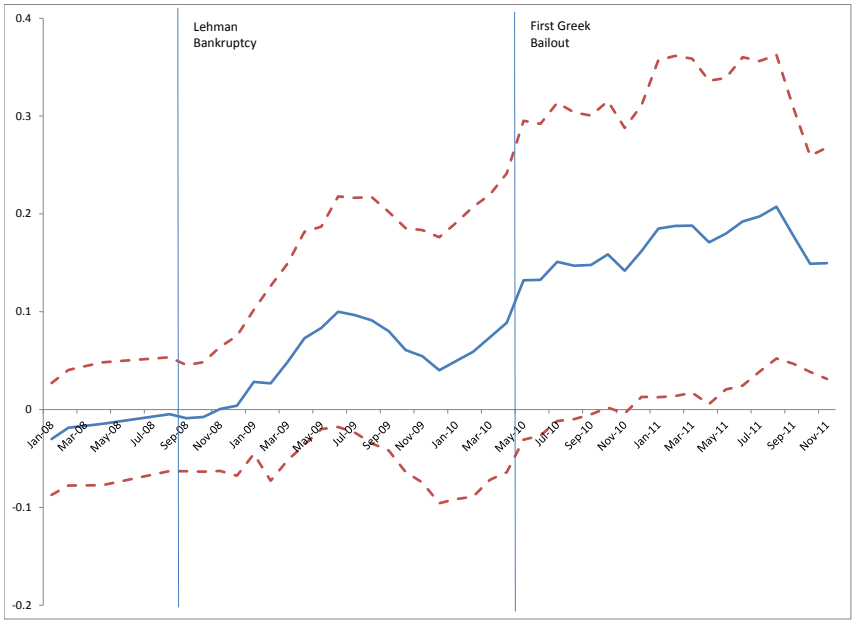
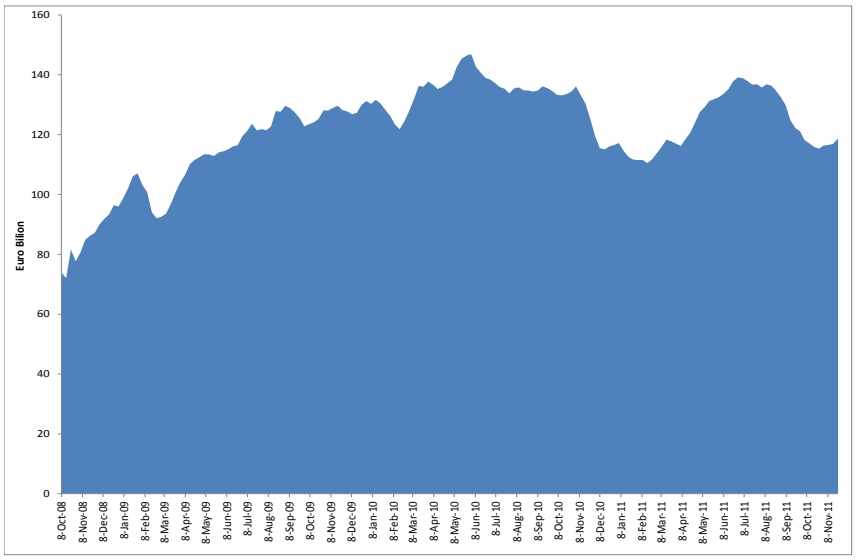


Figure 6

Panel A of Figure 6 plots total distressed-sovereign debt pledged during the sample period. Panel B plots total distressed-sovereign debt pledged by banks with August-2007 credit ratings of AA- or higher ("strongly-capitalized banks", dashed line) and banks with August-2007 credit ratings lower than AA- ("weakly-capitalized banks", solid line).

(A) Total distressed-sovereign debt pledged

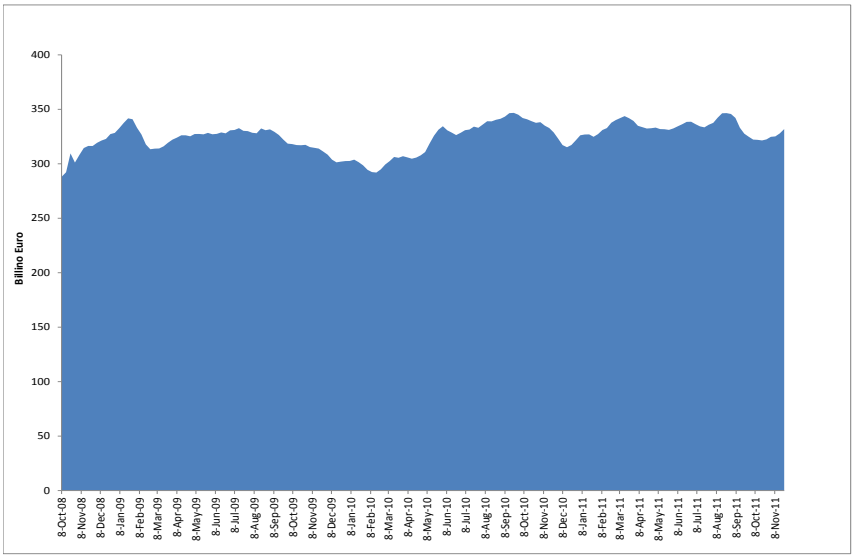



(B) Total distressed-sovereign debt pledged by strongly- and weakly-capitalized banks

Figure 7

Panel A of Figure 7 plots total debt originated in distressed countries and pledged during the sample period. Panel B plots total debt originated in distressed countries and pledged by banks with August-2007 credit ratings of AA- or higher ("strongly-capitalized banks", dashed line) and banks with August-2007 credit ratings lower than AA- ("weakly-capitalized banks", solid line).

(A) Total distressed-country debt pledged




(B) Total debt originated in distressed countries pledged by strongly- and weakly-capitalized banks

**Table 1: Summary Statistics**

This table provides summary statistics from August 2007 to December 2011. All variables are for the entire sample (except credit default swap (CDS) prices and market leverage, which are only available for banks with a traded CDS and publicly listed banks, respectively). The variable definitions and data sources are described in the Appendix.

| | All (292 Banks) | | Non-Distressed Country (234 Banks) | | Distressed Country (58 Banks) | |
|---|---|---|---|---|---|---|
| | Mean | Std. Dev. | Mean | Std. Dev. | Mean | Std. Dev. |
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Bank Characteristics | | | | | | |
| Total Assets (Euro bil) | 112.9 | 306.3 | 113.5 | 325.4 | 110.4 | 212.2 |
| Book Equity (Euro bil) | 5.3 | 14.4 | 4.7 | 14.3 | 7.4 | 14.7 |
| Bank Rating | 5.6 | 2.2 | 5.2 | 1.9 | 7.1 | 2.6 |
| Market Leverage | 45.3 | 57.4 | 48.3 | 56.7 | 42.3 | 58 |
| Credit Default Swap Price | 244.8 | 298.4 | 163.5 | 115.1 | 391.7 | 438.8 |
| Loan Share | 56.7% | 18.0% | 54.6% | 17.3% | 64.3% | 19.4% |
| Deposit Share | 65.5% | 23.7% | 68.6% | 24.5% | 53.3% | 13.9% |
| Book Equity/Assets | 6.0% | 3.4% | 5.8% | 2.7% | 6.7% | 5.4% |
| Tier 1 Ratio | 11.3% | 6.8% | 12.0% | 7.8% | 9.8% | 4.0% |
| Located in distressed country | 19.8% | 38.9% | 0.0% | 0.0% | 100.0% | 0.0% |
| Central Bank Borrowing | | | | | | |
| Any borrowing (Yes=1) | 57.9% | 49.4% | 53.5% | 49.8% | 75.4% | 43.0% |
| Total Borrowing (Euro bil) | 1.77 | 5.93 | 1.34 | 5.83 | 3.46 | 6.05 |
| Log(Borrowing) | 0.43 | 0.81 | 0.32 | 0.71 | 0.89 | 1.00 |
| Borrowing/Book Equity | 64.3% | 152.9% | 53.1% | 136.7% | 109.5% | 194.7% |
| Borrowing/Collateral | 33.0% | 34.7% | 28.7% | 33.2% | 50.0% | 35.4% |
| Central Bank Collateral | | | | | | |
| Any collateral (Yes=1) | 90.9% | 28.7% | 90.8% | 28.8% | 90.9% | 28.7% |
| Collateral Pledged (Euro bil) | 5.23 | 12.44 | 4.91 | 12.91 | 6.51 | 10.23 |
| Collateral/Book Equity | 165.3% | 206.4% | 157.0% | 196.4% | 175.9% | 218.3% |
| Haircut | 7.1% | 4.0% | 6.7% | 3.9% | 8.6% | 4.4% |
| Rated share (%) | 79.5% | 24.8% | 79.6% | 25.6% | 79.2% | 26.1% |
| Average Rating | 2.75 | 1.46 | 2.7 | 1.26 | 3.01 | 2.21 |
| Distressed-Sovereign Debt | 0.44% | 1.64% | 0.16% | 0.76% | 1.58% | 3.09% |
| Observations | | | | | | |
| N | 51,648 | | 41,418 | | 10,266 | |

**Table 2: 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 whether a bank borrows from the ECB. *Log(Borrowing)*$_{it}$ is the natural logarithm of total borrowing plus one. *Collateral Rating* is the market value-weighted average credit rating of collateral. *Distressed-Sovereign Debt*$_{it}$*/Assets*$_{i,07}$ is total sovereign debt issued by distressed countries (Greece, Ireland, Italy, Portugal, and Spain) relative to bank assets as of December 2007. *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. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

| | Borrowing Indicator$_{it}$ | Log(Borrowing)$_{it}$ | Collateral Rating$_{it}$ | Distressed-Sovereign Debt$_{it}$/Assets$_{i,07}$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Bank Rating$_{i,07}$* Post-Greek Bailout$_t$ | 0.053*** | 0.068*** | 0.144*** | 0.180*** |
| | (0.011) | (0.017) | (0.039) | (0.063) |
| Bank Rating $_{i,07}$* Post-Lehman$_t$ | 0.011 | 0.023* | 0.001 | 0.070 |
| | (0.011) | (0.013) | (0.023) | (0.044) |
| Time Fixed Effects | Y | Y | Y | Y |
| Bank Fixed Effects | Y | Y | Y | Y |
| Banks | 292 | 292 | 287 | 276 |
| Observations | 51,684 | 51,684 | 45,997 | 48,852 |
| R2 | 0.476 | 0.789 | 0.672 | 0.645 |

**Table 3: 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$_{it}$/Assets$_{i,07}$* and *Distressed-Sovereign Debt Holdings$_{it}$/Assets$_{i,07}$* are collateral pledged and holdings of distressed-sovereign debt (Greece, Ireland, Italy, 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. The variable $\Delta_{t+1,i}$ denotes the change in a bank *i*'s variable from time t+1 to t. Columns (2), (4), and (6) include time fixed effects. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 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 Debt Pledged$_t$/Assets$_{i,07}$ | 0.447** | 0.444** | 0.563** | 0.542** | 0.026 | 0.047 |
| | (0.200) | (0.185) | (0.210) | (0.196) | (0.181) | (0.182) |
| Time Fixed Effects | N | Y | N | Y | N | Y |
| Banks | 53 | 53 | 25 | 25 | 28 | 28 |
| Observations | 106 | 106 | 50 | 50 | 56 | 56 |
| R2 | 0.162 | 0.198 | 0.236 | 0.274 | 0.001 | 0.025 |

**Table 4: 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 2. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

| Dependent Variable | Borrowing Indicator$_{it}$ | Log(Borrowing)$_{it}$ | Collateral Rating$_{it}$ | Distressed Sovereign Debt$_{it}$/Assets$_{i,07}$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Bank Rating$_{i,07}$* Post-Greek Bailout$_t$ | 0.047*** | 0.035** | 0.062** | 0.054* |
| | (0.012) | (0.016) | (0.030) | (0.030) |
| Bank Rating $_{i,07}$* Post-Lehman$_t$ | 0.013 | 0.009 | -0.005 | -0.015 |
| | (0.011) | (0.014) | (0.024) | (0.035) |
| Country-Time Fixed Effects | Y | Y | Y | Y |
| Bank Fixed Effects | Y | Y | Y | Y |
| Banks | 292 | 292 | 287 | 276 |
| Observations | 51,684 | 51,684 | 45,997 | 48,852 |
| R2 | 0.518 | 0.818 | 0.766 | 0.733 |

**Table 5: Bank Rating and LOLR Borrowing (non-distressed 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 non-distressed countries (European countries other than Greece, Ireland, Italy, Portugal, and Spain) from August 2007 to December 2011. All variables are defined in Table 2. All columns include week fixed effects and bank fixed effects. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

| Sample | Non-distressed Sovereigns | | | |
|---|---|---|---|---|
| Dependent Variable | Borrowing Indicator$_{it}$ | Log(Borrowing)$_{it}$ | Collateral Rating$_{it}$ | Distressed Sovereign Debt$_{it}$/Assets$_{i,07}$ |
| | (1) | (2) | (3) | (4) |
| Bank Rating$_{i,07}$* Post-Greek Bailout$_t$ | 0.043*** | 0.047*** | 0.068** | 0.049* |
| | (0.012) | (0.015) | (0.033) | (0.026) |
| Bank Rating $_{i,07}$* Post-Lehman$_t$ | 0.012 | 0.011 | 0.012 | 0.003 |
| | (0.013) | (0.014) | (0.023) | (0.023) |
| Time Fixed Effects | Y | Y | Y | Y |
| Bank Fixed Effects | Y | Y | Y | Y |
| Banks | 234 | 234 | 229 | 221 |
| Observations | 41,418 | 41,418 | 36,912 | 39,117 |
| R2 | 0.486 | 0.799 | 0.769 | 0.673 |

**Table 6: 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 2. All variables include controls for bank size, deposit share, loan share, distressed-country debt (as of August 2007) 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. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

| Dependent Variable | Borrowing Indicator$_{it}$ | Log(Borrowing)$_{it}$ | Collateral Rating$_{it}$ | Distressed Sovereign Debt$_{it}$/Assets$_{i,07}$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Bank Rating$_{i,07}$* Post-Greek Bailout$_t$ | 0.039*** | 0.055*** | 0.171*** | 0.207** |
| | (0.011) | (0.019) | (0.047) | (0.067) |
| Bank Rating $_{i,07}$* Post-Lehman$_t$ | -0.013 | 0.042*** | -0.004 | 0.098* |
| | (0.010) | (0.015) | (0.027) | (0.048) |
| Time Fixed Effects | Y | Y | Y | Y |
| Bank Fixed Effects | Y | Y | Y | Y |
| Banks | 292 | 292 | 272 | 276 |
| Observations | 48,852 | 48,852 | 43,720 | 48,852 |
| R2 | 0.492 | 0.811 | 0.684 | 0.656 |

**Table 7: Bank Rating and LOLR Borrowing (publicly-listed bank sample)**

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 publicly-listed banks (57 banks) during the period from August 2007 to December 2011. All variables are defined in Table 2. All columns include week fixed effects and bank fixed effects. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

| Dependent Variable | Borrowing Indicator$_{it}$ | Log(Borrowing)$_{it}$ | Collateral Rating$_{it}$ | Distressed Sovereign Debt$_{it}$/Assets$_{i,07}$ |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| Bank Rating$_{i,07}$* Post-Greek Bailout$_t$ | 0.088*** | 0.331*** | 0.448*** | 0.695*** |
| | (0.029) | (0.075) | (0.139) | (0.247) |
| Bank Rating $_{i,07}$* Post-Lehman$_t$ | 0.027 | 0.127*** | -0.034 | 0.288** |
| | (0.018) | (0.046) | (0.046) | (0.118) |
| Time Fixed Effects | Y | Y | Y | Y |
| Bank Fixed Effects | Y | Y | Y | Y |
| Banks | 57 | 57 | 57 | 57 |
| Observations | 10,085 | 10,085 | 9,894 | 10,085 |
| R2 | 0.480 | 0.668 | 0.683 | 0.748 |

**Table 8: 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 covers banks with traded CDS prices (36 banks) during the period from August 2007 to December 2011. $Log(CDS)_{i,10}$ is the natural logarithm of the CDS price as of the January 4, 2010. All other variables are defined in Table 2. All columns include week fixed effects and bank fixed effects. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

| Dependent Variable | Borrowing Indicator$_{it}$ | Log(Borrowing)$_{it}$ | Collateral Rating$_{it}$ | Distressed Sovereign Debt$_{it}$/Assets$_{i,07}$ |
|---|---|---|---|---|
| | (1) | | (2) | (3) |
| Log(CDS)$_{i,10}$* Post-Greek Bailout$_t$ | 0.065 | 0.952* | 2.115*** | 1.791* |
| | (0.129) | (0.513) | (0.762) | (0.937) |
| Log(CDS) $_{i,10}$* Post-Lehman$_t$ | -0.076 | 0.593** | -0.170 | 1.283 |
| | (0.084) | (0.260) | (0.294) | (0.745) |
| Time Fixed Effects | Y | Y | Y | Y |
| Bank Fixed Effects | Y | Y | Y | Y |
| Banks | 36 | 36 | 36 | 36 |
| Observations | 6,372 | 6,372 | 6,197 | 6,372 |
| R2 | 0.489 | 0.588 | 0.683 | 0.766 |

**Table 9: 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$_t$ is the natural logarithm of total borrowing relative to collateral. All variables are defined in Table 2. All columns include bank and week fixed effects. Column (2) also includes country-time fixed effects (similar to Table 4). Column (3) restricts the sample to banks headquartered in non-distressed countries (similar to Table 5). All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

| Dependent Variable | Borrowing/ Collateral$_{it}$ | Borrowing/ Collateral$_{it}$ | Borrowing/ Collateral$_{it}$ |
|---|---|---|---|
| Sample | All | All | Non-distressed |
| | (1) | (2) | (3) |
| Bank Rating$_{i,07}$* Post-Greek Bailout$_t$ | 0.180*** | 0.088** | 0.177*** |
| | (0.055) | (0.040) | (0.062) |
| Bank Rating $_{i,07}$* Post-Lehman$_t$ | 0.102** | 0.066** | 0.095** |
| | (0.039) | (0.032) | (0.046) |
| Time Fixed Effects | Y | Y | Y |
| Bank Fixed Effects | Y | Y | Y |
| Country-time fixed effects | N | Y | N |
| Banks | 283 | 283 | 226 |
| Observations | 29,927 | 29,927 | 22,184 |
| R2 | 0.556 | 0.250 | 0.609 |

**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 (Greece, | ECB |
| Central Bank Borrowing | | |
| Any borrowing (Yes=1) | Indicator variable 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, ..) | ECB |
| Distressed Sovereign debt | Sovereign Debt issued by Distressed Countries | ECB |