Who Borrows from the Lender of Last Resort?*

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Abstract

Understanding why banks borrow from the Lender of Last Resort (LOLR) during a financial crisis is crucial to understanding the macroeconomic impact of such large-scale interventions. We document a strong divergence among banks' take-up of LOLR assistance during the financial crisis in the euro area, as banks which borrowed heavily also used increasingly risky collateral. We propose four explanations for this divergence: (1) illiquidity, (2) risk-shifting, (3) political economy, and (4) differences in banks' private valuations. We test these explanations using proprietary data on all central bank borrowing and collateral pledged in the euro area from 2008 to 2011, together with holdings data from the European bank stress tests. Our results strongly support the risk-shifting explanation. We find it both in the financially-distressed countries, where illiquidity and political economy are also at work, and in the non-distressed countries, where it appears to be the main driver of differences in bank's behavior.

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1 Introduction

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 seems very important to understand how these interventions impact the financial system and, ultimately, the economy. This question is particularly relevant in recent times, as central banks around the world have responded to the financial crisis that began in 2008 by engaging in unprecedented large-scale LOLR interventions.

The theory of the LOLR says that lending to illiquid (but solvent) banks during a financial crisis has large welfare benefits. The idea goes back to Thornton (1802) and Bagehot (1873), who were among the first to analyze the role of the LOLR. Their analysis is based on the assumption that financial crises are due to market failures, such as information asymmetries and the threat of bank runs, which prevent the optimal allocation of capital. As a result, banks cannot secure funding during crises and need to sell assets at fire-sale discounts. This depletes bank capital and reduces financing for the real economy, leading to a credit crunch. LOLR theory suggests that the government can address this market failure by providing funding to banks, thereby alleviating the credit crunch.

In this paper we analyze why banks borrow from the LOLR. Is borrowing driven by bank's illiquidity, as LOLR theory suggests, or are there other motivations that explain LOLR borrowing? The answer to this question is crucially important for understanding the welfare implications of LOLR interventions. If banks' borrowing from the LOLR is due to illiquidity, as Bagehot (1873) had conjectured, then LOLR interventions will generate large welfare gains. However, if borrowing is driven by other motivations, such as risk seeking at the expense of the LOLR, or political capture, then the benefits may be much smaller. It may even be possible in extreme cases that LOLR funding could exacerbate a financial crisis.

Two main challenges arise in analyzing banks' motivation for borrowing from the LOLR. First, financial crisis are large shocks that affect all banks at the same time. Hence, from a

methodological point of view, one needs to develop empirical tests which distinguish between different motivations for LOLR borrowing in the midst of a crisis. Second, one needs detailed bank-level data on the take-up of LOLR assistance and the terms of this lending. However, such data are usually regarded as proprietary by central banks and not shared with the public.

In this paper we address both challenges. On the methodological side, this paper develops a novel empirical strategy to identify the motivation behind LOLR borrowing. We use variation in banks' capital *before* the financial crisis to test theories of LOLR borrowing *during* the crisis. Moreover, we analyze the dynamics of bank assets holdings and LOLR collateral to determine whether banks pledge existing asset holdings or actively invest in LOLR collateral. On the data side, we use a novel and proprietary dataset on *all* central bank borrowing and collateral pledged in the euro area from August 2007 to December 2011, together with holdings data from the European bank stress tests. Our sample captures the universe of banks in the euro zone and, to the best of our knowledge, this is the first paper using such a micro-dataset from a lender of last resort.

To understand the motivation for LOLR borrowing it is important to understand how LOLR lending is implemented. The European Central Bank (ECB) is the LOLR in the euro zone. It provides loans to banks via a lending arrangement that mirrors private 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" on the loan.[1] This haircut depends on which kind of collateral is used. Since the collateral serves to prevent the lender from counterparty risk, riskier collateral is penalized with a higher haircut.

The ECB provides repos to a broad swath of European banks against a broad range of collateral. Like private markets, the haircut on an ECB loan depends on the type of collateral used, but not on the specific borrowing bank. There is no cap on an individual bank's borrowing. Thus, a bank can borrow an unlimited amount as long as it provides

[1]For example, if \$100 market value bond is used as collateral and the haircut is 15%, then the borrower can borrow up to \$85.

sufficient collateral.[2]

ECB haircuts are often smaller than in private markets. For example, ECB haircuts on Greek sovereign debt remained at around 10% through the end of 2011, even as they rose to much higher levels in private repo markets. We refer to the difference between the private-market and ECB's haircut on a security as the security's implicit "haircut subsidy". In general, ECB haircuts on risky securities, such as mortgage-backed securities, covered bonds, and distressed-country sovereign debt, are less than those in the private market, while for safe assets they are they are the same or even higher. In other words, risky securities carry high haircut subsidies, while safe assets carry little or no subsidy.[3] In contrast, the interest rate charged by the ECB on its loans is *higher* than the interest rate which prevails in private repo markets.[4]

A bank's total take-up of ECB subsidies can therefore be measured by the average haircut subsidy of its collateral scaled by total borrowing. Hence, a natural starting point for analyzing LOLR borrowing is to examine whether the take-up of haircuts subsidies is roughly uniform across banks, or whether there are significant cross-sectional differences. To check this, we sort banks into quintiles based on their borrowing normalized by size and examine average collateral risk within the quintiles. Greater collateral risk among high-borrowing banks implies that there is a large difference across banks in the take-up of implicit subsidies, since both components of the total subsidy are concentrated within the same bank quintile. We find that this is clearly the case. Moreover, this difference steadily diverges from early 2010 until December 2011, the end of the sample period.

[2]In late 2008, the ECB switched to unlimited lending in response to the Lehman bankruptcy in September 2008. Before the Lehman bankruptcy, the ECB had a cap on total bank borrowing and distributed funds via auctions. The Lehman bankruptcy therefore marks the start of unlimited LOLR lending in the eurozone.

[3]Providing such haircuts subsidies is in keeping with the desire of the LOLR to intervene in markets to support bank lending, and is similar to other implementations of LOLR lending, such as that in the United States. In addition, one would expect that haircuts subsidies are larger for riskier assets because market haircuts rise more for such securities during a crisis.

[4]This structure of 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". Good collateral is understood to be "everything which in common times is a good 'banking security"' (Bank of England (2009)).

1.1 Theories and Evidence

Our analysis seeks to understand the motivation for take-up of LOLR lending in the eurozone. We focus on two important explanations that are highlighted in LOLR theory, which we call *illiquidity* and *risk-shifting*.

The *illiquidity* theory says that banks suffer from an inability to roll over financing of assets due to a market failure. Important examples are a panic-induced run on a bank's deposits or a run on private-market repo financing of some assets held by the bank. If LOLR assistance were unavailable, banks suffering from such illiquidity would be forced to sell some of their asset holdings. The rush to sell assets could lead to fire sales and the destruction of bank equity, causing a credit crunch. LOLR assistance provides such banks with financing for their existing assets, allowing them to slowly de-leverage and avoid fire sales. According to the illiquidity theory, the difference we find in the take-up of ECB subsidies reflects differences in illiquidity across banks. To explain the divergence over time, the theory suggests that the high-borrowing banks must have suffered disproportionately from a series of illiquidity shocks, and that they borrowed using increasingly risky collateral.

The *risk-shifting* theory says that, due to risk-shifting incentives, some banks use LOLR haircut subsidies to increase their risk taking. Under this theory, a crisis-induced decline in bank asset values raises the likelihood of default of poorly-capitalized banks, making it attractive for them to increase risk using LOLR loans. The reason is that haircut-subsidized loans are undercollateralized and hence the LOLR will bear some loss if the borrowing bank defaults just as the collateral value decreases. Therefore, risky, high haircut-subsidy assets represent an opportunity for poorly-capitalized to buy upside while leaving some of the downside risk with the LOLR. In contrast, well-capitalized banks are unlikely to default, and since the interest rate on ECB loans is higher than the rate charged in private repo markets, they will not view such loans as having a positive net benefit. Hence, the risk-shifting theory can explain both the difference and divergence in the take-up of LOLR subsidies if it is the poorly-capitalized banks which borrowed highly and financed increasingly risky assets with the ECB.

To test the risk-shifting theory we therefore analyze whether poorly-capitalized banks borrow more and pledge riskier collateral over time. A challenge with empirically identifying financially weak banks is that measures of a bank's financial strength during the financial crisis may also reflect the market's concerns about its degree of illiquidity. To address this concern we measure banks' financial strength *prior* to the start of the crisis, when illiquidity was not a concern, as a proxy for their financial strength, and hence risk-shifting incentives, during the crisis. Our identifying assumption is that banks with less pre-crisis capital are more likely to have risk-shifting incentives during the crisis and that pre-crisis capital levels have no other (direct) effects on LOLR borrowing. This assumption is plausible in the context of the European financial crisis because there is no evidence of bank illiquidity prior to the crisis. We provide several empirical tests to validate this assumption.

We measure a bank's pre-crisis financial strength using the median credit rating as of August 2007. We use OLS regressions to examine if poorly-capitalized banks are more likely to borrow and use riskier collateral. We use two measures of a bank's collateral risk, its average collateral credit rating, and the ratio of total distressed-country sovereign debt relative to bank's assets.[5] The first measure captures general collateral riskiness. The second measure is motivated by the observation that distressed-country sovereign yields were relatively high during the crisis, and due to their low regulatory risk weights represented an attractive vehicle for banks to take risk. Moreover, since the European bank stress tests forced banks to report their holdings of sovereign debt, it is the only type of asset for which micro data on banks' *holdings* is widely available.

We find that a bank's pre-crisis credit rating significantly predicts, both statistically and economically, its likelihood of borrowing and its collateral risk, using both of our measures. We further estimate this relationship quarter by quarter to examine its dynamics over time. Similar to the pattern we observe in the take-up of ECB subsidies, we find that the relationship between banks' pre-crisis credit rating and their borrowing and collateral risk strengthens starting in early 2010 and continues to intensify until the end of 2011. This

[5]We define distressed countries as the ones which were downgraded below 'AA' (Greece, Ireland, Italy, Portugal, and Spain).

leads us to conclude that the Greek debt crisis, which began in February 2010, was likely a source of the shock which amplified banks' risk-shifting incentives.

Our identifying assumption is that banks' credit ratings as of August 2007 only affect LOLR borrowing through the banks' risk-shifting incentives. A possible concern with this assumption is that banks' credit rating also captures a bank's illiquidity during the financial crisis. Even though there is no evidence of bank illiquidity in August 2007, this may be the case if pre-crisis bank capital levels happen to be correlated with illiquid assets holdings during the crisis. We conduct three tests to understand if illiquidity can account for our findings.

Our first test examines whether the increase in banks' risky collateral reflects an increase in their actual holdings of these assets. The answer to this question provides a clear distinction between the illiquidity and risk-shifting theories. Whereas the illiquidity theory predicts that banks use LOLR financing to avoid fire selling *existing* asset holdings, the risk-shifting theory predicts that banks use LOLR financing to increase risky asset holdings. We use data on banks' holdings of distressed-country debt obtained from the five European bank stress tests conducted between March 2010 and June 2012. As predicted by the risk-shifting theory, we find that a \$1 increase between stress tests in a bank's pledging of distressed-country debt is associated with a statistically significant \$0.45 increase in its distressed-country debt holdings. Illiquidity can therefore only explain at most the remaining 55% of banks' borrowing. Moreover, consistent with the risk-shifting theory, the relationship between changes in collateral and holdings is stronger for banks with lower pre-crisis capital.

Our second test directly examines the source of illiquidity. The most plausible drivers of differences in illiquidity across banks are likely to be country-level factors. For instance, there is evidence that the deterioration in health of distressed-country governments lead to deposit flight from these countries. To test this, we augment our main regression with country-time fixed effects and test whether banks' pre-crisis ratings remains predictive of borrowing and collateral risk within countries. Though we find that this causes the coefficient on credit rating to decrease by between 22% and 58%, it remains remains strongly statistically

significant. Hence, country-level differences in illiquidity can account for at most 58% of the observed variation in LOLR borrowing across banks.

Our third test examines banks that are unlikely to be affected by illiquidity. Since banks headquartered outside the non-distressed countries were not subject to deposit flight, we estimate our main regression using only the banks headquartered in the non-distressed countries. We find that the coefficient on bank rating remains statistically significant, though it is up to 60% smaller than for the full sample. Again, this result suggest that illiquidity cannot fully explain variation in LOLR borrowing.

Finally, we examine two other potential explanations that have been suggested for LOLR borrowing. We note that both of these explanations emphasize active risk-taking by banks and are therefore incompatible with illiquidity. The first, which we term *political economy*, maintains that some governments encouraged their banks to use LOLR financing to buy risky assets. In particular, distressed-country governments may have viewed this a way to reduce their cost of borrowing by increasing demand for their bonds. An implicit assumption of this explanation, is that banks' risk-shifting incentives made this government persuasion possible.[6] This theory may explain why the coefficient on bank rating is larger for the sample of distressed-country banks. However, it cannot explain why bank rating continues to predict collateral risk even for the banks of non-distressed countries.

The second explanation, which we call *differences in private valuation* theory, says that some banks use LOLR financing to take risk, but suggests that this is due to differences in banks' demand for these assets for reasons *other* than risk shifting. Specifically, some banks may be specialists in investing in certain types of risky assets, such as mortgage-backed securities, or they may be more optimistic about their payouts.[7] We test for this by controlling for bank characteristics, proxies for bank business type, and funding structure within our main regression. We find this has essentially no effect on the main result, lending little support to this explanation. It is also unlikely that this explanation can account for

[6] It is normally difficult for governments or regulators to force banks to act against their natural incentives.

[7] Note that risk-shifting incentives also leads to a difference in the bank's private valuation of risky assets. However, we treat it differently since, unlike the other reasons for differences in valuation, it is incompatible with firm value maximization.

our results on the sovereign debt of the distressed countries, since this is not a plausible area of specialty for banks.

Overall, we find evidence that risk-shifting accounts for a significant share of LOLR borrowing after 2010. Even though risk-shifting can reduce social welfare, we emphasize that such costs must be traded off against the benefits of LOLR interventions. Specifically, LOLR lending can prevent costly bank runs and support bank lending in distressed countries. Therefore, 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.[8]

The remainder of the paper is organized as follows. Section 2 discusses the related literature. Section 3 discusses the data and presents an overview of banks' borrowing from the ECB. Section 4 describes our empirical strategy and reports the results. Section 5 concludes.

2 Relation to the Literature

This paper relates to the literature on the role of the LOLR. This literature goes back to the seminal work by Thornton (1802) and Bagehot (1873), who was the first to formulate a specific role for central banks in the provision of liquidity in times of financial crisis. The idea is that central banks can mitigate the fundamental market failure of asymmetric information between borrowers and lenders during times of crises. Tucker (2009) paraphrases Bagehot's (1873) advice 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". 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

[8]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., where the Federal Reserve is both bank supervisor and LOLR.

original motivation for creating central banks in many countries was to contain financial crises.[9]

A large theoretical literature has re-examined the question of whether and how central banks should intervene during times of financial crises. For example, Goodfried and King (1988) argue that in developed economies solvent banks should always be able to obtain funding liquidity given the efficiency of money markets. They suggest that central banks should therefore 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. He argues that the existence of contagion may justify the rescue of a bank during times of crisis. 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). Stein (2012) argues that a primary function of central banks is to address the market failure of banks creating too much short-term debt and therefore leaving the system excessively vulnerable to costly financial crisis. Farhi and Tirole (2012) show that the government's inability to commit not to bail out banks during a systemic crisis generates an incentive for banks to excessively invest in assets that decline during systemic crises. Allen and Gale (1999) and Diamond and Rajan (2005) argue that, due to interconnectedness in the banking sector, a liquidity shock at one bank could propogate through the financial system. This provides a rationale for generous liquidity provision by the lender of last resort to all banks during a crisis.

Several authors argue that a LOLR can have positive effects. For example, Miron (1986), Bordo (1990) and Eichengreen and Portes (1987) examine empirically the effect of creating a LOLR and argue that the existence of such a lender 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

[9]For an excellent survey of the issue see Freixas and Rochet (2008).

cases of financial panics arose because Central Banks did not follow Bagehotian principles". Bernanke (1983) further argues that the destruction of informational bank capital due to bank failures deepened the economic 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 (a 'credit crunch') thereby amplifying the real effects of a negative macroeconomic shock. LOLR intervention represents a way of dampening this cycle by relaxing collateral constraints.

However, other studies point out that LOLR lending can exacerbate and prolong financial crisis. Caballero, Hoshi, and Kashyap (2008) examines 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 because it let insolvent banks continue to operate, which encouraged them to increase their risk exposure. Goodhart and Schoenmaker (1995) find empirical evidence using 104 failing banks across multiple countries that central banks have a strong tendency to bail out, rather than liquidate, banks in financial distress.

There are only a few studies examining the mechanics of specific LOLR interventions, most of which focus on the financial crisis of 2007 to 2011. Cassola, Hortacsu, and Kastl (2009) examine variable rate tender auctions conducted by the ECB prior to the Lehman bankruptcy. They find that some banks were willing to pay large premia to access central bank funding. Armantier, Ghysels, Sarkar and Shrader (2011) examine the question of whether there is an asymmetric information between banks and outside investors leading to stigma in borrowing from central banks. Comparing different lending mechanisms provided by the Federal Reserve, they find that banks were willing to pay a premium to borrow through auctions rather than borrowing individually via the discount window. They interpret this finding as suggestive of stigma, though the effect is quantitatively small.

Overall, the differences in views on LOLR can be traced to whether the central bank is dealing with illiquid or insolvent institutions. Proponents of LOLR facilities usually emphasize the illiquidity arising from asymmetric information and externalities, such as bank runs, fire sales, and depressed lending, that can be addressed by providing central bank lending. In contrast, critics of LOLR lending usually emphasize the moral hazard cost of lending to insolvent institutions, leading to zombie lending or even increased risk shifting by insolvent banks. To the best of our knowledge, our paper is the first one to use micro-data to evaluate different theories of the LOLR.

3 Setting and Data

Our analysis focuses on open market operations conducted by the ECB. The ECB engages in two types of open market operations: main refinancing operations (MRO) and longer-term refinancing operations (LTRO). MROs are regular liquidity-providing transactions with a weekly frequency and a maturity that is normally one week. LTROs are liquidity-providing transactions offered every other week and usually have a maturity of one to three months. On two occasions, the ECB decided to provide even longer maturities - namely a one-year LTRO (July 2009) and a three-year LTRO (December 2011, February 2012).[10]

The ECB engages in lending to a large number of financial institutions. These institutions need to satisfy eligibility criteria regarding their reserves within the Eurosystem and their financial soundness. Financial soundness is determined by the national authority in which the bank is headquartered. The ECB maintains a complete list of financial institutions that can participate in open market operations on its website.[11] The coverage in terms of access to ECB lending varies across countries and typically depends on national guidelines that preceded the establishment of the ECB. In general all large banks with assets of at least €10

[10] Apart from MRO and LTRO, the ECB also engages in fine-tuning operations on an ad hoc basis as part of its open market operations. These operations are quantitatively very small and are therefore not included in our analysis. The history of all open market operations is available at *http://www.ecb.int/mopo/implement/omo/html/top_history.en.html.*

[11] The updated list is available at *https://www.ecb.europa.eu/stats/money/mfi/general/html/elegass.en.html.*

billion have access to ECB lending. Depending on the country, many banks with assets of less than €10 billion also have access to ECB lending. This includes financial institutions that have subsidiaries in Eurozone member states but are not headquartered in the Eurozone. As of January 2011, a total of 3,211 financial institutions were eligible to borrow from the ECB. We find that a total of 1,826 financial institutions borrowed from the ECB at least once in the period from January 2009 to December 2011.

The ECB open-market operations are executed either in terms of variable or fixed-rate auctions. Prior to October 2008, the ECB primarily conducted variable rate auctions. In a variable rate auction, the ECB asks banks to submit bids for requested borrowing quantities at various interest rates. The ECB then aggregates all bids and determines the maximum interest rate at which demand exceeds supply. All bids for higher interest rates are satisfied and demand at the marginal rate is rationed proportionally. Starting from October 15 2008, the ECB switched to fixed-rate auctions with full allotment. In a fixed rate auction, the ECB sets an interest rate and banks can borrow an unlimited amount at the given interest rate. This switch in the auction format was intended to lessen concerns among banks to access ECB funding in times of crisis. The ECB has publicly committed itself to maintain the fixed rate auction format until at least July 2012.[12]

To borrow from the ECB banks must provide adequate collateral. Adequate collateral needs to satisfy eligibility criteria regarding the type of assets, credit standards, place of issue, type of issuer, currency, asset marketability, and other characteristics. The eligibility are applied uniformly across the Euro area. In general the ECB seeks to require high-quality collateral that reduces the likelihood of a credit loss in case a counterparty defaults. The ECB applies differential haircuts to collateral depending on asset quality. A list of current eligible assets is provided on the ECB's website.[13,14]

[12] As indicated in a speech by the ECB Executive Board Member Jose Manuel Gonzalez-Pramo in October 2011.

[13] The list is available at *https://www.ecb.europa.eu/paym/coll/assets/html/index.en.html*

[14] Throughout the period of our study the ECB was not responsible for the supervision of banks in the euro area. Banks were allowed to post collateral and receive liquidity only if they were deemed financially sound by their national supervisors. On December 12, 2012, the ECOFIN decided to grant the ECB the prime responsibility to supervise banks in the euro area.

3.1 Data

Our dataset is from the ECB and contains bank-level information about total borrowing and collateral pledged with the ECB. These data are collected in the process of implementing monetary policy via open market operations. The dataset covers the period from 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.

The data identify all banks which borrow from the ECB in each week. The ECB consolidates all banks subsidiaries with bank headquarters. If a bank is headquartered outside the Eurozone, then the ECB consolidates the bank at the level of subsidiary located in the Eurozone. For each bank the dataset provides information about all of the collateral pledged by the bank to the ECB. Collateral is identified at the asset level (ISIN code) and nominal values and pre- and post-haircut market values are recorded (the ECB estimates market values for non-marketable collateral). The total post-haircut market value of collateral represents a bank's total borrowing capacity with the ECB. The dataset also reports total borrowing with the ECB by MRO and LTRO operation.

The dataset categorizes collateral based on the type of asset. Categories include government bonds, corporate bonds, asset-backed securities, covered bonds, and non-marketable collateral. For any collateral that is rated it further gives ratings from up to three ratings agencies. In our analysis we use the rating used by the ECB to assess eligibility if an asset is rated by more than one rating agency.

We match the ECB dataset to several other data sets. First, we use the SNL Financial European bank dataset to identify all publicly listed banks that are headquartered in Europe. We then match the SNL Financial Data to data on market values and equity returns for the period from January 2006 to December 2011 from Datastream. We exclude stale data by dropping observations with at least four consecutive days of zero returns (almost all stale observations occur before September 2008). We exclude banks that are headquartered outside the Eurozone. Our matched dataset yields a total of 76 banks.

Second, we use the SNL Financial European dataset (combined with Bankscope) to

identify all banks with assets of at least €10 billion. Next, we use Datastream to select all banks with traded credit default swap (CDS) prices. We then match the SNL Financial Data with CDS prices for the period from January 2006 to December 2011. We exclude stale data by dropping observations with at least four consecutive days of zero change in CDS price (almost all stale observations occur before September 2008). We exclude banks headquartered outside the Eurozone. Our matched dataset includes a total of 56 banks with traded CDS. The main difference relative to the publicly listed sample 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.

Third, we use the ECB bank credit rating data to identify all banks with at least one credit rating. We match all banks with credit ratings to the bank dataset Bankscope. If a bank has more than one credit rating, we assign the median rating. To cross-check our listed banks sample, we verify with the Bankscope data that there are no publicly listed banks that are excluded from the listed bank sample. 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 Financial dataset and find an almost perfect overlap for the banks that are reported in both datasets. Our dataset for banks with a credit rating yields a total of 292 banks.

To ensure the accuracy of our dataset, we aggregate total borrowing and total collateral by week. We match our data with publicly available information from the ECB on weekly borrowing under MRO and LTRO and find a perfect overlap. We also aggregate collateral by loan type and year. We check the accuracy using information from the ECB Financial Statements and find an almost perfect overlap. We also aggregate total borrowing by country and check the releases on total borrowing by national member banks. All our tests indicate that our data is highly accurate and complete.[15]

Panel A of Figure 1 shows total lending by the European Central Bank in the period

[15]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 total 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 lending directed to Greek and Irish banks.

from October 2008 to December 2011. At the beginning of October 2008, European banks were borrowing about €500 billion from the ECB. In July 2009, the ECB offered LTRO with a one-year maturity leading to an additional borrowing of about €300 billion. Total borrowing peaked at €900 billion prior to the expiration of the one-year LTRO in June 2010. After July 2010, total borrowing dropped by €300 billion and declined gradually thereafter. Starting in June 2011, this trend reversed and ECB borrowing increased again. The last observation in 2011 indicates the take-up of the first round of three-year LTRO offered at the end of December 2011. The net increase in borrowing due to the first round of three-year LTRO was about €300 billion.

Panel B of Figure 1 shows the share of financial institutions that borrow from the Central Bank in the period of October 2008 to December 2011. We compute the ratio as the number of financial institutions that borrow from the ECB in a given week relative to the number of financial institutions that borrow at least once throughout our analysis period. The figure shows that in October 2008 about 45% of financial institutions were borrowing from the ECB. Borrowing peaks during the one-year LTRO with more than 70% of financial institutions borrowing from the ECB. After the expiration of the one-year LTRO in June 2010, the share of borrowing banks drops to less than 30%. The last observation in 2011 indicates the take-up of three-year LTRO with a jump in the share of banks borrowing to 30%.

Figure 2 shows total collateral pledged with the ECB. Panel A plots total market value before and after haircuts. As shown in the figure, total collateral pledged is fairly stable at about €2 trillion. The only marked increase is at the end of the analysis period, which is probably due to first round of the three-year LTRO. Moreover, the average ECB haircut on collateral is fairly stable at less than 10%. Panel B plots collateral by asset type. The collateral is a mix of sovereign debt, asset-backed securities, corporate bonds, covered banks, and non-marketable assets. As shown in the figure, the share of each asset type is fairly stable throughout the financial crisis.

3.2 Summary Statistics

Table 1 provides summary statistics for the sample of banks with credit ratings. These banks represent more than 95% of bank assets in the euro zone. Our sample contains 292 unique banks and 55,298 bank-week observations in the period from January 2009 to December 2011. As shown in column (1), average bank size is €143 billion and average book equity is €6.6 billion. The banks are relatively highly levered with a ratio of book equity to total assets of 6.0% and a Tier 1 ratio of 11.3%. About 57% of assets are loans and about 64% of liabilities are financed with deposits. The average bank credit rating is A.[16] About 19% of assets are headquartered in distressed countries (Greece, Ireland, Italy, Portugal, and Spain). For the subsample of banks that are publicly traded (76 banks), market leverage is 45.3. For the subsample of banks that have a traded credit default swap (CDS) spread (56 banks), the average CDS spread is 245 basis points.

About 55% of banks borrow from the ECB in a given week. The total borrowing per bank (including observations with zero borrowing) is €1.6 billion, which represents about 59% of book equity. We find that banks overcollateralize their borrowing and on average borrow about 30% of the value of their collateral. The breakdown by type of lending facility is 23% for LTRO and 8% for MRO borrowing.

About 92% of banks have collateral pledged with the ECB in a given week. This indicates that most banks pledge collateral even if they do not borrow from the ECB. The reason is that collateral has to be approved by the ECB and thus pledging collateral can take some time. Many banks pledge excess collateral to ensure that they have access to ECB funding at a short notice. To the extent that such collateral could be used elsewhere, this is costly because banks cannot pledge unused collateral with other market participants. About 81% of collateral is rated by at least one of the three rating agencies. The average rating is 2.7, or equivalently, a rating between AA+ and AA. Assets without credit ratings are non-marketable assets or assets that were not matched to ratings by the ECB. Banks pledge

[16] We assign higher numerical values for lower ratings such that AAA=1, AA+=2, AA=3, AA-=4, A+=5 and so on.

about 0.3% of distressed sovereign debt relative to banks size as of December 2007.

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 total bank assets of €141 billion and €153 billion, respectively. Banks in non-distressed countries have a lower CDS relative to banks in distressed countries, 163 versus 391 basis points, they have higher bank ratings, 5.2 versus 7.2, and higher tier-1 ratios, 12.0% versus 9.8%. Hence, banks in non-distressed countries appear to be less risky than banks in distressed countries.

Banks in non-distressed countries are less likely to borrow from the LOLR relative to banks in distressed countries, a likelihood of borrowing of 50% versus 76%, and they tend to borrow less relative to bank equity, 48% versus 107%. Banks from both non-distressed and distressed countries are equally likely to post collateral with the LOLR (about 92%). However, banks from non-distressed countries pledge safer collateral relative to banks from distressed countries: the average collateral credit rating is 2.7 versus 3.0 and the average haircuts is 6.7% versus 8.6%, respectively.

In short, banks from distressed countries are somewhat riskier than banks from non-distressed countries, they are more likely to borrow from the LOLR, and they pledge riskier collateral. This observation is consistent with all explanations of LOLR borrowing. The main objective of our empirical analysis is to develop a test to distinguish between different explanations.

3.3 Divergence of Haircut Subsidies

We begin our analysis by examining if there are significant differences in the take-up of ECB subsidies across banks. As described in the introduction, the ECB provides implicit subsidies to banks by applying lower haircuts against certain types of collateral than are required in private repo markets. We refer to the difference between the private-market and ECB haircut on a piece of collateral as its haircut subsidy. While data on private-market

repo haircuts is sparse, it is clear that haircut subsidies are small (or zero) for very safe collateral and larger for riskier collateral. This is because ECB haircuts are less sensitive to asset quality than are private-market haircuts. For example, at the end of 2010 the ECB's haircut on (very safe) 5-year German Bunds was 3.00%, while LCH clearnet, a private repo exchange, applied only a 2.00% haircut on these bonds. In contrast, LCH Clearnet applied a 10.00% haircut to the significantly riskier 10-year Portugal bonds, while the ECB haircut was only 4.00%.

A stark example of haircut subsidies is Greek sovereign bonds. Panel A of Figure 3 plots the average haircut charged by the ECB on Greek sovereign debt over the sample period, together with a plot of the (log) CDS on Greek government debt. The plot shows that the average ECB haircut only these bonds was only 8% throughout this period, even as Greek CDS increased dramatically. Panel B shows that, consequently, Greek sovereign bond collateral largely migrated from private markets to the ECB.

Since the haircut subsidy on collateral is increasing in its risk, we proxy for the average haircut subsidy on a bank's collateral using measures of the collateral's riskiness. Our 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 its individual asset ratings. A higher value for the average rating measure indicates riskier collateral (lower collateral quality). Our second measure of the bank's collateral risk is the share of its total collateral that is sovereign debt originated in the distressed countries (Greece, Italy, Ireland, Portugal, Spain). We use this measure since buying distressed-country sovereign debt was a well-known and capital-efficient way that banks could accumulate high-yielding assets over the sample period.

The total ECB 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 subsidy is captured by banks that engage in a high level of borrowing against risky collateral. To determine whether there are large cross-sectional differences in the takeup of ECB subsidies, we therefore examine whether there is a positive relation between a bank's ECB borrowing

and its collateral risk. Towards that end we sort banks into quintiles based on their ECB borrowing normalized by size as of July 2010 and examine the average collateral risk of the banks within these quintiles.

Figure 4 plots the time series of the collateral risk measure for the lowest and highest borrowing quintiles. In Panel A, collateral risk is measured using the average collateral rating measure. The plot shows that the collateral risk of the banks in the lowest borrowing quintile remains roughly constant throughout the whole sample period. At the beginning of the period, the collateral risk of the high borrowing quintile is similar to that of the low borrowing quintile. However, starting in early 2010 it begins to diverge markedly from the low borrowing quintile. 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 4 shows a similar result using our second measure of collateral risk, the distressed-sovereign debt share. In this case, the collateral risk of the high-borrowing quintile is already significantly higher in 2009. Yet, as in Panel A the difference begins to grow in 2010 and continues doing so until roughly the end of 2011.

For comparison, Figure 5 shows the time series of the collateral risk measures at the aggregate level. Panel A shows that the average collateral rating trends upwards over the sample period, but much more slowly than for the high-borrowing quintile. Panel B shows a similar result for the distressed-sovereign debt share. On an equal-weighted basis it is essentially constant at the aggregate, while on a value-weighted basis it trends upwards at roughly a third the rate of the high-borrowing quintile.

Hence, the evidence in Figure 4 clearly points to a difference in the take-up of ECB subsidies across banks, as the highest-borrowing banks also use the riskiest collateral. For both measures this difference is apparent since early 2010 and grows steadily thereafter, with ECB subsidies becoming increasingly concentrated in the high-borrowing banks.

In what follows we seek to understand what accounts for this divergence across banks in the take-up of ECB subsidies. We analyze four theories that have been put forth to explain such differences in banks' take-up of LOLR subsidies.

4 Empirical Analysis

4.1 Identification Strategy

The objective of our identification strategy is to identify the motivation for bank's borrowing from the LOLR. We focus our analysis on the risk-shifting explanation. The risk-shifting explanation emphasizes the effect of banks' financial strength on risk-taking. The main prediction is that poorly-capitalized banks risk-shift onto the LOLR. We can therefore test the risk-shifting explanation by examining the effect of bank financial strength on LOLR borrowing and collateral risk.

The main challenge in testing the theory is that bank financial strength may be determined by other (omitted) variables that also affect bank borrowing. For example, bank financial strength during a financial crisis may also reflect concerns about bank illiquidity, which may directly affect whether a bank borrows from the LOLR. More generally, any omitted variable that affects both bank financial strength and LOLR borrowing during a crisis may confound the empirical analysis.

We address this identification problem by analyzing measures of bank financial strength *before* the start of the financial crisis. Specifically, we measure bank financial strength as of August 2007. The idea behind this identification strategy is that banks entering the crisis with lower capital levels were more likely to experience 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 identification strategy is that pre-crisis bank capital affects LOLR borrowing and collateral risk *only* through the bank's risk-shifting incentives. We believe that this assumption is plausible because alternative explanations emphasize changes in bank risk taking as a result of the crisis. Specifically, illiquidity of European banks only became a concern after the Lehman bankruptcy in September 2008 and intensified after the Greek crisis in March 2010. Hence, it is unlikely that bank financial strength in August 2007 reflects any concerns about bank illiquidity. Also, there is no

evidence of political pressure or differences in private valuation that may explain differences in bank financial strength prior to the start of the financial crisis. Instead, it is more likely that bank capital levels reflect heterogeneity in banks' capital structure that is unrelated to the financial crisis and can therefore be used as an instrument.

We also note that it is unlikely that banks adjusted their capital structure 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 spreads on the main European banks indicated that the likelihood of bank failure was very low (Acharya, Drechsler, and Schnabl (2012)). Hence, there was no evidence that banks adjusted their capital levels due to concerns about a financial crisis.

In short, we believe that pre-crisis capital levels provide a good instrument to identify the effect of risk-shifting onto the LOLR. However, we acknowledge remaining concerns that pre-crisis capital levels may also correlate with other variables that affect LOLR borrowing and collateral risk. For example, variation in bank capital levels across countries may correlate with the extent of bank illiquidity during the crisis. This may be the case if banks in financially-distressed countries both enter the crisis with lower capital levels and borrow more against illiquid assets during the crisis. Even though it is not a priori obvious why this should be the case, we address this concern in a series of empirical tests discussed below.

4.2 Do Bank Risk-shift onto the LOLR?

Our identification strategy is based on bank financial strength before the financial crisis. We measure bank financial strength using a bank's credit rating as of August 2007. We choose the credit rating as our preferred measure of bank financial strength for two reasons. First, we want to use a market-based measure to capture the extent of bank risk as perceived by market participants. We believe that a market-based measures provides a more accurate proxy for bank risk than accounting-based measures because the latter may be prone to manipulation. Second, we use credit ratings because they are available for 292 banks, which

represent more than 95% of bank assets in the euro zone.[17]

We collect information on bank credit ratings from the three main credit rating agencies (Moody's, S&P, and Fitch). We assign numerical value to bank credit ratings following the standard convention of using a simple numerical scale such that AAA is equal to 1, AA+ is equal to 2, and so on. Bank risk is thus increasing in our credit rating measure. Most banks are rated by more than one credit ratings agency. If ratings differ across rating agencies, then we assign the median credit rating. Throughout our analysis, we keep the bank credit rating constant as of August 2007. We measure risk-shifting by examining the take-up of implicit haircut subsidies.

We use three outcome variables to measure LOLR borrowing and collateral risk. The first outcome variable is an indicator variable of whether a bank borrows from the ECB. This variable captures the extensive margin of whether a bank receives any haircut subsidy. In robustness tests, we also examine measures of the intensive margin, but this requires imposing more structure on the estimation because of censoring at zero. The second outcome variable is the value-weighted credit ratings of the securities pledged with the LOLR. The third outcome variable is total distressed country debt (sovereign debt issued by Greece, Ireland, Italy, Portugal and Spain), normalized by bank size. We measure bank size as of December 2007 to avoid endogeneity with respect to the scaling variable.

We implement our analysis using a standard difference-in-differences framework. Our estimation controls for time fixed effects to capture time-series variation that is common to all banks. In some specifications, we also include bank fixed effects to control for any time-invariant characteristics that affect LOLR borrowing and collateral risk. Our main variable is the coefficient on pre-crisis bank capital interacted with time fixed effects. These coefficients capture the effect of pre-crisis capital levels on LOLR borrowing and collateral risk over time.

[17]Other market-based measures such as CDS spreads are only available for a much smaller sample. We examine CDS spreads in one of our robustness tests.

We estimate the following OLS regression:

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

where y_{it} is an outcome 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-quarter indicator variables, α_i are bank fixed effects and δ_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 6 plots the coefficients on the year-quarter indicator variables for the specification with the borrowing indicator as outcome variable. We use vertical lines to indicate the month of the Lehman bankruptcy (September 2008) and the month of the first Greek crisis (March 2010). We find no evidence of a pre-trend. The likelihood of LOLR borrowing is the same for highly- and poorly-capitalized banks from August 2007 until March 2010. This result shows that there is no evidence of risk-shifting onto the LOLR prior to early 2010.[18]

The relationship between pre-crisis capital levels and LOLR borrowing changes in early 2010. Starting in the first half of 2010, we find that poorly-capitalized banks increase their borrowing relative to highly-capitalized banks. Specifically, a one-notch decrease in a bank's pre-crisis credit rating increases the likelihood of borrowing by about 5 percentage points after March 2010. This difference is statistically significant as indicated by the 95%-confidence interval. This estimate is also economically significant: a one-standard deviation decrease in a bank's pre-crisis credit rating leads to a 12.5 percentage point increase in the likelihood of borrowing (about 24% of the mean). In short, this result shows that banks with low levels of pre-crisis capital increased LOLR borrowing after the European financial crisis worsened in early 2010.

Next, we analyze the impact of pre-crisis bank capital on collateral risk. Panel B of Figure 6 plots the coefficients on the year-quarter indicator variables for the specification

[18]This result also indicates that there is no mechanical relationship between pre-crisis capital levels and LOLR borrowing.

with value-weighted collateral credit rating as outcome variable. The figure shows a similar pattern as for the borrowing measure. The coefficient on pre-crisis bank rating is close to zero until March 2010. However, starting in early 2010, we find divergence in the collateral risk of highly- vs. poorly-capitalized banks. A one-standard deviation decrease in a bank's pre-crisis credit rating increase the value-weighted collateral credit risk by about 0.15 notches (about 0.23% standard deviations). This finding is statistically significant as indicated by the 95%-confidence interval.

We find a similar result for our second measure of collateral risk. Panel C of Figure 6 plots the coefficients on the year-quarter indicator variables for the specification with distressed-sovereign debt as outcome variable. Again, there is no statistically significant difference between poorly- and highly-capitalized banks before 2010. However, starting in early 2010, a one-standard deviation decrease in a bank's pre-crisis capital level raises financially-distressed country debt pledged as collateral by 2.4 percentage points (about 25% standard deviations).

We explore the robustness of these results by controlling for bank fixed effects. These controls capture the effect of any time-invariant bank characteristics that may be correlated with bank credit ratings and affect LOLR borrowing. We do so by estimating our regressions using indicator variables for the three main periods of the financial crisis: pre-Lehman (August 2007 to September 2008), post-Lehman (October 2008 to Jun 2010), and post-Greek Bailout (July 2010 to December 2011). We choose the timing of these periods to match the three main phases during the European financial crisis.

Table 2 presents the results. Column (1) and (2) show the specifications with the borrowing indicator as outcome variable. As shown in Column (1), we find that a one-notch decrease in the pre-crisis bank credit rating increases the likelihood of borrowing by 6.2 percentage points in the post-Greek bailout period. As shown in Column (2), the coefficient is almost unchanged after including bank fixed effects. This finding indicates that our result cannot be explained by omitted time-invariant bank characteristics. Columns (3) and (4) show the results for the value-weighted collateral credit rating as outcome variable. A one-notch decrease in the pre-crisis bank credit rating increases the collateral risk by 0.21 notches.

The coefficient decreases to 0.15 after including bank fixed effects but remains statistically significant at the 1%-level. Columns (5) and (6) show the results for distressed-sovereign debt as outcome variable. A one-notch decrease in the pre-crisis bank credit rating increases the use of distressed-sovereign debt by 1.3 percentage points. The result is unchanged after including bank fixed effects.

Overall, we find that pre-crisis poorly-capitalized banks increase LOLR borrowing and collateral risk relative to pre-crisis highly-capitalized banks after the start of the first Greek crisis. This finding suggests that there is no evidence of risk-shifting prior to the Greek crisis. However, we find that poorly-capitalized banks started to risk-shift after the European crisis worsened in early 2010. Hence, the risk-shifting explanation can account for the divergence across banks in the take-up of LOLR borrowing which starts in 2010.[19]

4.3 Testing Illiquidity versus Risk-shifting

Our results indicate that banks risk-shift onto the LOLR. A possible concern with these results is that pre-crisis bank capital is correlated with bank illiquidity during the crisis. Even though bank illiquidity was not an important concern before the crisis, this correlation may arise if banks that are poorly-capitalized before the crisis also happen to hold assets that eventually become illiquid. It is a priori not obvious why this may be the case but it is certainly possible. We therefore develop three separate tests to distinguish between risk-shifting and illiquidity.

4.3.1 Do bank actively invest in risky assets?

The unique prediction of the *illiquidity* explanation is that banks change their collateral pledged without changing their holdings. This is because the illiquidity explanation emphasizes changes in funding liquidity that are unrelated to the quality of bank assets. Such changes in funding liquidity may be caused by information asymmetries between banks and

[19]This evidence also indicates that haircut subsidies became increasingly concentrated in poorly-capitalized banks after the Greek bailout.

investors and are possibly amplified by bank runs. The LOLR theory often refers to such banks as 'illiquid but solvent' and recommends providing them with direct LOLR financing.[20]

We test the unique prediction of the illiquidity explanation by examining the association between a bank's holdings of risky assets and its pledging of risky collateral. In general, public information about banks' asset holdings is extremely limited since these data are considered proprietary. However, as part of the European bank stress tests, bank regulators published information on bank holdings of distressed-sovereign debt. European banks conducted three separate rounds of bank stress tests (March 2010, December 2010, September 2011), which allows us to analyze a panel of bank holdings of distressed-country debt. The bank stress tests were designed to include the largest banks in Europe. Participation was mandatory and regulators ensured that the largest banks were present in all rounds. We therefore focus our analysis on the sample of 54 banks that participated in all three rounds. These banks are the largest banks in Europe and represent almost 50% of total European bank assets.

We first analyze the relationship between collateral pledged and holdings of distressed-country debt. We estimate the relationship in changes to control for pre-existing bank-level variation in the holdings of distressed country debt. 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 $Holdings_{it}$ from time t to $t+1$, $\Delta Pledged_{it}$ is bank i's change in distressed-sovereign debt pledged as collateral between time t and $t+1$, and δ_t are time fixed effects. 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 1% increase in distressed-sovereign debt pledged with the ECB is associated with 0.45% increase in distressed country debt. As shown in Column (2), the coefficient is unchanged if we control for time fixed effects.

[20]We note that the risk-shifting explanation also predicts a decline in funding liquidity. However, the difference relative to the illiquidity explanation is that the risk-shifting explanation suggests that the decline in funding liquidity reflects underlying differences in bank asset quality. In contrast, the illiquidity explanation suggests that the decline in funding liquidity greatly exaggerates any differences in bank asset quality. The classical example of an illiquidity situation is a Diamond and Dybvig (1983) type bank run.

This result suggests that for each marginal dollar of distressed-sovereign debt pledged with the ECB, banks actively invest \$0.45 in distressed-sovereign debt. This result suggests that risk-shifting accounts for at least 45% of the cross-sectional variation in the change of distressed sovereign debt pledged with the LOLR.

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 in two subsamples: poorly-capitalized banks with a credit rating of A+ or less (25 banks) and highly-capitalized banks with a credit rating of AA- or higher (28 banks) as of August 2007. We then estimate our main specification separately for each sample.

Column (3) and (4) present the results for the sample of poorly-capitalized banks. We find that the association between changes in distressed-sovereign debt and changes in holdings of distressed-sovereign debt increases: a 1% increase in distressed-sovereign debt pledged with the ECB is associated with 0.56% increase in distressed-sovereign debt holdings. The result is robust to including time fixed effects. Columns (5) and (6) examine the sample of highly-capitalized banks. We find that the coefficient drops to 0.03 and is not statistically significant. The coefficient is almost unchanged controlling for time fixed effects. The difference between the poorly- and highly-capitalized banks is statistically significant at the 5%-level. Hence, the positive association is primarily driven by the poorly-capitalized banks.

In short, we find that banks actively increase their pledging of distressed-sovereign debt by about 50% as they increase their holdings of distressed sovereign debt. This finding suggests that risk-shifting can explain about 50% of the cross-sectional variation in the use of distressed-sovereign debt with the ECB. Finally, we note that the results are stronger for the sample of poorly-capitalized banks. This finding provides further support for the risk-shifting explanation.

4.3.2 Are the Results Driven by Illiquidity across Countries?

As an alternative test of the illiquidity explanation, we also test directly for the main source of bank illiquidity. The most likely source of illiquidity that can account for the gradual increase in collateral riskiness among poorly-capitalized banks is an ongoing decline in the macroeconomic health of a bank's home country. Specifically, some countries may suffer a 'quiet' bank run in which depositors (slowly) move deposits to other countries. This would imply that country-level changes in the supply of bank funding can potentially explain the divergence in the take-up of haircut subsidies by banks over time. 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 variations in borrowing or changes to collateral risk that affect all banks within a country.

Table 4 presents the results. As shown in Column (1), we find that the effect of pre-crisis bank credit rating on LOLR borrowing remains economically and statistically significant: a one-notch decrease in a bank's pre-crisis credit rating increases the likelihood of borrowing by 4.5 percentage points. We find similar result for collateral risk. As shown in Columns (2) and (3), a one-notch decrease in a bank's pre-crisis credit rating increases the value-weighted collateral risk by 0.11 notches and financially-distress country debt by 0.6 percentage points. Compared to Table 2, the coefficients are about 22-58% smaller than the corresponding coefficients in specifications without country-time fixed effects. These results indicate that at most 58% of our results are driven by cross-county differences. Given that most explanations based on illiquidity emphasize the importance of cross-country difference, these findings provide further support for the risk-shifting explanation.

4.3.3 Are the Results Driven by Distressed Sovereigns?

As an alternative test of the illiquidity explanation, we can also examine banks in non-distressed countries. Given that explanations of bank illiquidity focus on distressed countries, we do not expect to find differences across bank in non-distressed countries. Hence, we test for the illiquidity explanation by estimating our main specification separately for banks in

distressed and non-distressed countries.

Columns (1) to (3) of Table 5 present the results for banks located in non-distressed sovereigns. As shown in Column (1), the effect of bank credit rating on LOLR borrowing remains economically and statistically significant: a one-notch decrease in a bank's credit rating increases the likelihood of borrowing by 4.5 percentage points. We find similar result for collateral risk. As shown in Columns (2) and (3), a one-notch decrease in a bank's pre-crisis credit rating increases the value-weighted collateral risk by 0.06 notches and distressed-sovereign debt by 0.3 percentage points. Compared to Table 2, the coefficients are about 22-65% smaller than the coefficients in specifications without country-time fixed effects.

For comparison, Columns (4) to (6) of Table 5 estimate the main specifications for banks located in distressed sovereigns. We find a similar coefficient for the borrowing variable and larger coefficients for collateral risk. Consistent with our earlier results, these findings suggest that risk-shifting incentives (and possibly illiquidity) are larger in distressed countries.

Overall, these result indicate that risk-shifting can explain LOLR borrowing and collateral risk in non-distressed sovereigns. Importantly, the effects are quantitatively smaller than for those in distressed countries, which is consistent with the observation that banks in non-distressed countries were less likely to experience losses and therefore less likely to experience risk-shifting incentives. Hence, even after controlling for the main source for illiquidity, we find a role for risks-shifting in explaining LOLR borrowing and collateral risk.

4.4 Are the Results Driven by Regulatory Pressure?

The *political economy* explanation suggets that poorly-capitalized banks increase LOLR borrowing because they are encouraged (or forced) to do so by their national regulators. This may be the case because distressed-sovereign governments experienced high sovereign borrowing costs and may have put pressure on national banks to invest in their sovereign debt in order to decrease borrowing rates. Alternatively, since the ECB cannot recapitalize weak banks, it may have encouraged banks to engage in the purchase of sovereign debt as a way to improve bank balance sheets. Most importantly, these explanations are focused on

the distressed countries, since that is where sovereigns experienced high costs of borrowing.[21]

We therefore test for the political economy explanation by estimating our main regression equation (1) *only* for the sample of banks headquartered *outside* the distressed countries. The idea is that we should find no effect if political economy considerations can account for the entire borrowing-collateral-risk relationship. Importantly, we expect the effect on distressed-sovereign debt to disappear because this is the main focus of the political economy explanation.

The results are presented in Table 5 and discussed above. These results show that the borrowing and collateral relationships are not simply driven by banks headquartered in the distressed countries. Even amongst bank based outside of the distressed countries we find a statistically significant effect of bank credit rating on LOLR borrowing and collateral risk. Moreover, this relationship exists even for distressed-sovereign debt. These finding imply that there remains an important role for the risk-shifting explanation even after controlling for political economy considerations. However, it also suggest that some of the LOLR borrowing by banks located in distressed sovereign may be driven by political economy.

4.5 Are the Results Driven by Differences in Private Valuation?

The *differences in private valuation* explanation suggests that highly-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, or business model. For example, some banks may be more experienced in dealing with sovereign debt and are therefore more likely to borrow from the LOLR.

We test for such explanations by controlling for bank characteristics (other than pre-crisis debt) 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

[21] We note that the political economy explanation interacts with the risk-shifting explanation because banks suffering from debt overhang should be the most willing to act on the encouragement put forth by regulators. Nevertheless, we treat this explanation as separate because regulators may have exerted pressure on banks independent of whether or not they are solvent.

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 main time periods. We choose this specification because it is consistent with the estimation of the impact of the pre-crisis credit rating.[22].

Table 6 presents the results. We find that all coefficients are almost unchanged relative to Table 2. Moreover, all results remain statistically significant. In short, we find no evidence that bank observables other than pre-crisis capital predict LOLR borrowing and collateral risk. This finding suggests that difference in private valuations (other than risk-shifting) cannot explain the observed divergence in LOLR borrowing and collateral risk.

4.6 Are the Results Robust to Alternative Specifications?

4.6.1 Do results hold for publicly listed banks?

We estimate our regressions for banks that are rated by at least one rating agency (292 banks). We choose this sample because it represents more than 95% of European bank assets. Alternatively, we can also examine the sample of publicly listed banks (76 banks). These banks are relatively large banks and they may be more willing to take advantage of opportunities to risk-shift. Moreover, these banks represent about 50% of total bank assets and are important for assessing the impact of risk-shifting at the macro level. We thus estimate the main specification (1) for the sample of publicly listed banks.

We present the result 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-notch decrease in pre-crisis bank credit rating is about 1.5 times larger than for the full sample (9.3 percentage points versus 6.2 percentage points). In terms of

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

collateral risk, we find that the effect is about 2 to 3 times larger for both measures of collateral risk. For example, a one-notch decrease in bank ratings leads to a 0.48% increase in distressed-sovereign debt pledged with the LOLR (relative to 0.12% for the full sample).

Hence, we find even stronger results for the sample of publicly listed banks than for the full sample. This finding suggests that our results are robust to using a sample of economically large banks. Moreover, the results indicate that the macro effects of risk-shifting are even larger than the effect for the average bank.

4.6.2 Measuring bank financial strength using CDS spreads

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 spread to estimate the impact of bank financial strength on risk-taking. However, we note that CDS spreads are only available for relatively large banks and most of these banks were considered relatively safe before the financial crisis. Hence, there is little variation in bank CDS prior to the Lehman bankruptcy, which makes it difficult to estimate the effect of 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 in early 2010. Hence, we can measure bank credit 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. This is plausible given that the financial crisis significantly worsened after March 2010. We thus estimate the main specification (1) for the sample of banks with traded CDS. We measure bank financial strength using the natural logarithm of CDS as of January 2010.

We present the results in Table 8. We find economically large effects across all specifications, although the specifications for the borrowing variable is not statistically significant. The lack of statistical significance may be due to the small sample size and lack of variation on the extensive borrowing variable. However, the sign of the coefficients are consistent

with our earlier results. Hence, this finding provides further robustness regarding our main specification.

5 Conclusion

Since their advent one of the key capacities of central banks has been to act as Lender of Last Resort during financial crises. The role of LOLR is usually motivated by the idea of provide temporary funding to illiquid financial institutions. 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 substantially suboptimal allocation of capital that could, in an extreme case, actually exacerbate a financial crisis.

We examine the role of the LOLR during the European financial crisis of 2008-11. We document a strong divergence among banks in the take-up of implicit subsidies from the European Central Bank (ECB) over the financial crisis, as banks with high levels of ECB borrowing also used increasingly risky collateral. We propose four potential explanations for this divergence: (1) illiquidity, (2) risk-shifting, (3) political economy, and (4) differences in private valuations. We test these explanations using a novel dataset that includes detailed information on all borrowing and collateral pledged with the ECB from 2008 to 2011 and data on holdings from the European bank stress tests.

We find that banks with lower financial strength increasingly pledge riskier collateral. This result strongly supports risk-shifting as an important driver of the divergence in banks's take-up of ECB subsidies. In distressed countries, we find that other explanations also contribute to the increase in collateral risk. Our results suggest that illiquidity may account for up to half of the observed increase in collateral risk in distressed countries and political economy considerations may also be at work. Outside the distressed countries, we find no evidence that explanations other than risk-shifting explain the divergence among banks in collateral risk.

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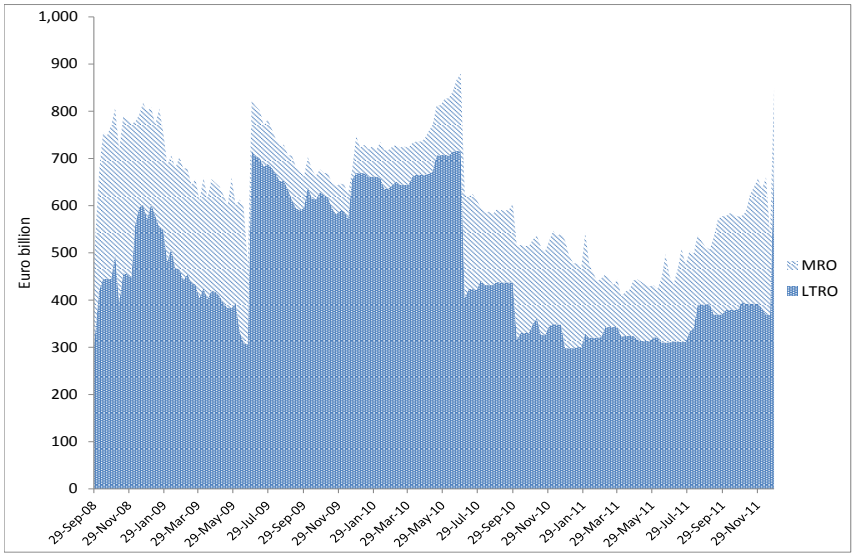
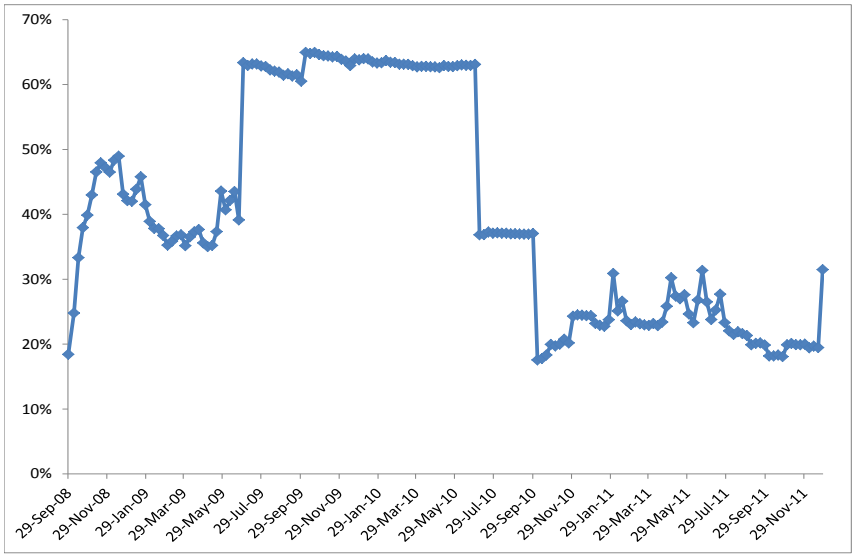
Figure 1

(A) Total Borrowing



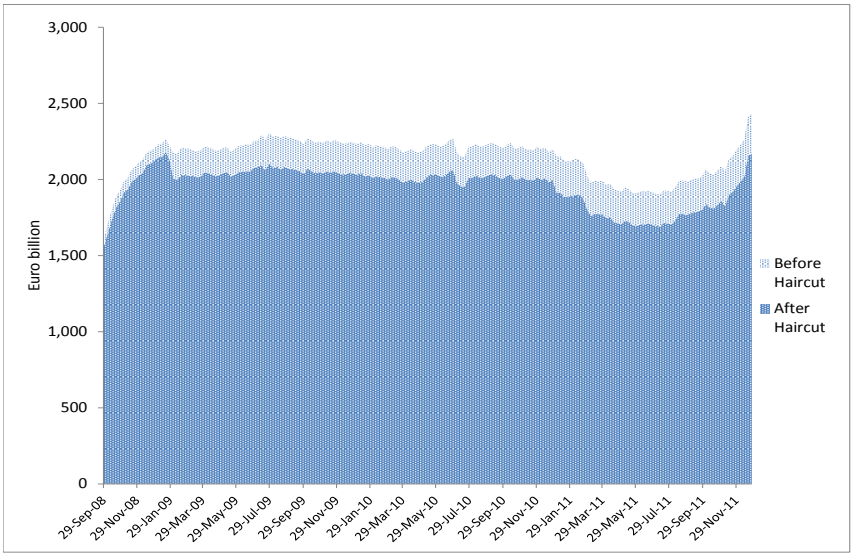
(B) Fraction of Banks that Borrow



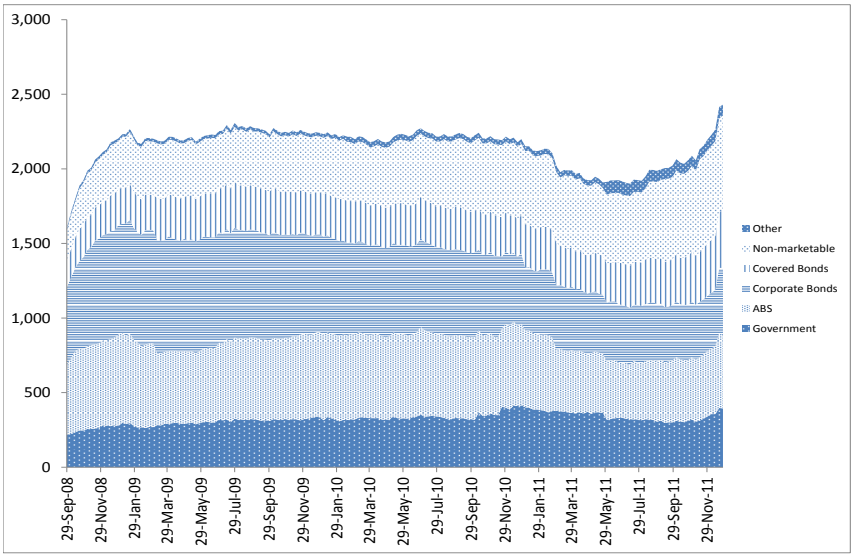
Panel A of Figure 1 plots the time series of borrowing from the ECB under long-term refinancing operations (LTRO) and main refinancing operations (MRO) in € billion. Panel B shows the time series of the fraction of banks which borrow from the ECB.

Figure 2

(A) Total Collateral



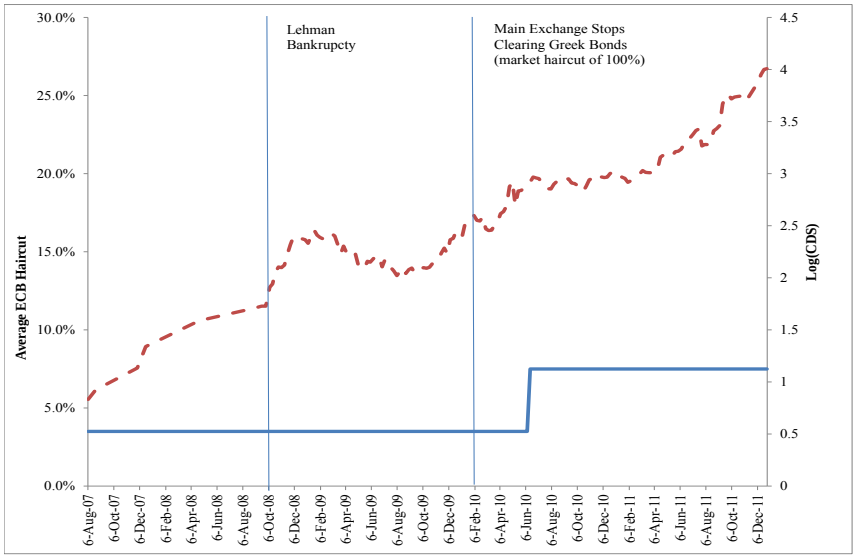
(B) Collateral by Type



Panel A of Figure 2 plots the time series of total collateral pledged to the ECB before and after ECB haircuts in € billion. Panel B shows the time series of total collateral pledged broken down by the type of asset in € billion.

Figure 3

(A) Greek Sovereign Risk and ECB Haircut



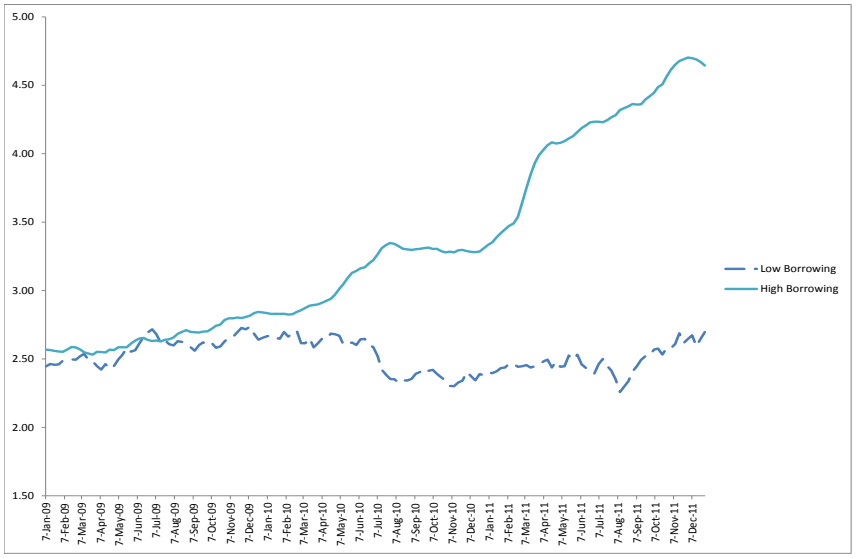
(B) Collateral Use of Greek Sovereign Bonds

Source: Goldman Sachs and International Capital Markets Association reports

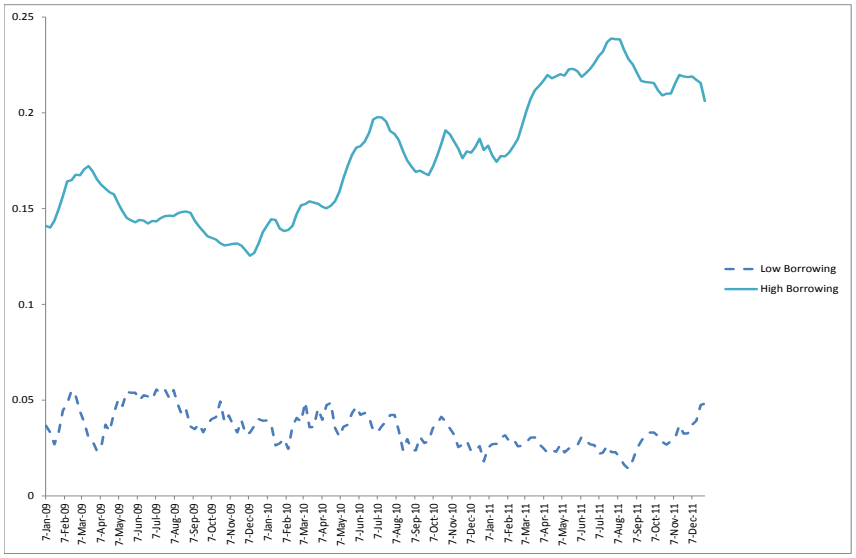
Panel A of Figure 3 plots the time series of the natural logarithm of the Greek credit default swap price (right axis) and the average ECB haircut on Greeks sovereign bonds pledged with the ECB in percentage points (left axis). Panel B shows the time series of total Greek sovereign bonds (in market values) pledged as collateral in private markets versus the ECB.

Figure 4

(A) Average Rating by Borrowing Quintile



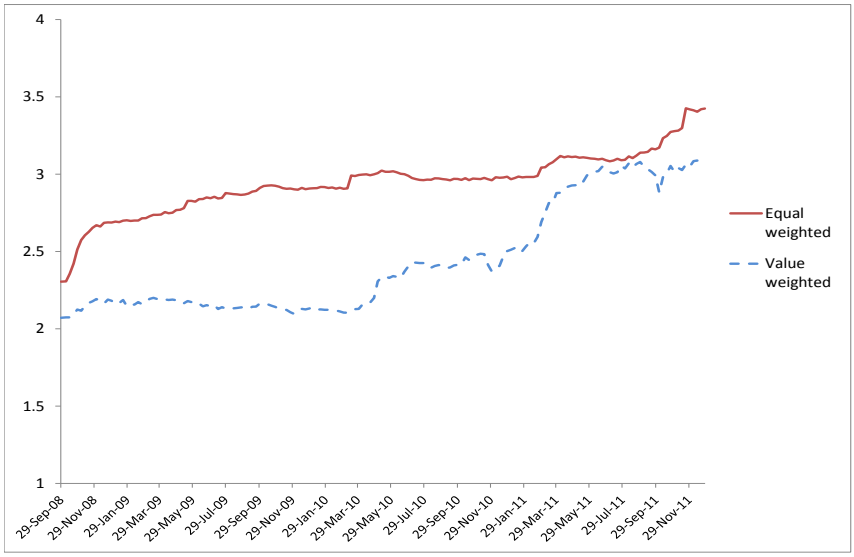
(B) Share of Distressed-Sovereign Debt by Borrowing Quintile



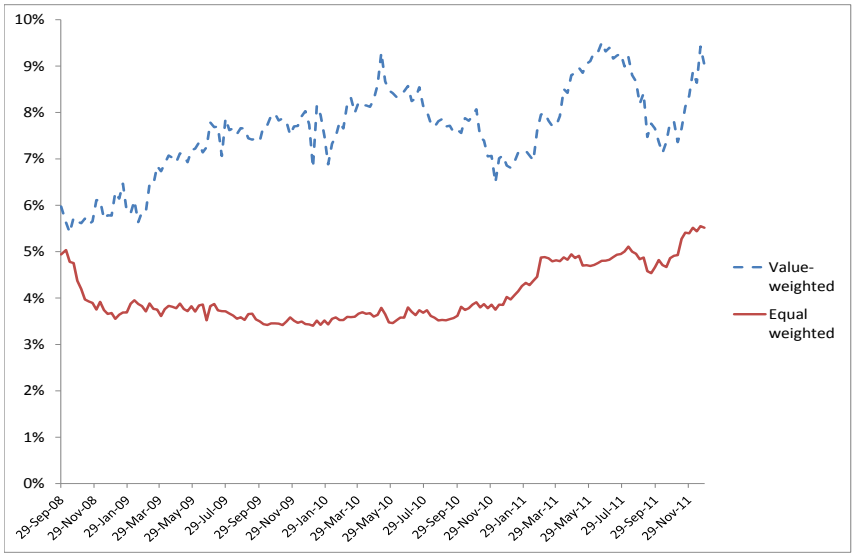
Panel A of Figure 4 plots the average collateral credit rating of banks in the highest borrowing quintile (dashed line) and banks in the lowest borrowing quintile (dotted line). Panel B plots distressed-sovereign debt as share of total collateral pledged for banks in the highest borrowing quintile (dashed line) and in the lowest borrowing quintile (dotted line). The borrowing quintiles are based on the ratio of borrowing to total collateral pledged as of July 2010.

Figure 5

(A) Average Collateral Rating



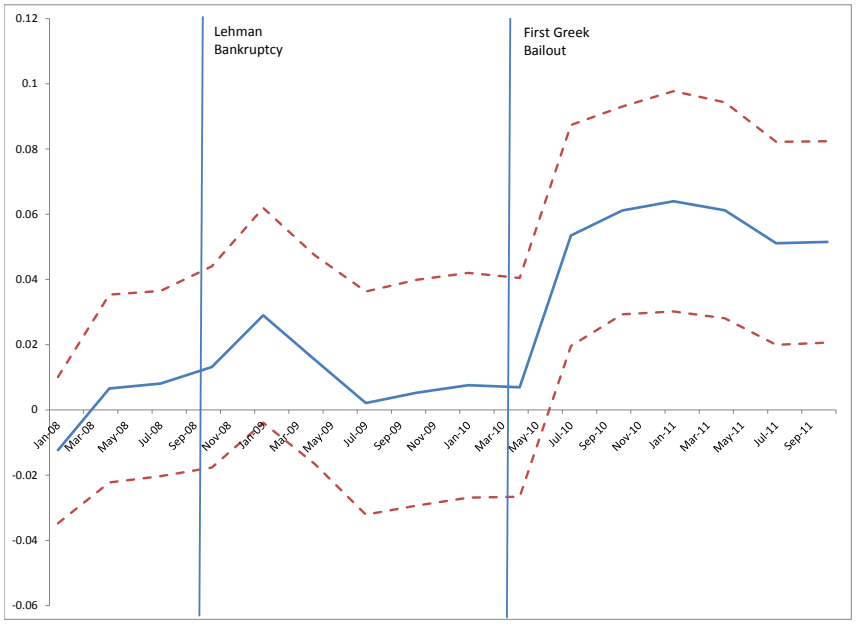
(B) Distressed-Sovereign Debt as Share of Collateral



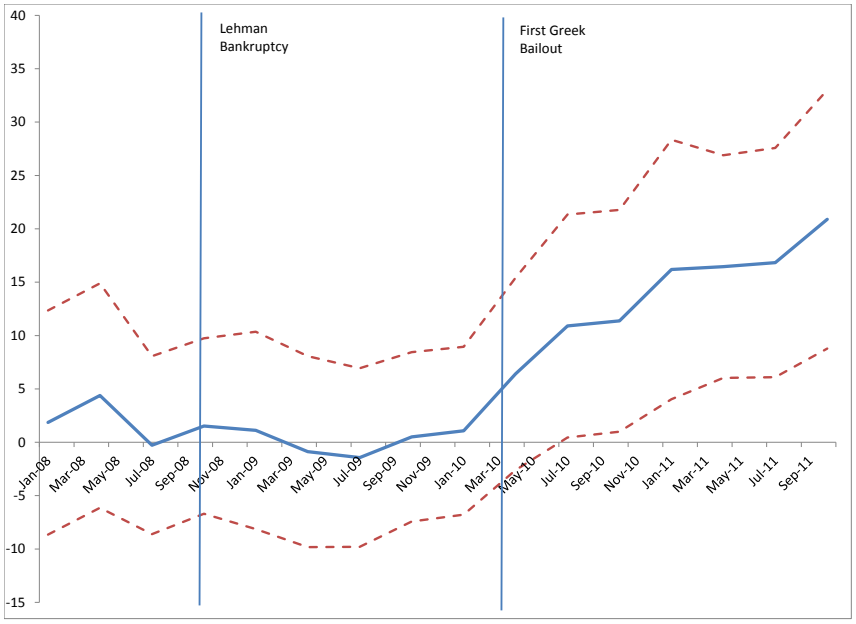
Panel A of Figure 5 plots the average credit rating of all collateral pledged with the ECB. We assign the value '1' for AAA, '2' for $AA+$, and so on. Panel B shows the share of collateral pledged that is due to distressed-sovereign debt (sovereign debt originated in Greece, Ireland, Italy, Spain, and Portugal). Both panels plot both the equal-weighted average (solid line) and the value-weighted average (dashed line).

Figure 6

(A) Borrowing Indicator



(B) Value-weighted collateral credit rating



(C) Distressed-sovereign debt

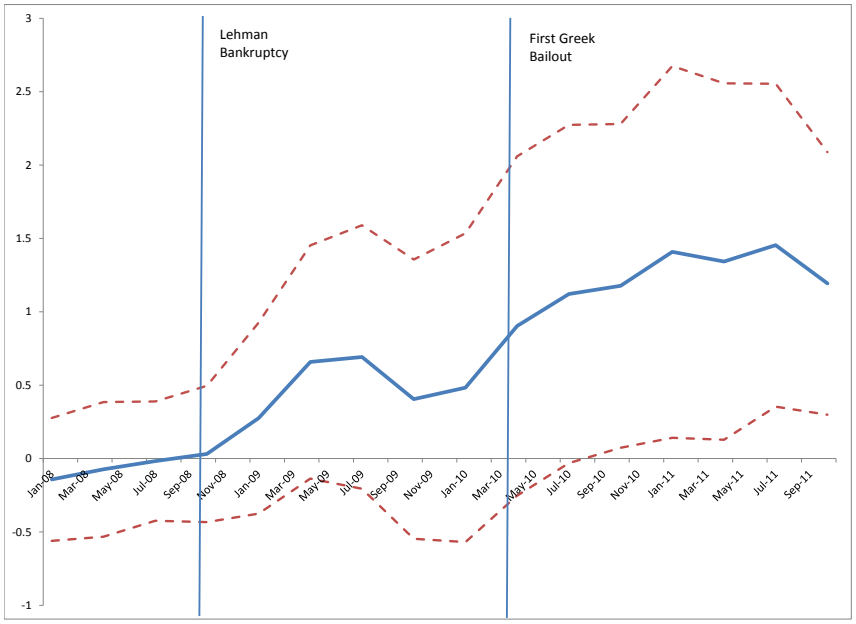


Figure 6 plots the coefficients on the quarter-time dummies interacted with pre-crisis bank credit rating when the outcome variable is the borrowing indicator (Panel A), the value-weighted collateral credit rating (Panel B), and distressed-sovereign debt (Panel C).

Table 1: Summary Statistics of European Banks

This table provides summary statistics from August 2007 to December 2011. All variables are for the entire sample (except CDS spread 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)	143.5	408.8	141.5	430.6	152.8	292.9
Book Equity (Euro bil)	6.6	18.9	5.8	18.6	10.2	19.9
Bank Rating	5.6	2.2	5.2	1.9	7.2	2.6
Market Leverage	45.3	57.4	48.3	56.7	42.3	58.0
Credit Default Swap Spread (CDS)	244.8	298.4	163.5	115.1	391.7	438.8
Loan Share	56.7%	18.0%	54.6%	17.3%	65.1%	18.3%
Deposit Share	64.3%	23.7%	67.1%	24.8%	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%	7.7%	9.8%	4.0%
Located in distressed sovereign	18.6%	38.9%	0.0%	0.0%	100.0%	0.0%
Central Bank Borrowing						
Any borrowing (Yes=1)	55.1%	49.7%	50.3%	50.0%	75.9%	42.8%
Total Borrowing (Euro bil)	1.61	5.64	1.19	5.48	3.41	5.96
Borrowing/Book Equity	59.1%	145.4%	48.3%	129.2%	106.7%	194.7%
Borrowing/Collateral	30.4%	33.9%	26.0%	32.1%	49.6%	35.2%
MRO-Borrowing/Collateral	7.7%	19.1%	6.4%	18.0%	13.4%	22.6%
LTRO-Borrowing/Collateral	22.7%	29.6%	19.6%	28.3%	36.3%	31.3%
Collateral						
Any collateral (Yes=1)	91.6%	27.8%	91.6%	27.8%	91.5%	27.9%
Collateral Pledged (Euro bil)	4.81	11.89	4.41	12.23	6.54	10.11
Collateral/Book Equity	168.6%	209.7%	163.3%	204.2%	175.4%	216.4%
Haircut	7.1%	4.0%	6.7%	3.8%	8.6%	4.3%
Rated share (%)	80.6%	24.8%	80.7%	24.7%	80.1%	25.4%
Average Rating	273.0	145.7	267.8	128.9	295.7	202.2
Distressed-Sovereign Debt	0.30%	1.08%	0.12%	0.67%	1.07%	1.90%
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 as of August 2007. We collect ratings from the three main ratings agencies and assign the median rating if a bank has more than one rating. We assign assigning numerical values to each rating (AAA=1, AA+=2, AA=3, etc.). *Collateral Rating* is value-weighted average rating of collateral (constructed the same way as bank ratings) per bank-week. *Collateral Rating* is value-weighted average rating of collateral (constructed the same way as bank ratings) per bank-week. 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. *Borrowing* is an indicator variable whether a bank borrows from the ECB. *Post-Lehman* and *Post-Greek Bailout* are indicator variables for the periods from October 2008 to June 2010 and July 2010 to December 2011, respectively. from All columns include week fixed effects. Columns (2), (4), and (6) include 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	$Borrowing_{it}$		Collateral $Rating_{it}$		Distressed-Sovereign $Debt_{it}/Assets_{i,07}$	
	(1)	(2)	(3)	(4)	(5)	(6)
Bank $Rating_{i,07}$* Post-Greek $Bailout_t$	0.056***	0.056***	20.573***	14.825***	0.130***	0.130***
	(0.012)	(0.012)	(5.377)	(3.998)	(0.045)	(0.045)
Bank $Rating_{i,07}$* Post-$Lehman_t$	0.010	0.010	0.418	0.489	0.053*	0.053
	(0.011)	(0.011)	(2.829)	(2.296)	(0.032)	(0.033)
Bank $Rating_{i,07}$	-0.002		7.540*		0.002	
	(0.013)		(3.952)		(0.014)	
Week Fixed Effects	Y	Y	Y	Y	Y	Y
Bank Fixed Effects	N	Y	N	Y	N	Y
Banks	292	292	287	287	276	276
Observations	51,684	51,684	45,997	45,997	48,852	48,852
R2	0.114	0.477	0.085	0.672	0.033	0.664

Table 3: Distressed-Sovereign Debt Pledged and Distressed-Sovereign Debt Holdings

This table examines the correlation between collateral pledged and holdings of periphery sovereign debt. The sample is all banks that participated in the three rounds of European bank stress tests. *Distressed-Sovereign Debt Pledged$_{it}$/Assets$_{i,07}$* and *Distressed-Sovereign Debt Holdings$_{it}$/Assets$_{i,07}$* are collateral pledged and holdings of issued by financially distressed countries (Greece, Ireland, Italy, Portugal, and Spain) divided by banks assets as of December 2007, respectively. *Bank Rating$_{it}$* is a bank's credit rating (AAA=1, AA+=2, AA=3, etc.) $\Delta_{t+1,i}$ denotes the change in a bank *i*'s variable from time t+1 to t. Columns (2), (4), (6), (8), and (10) include fixed effects for each round of bank stress tests. 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
Obs	106	106	50	50	56	58
Banks	54	54	25	25	28	28
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. All variabels 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	$Borrowing_{it}$	$Collateral\ Rating_{it}$	Distressed Sovereign $Debt_{it}/Assets_{i,07}$
	(1)	(2)	(3)
$Bank\ Rating_{i,07}$* $Post\text{-}Greek\ Bailout_t$	0.045***	10.600***	0.060**
	(0.012)	(3.265)	(0.025)
$Bank\ Rating_{i,07}$* $Post\text{-}Lehman_t$	0.012	0.474	0.027
	(0.011)	(2.415)	(0.022)
Country-Month Fixed Effects	Y	Y	Y
Bank Fixed Effects	Y	Y	Y
Banks	292	287	276
Observations	51,684	45,997	48,852
R2	0.531	0.784	0.717

Table 5: Bank Rating and LOLR Borrowing (distressed versus non-distressed sovereigns)

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 columns include week and bank fixed effects. Columns (1) to (3) cover bank in non-distressed countries and Column (4) to (6) cover banks in financially distressed-countries. 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			Distressed Sovereigns		
Dependent Variable	$Borrowing_{it}$	Collateral $Rating_{it}$	Distressed Sovereign $Debt_{it}/Assets_{i,07}$	$Borrowing_{it}$	Collateral $Rating_{it}$	Distressed Sovereign $Debt_{it}/Assets_{i,07}$
	(1)	(2)	(3)	(4)	(5)	(6)
$Bank\ Rating_{i,07}$* Post-Greek $Bailout_t$	0.045***	7.090*	0.036*	0.045	24.070*	0.299*
	(0.013)	(3.702)	(0.019)	(0.028)	(13.886)	(0.151)
$Bank\ Rating_{i,07}$* $Post\text{-}Lehman_t$	0.011	1.318	0.003	0.030	-1.875	0.199*
	(0.013)	(2.283)	(0.017)	(0.021)	(7.458)	(0.117)
Week Fixed Effects	Y	Y	Y	Y	Y	Y
Bank Fixed Effects	Y	Y	Y	Y	Y	Y
Banks	234	229	221	58	58	55
Observations	41,418	36,912	39,117	10,266	9,085	9,735
R2	0.486	0.769	0.673	0.505	0.635	0.623

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 and interactions of these variables with *Post-Greek Bailout*$_t$ and *Post-Lehman*$_t$. All columns include week fixed effects. Columns (2), (4), and (6) include 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$_{it}$		Collateral Rating$_{it}$		Distressed Sovereign Debt$_{it}$/Assets$_{i,07}$	
	(1)	(2)	(3)	(4)	(5)	(6)
Bank Rating$_{i,07}$* Post-Greek Bailout$_t$	0.045***	0.042***	21.850***	12.256***	0.080**	0.106**
	(0.012)	(0.014)	(7.489)	(4.404)	(0.036)	(0.045)
Bank Rating $_{i,07}$* Post-Lehman$_t$	-0.014	-0.014	0.251	0.518	0.072**	0.069**
	(0.010)	(0.010)	(2.830)	(2.514)	(0.032)	(0.031)
Bank Rating $_{i,07}$	0.030**		3.436		0.009	
	(0.012)		(3.898)		(0.006)	
Week Fixed Effects	Y	Y	Y	Y	Y	Y
Bank Fixed Effects	N	Y	N	Y	N	Y
Banks	276	276	268	268	276	276
Observations	38,748	38,748	34,790	34,790	38,748	38,748
R2	0.156	0.518	0.127	0.698	0.233	0.738

Table 7: Bank Rating and ECB 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 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 and interactions of these variables with *Post-Greek Bailout*$_t$ and *Post-Lehman*$_t$. All columns include week fixed effects. Columns (2), (4), and (6) include 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$_{it}$		Collateral Rating$_{it}$		Distressed Sovereign Debt$_{it}$/Assets$_{i,07}$	
	(5)	(6)	(1)	(2)	(3)	(4)
Bank Rating$_{i,07}$* Post-Greek Bailout$_t$	0.093***	0.093***	49.067***	46.119***	0.482***	0.482***
	(0.029)	(0.029)	(13.903)	(14.203)	(0.166)	(0.167)
Bank Rating $_{i,07}$* Post-Lehman$_t$	0.026	0.026	1.714	-1.945	0.220**	0.220**
	(0.018)	(0.018)	(5.095)	(4.697)	(0.088)	(0.088)
Bank Rating $_{i,07}$	-0.044*		15.486		0.061*	
	(0.024)		(9.714)		(0.036)	
Week Fixed Effects	Y	Y	Y	Y	Y	Y
Bank Fixed Effects	N	Y	N	Y	N	Y
Observations	10,085	10,085	9,894	9,894	10,085	10,085
R2	0.072	0.483	0.227	0.683	0.187	0.757

Table 8: Borrowing and Collateral Risk (alternative measure)

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 and interactions of these variables with *Post-Greek Bailout*$_t$ and *Post-Lehman*$_t$. All columns include week fixed effects. Columns (2), (4), and (6) include 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	$Borrowing_{it}$	Collateral $Rating_{it}$	Distressed Sovereign $Debt_{it}/Assets_{i,07}$
	(1)	(2)	(3)
$Log(CDS)_{i,10}$* Post-Greek $Bailout_t$	0.079	219.110***	1.267*
	(0.129)	(77.212)	(0.662)
$Log(CDS)_{i,10}$* Post-$Lehman_t$	-0.08	-11.05	0.951*
	(0.084)	(30.532)	(0.479)
Week Fixed Effects	Y	Y	Y
Bank Fixed Effects	Y	Y	Y
Observations	6,372	6,197	6,372
R2	0.491	0.684	0.765

Appendix: Variables Definition and Data Sources

Variable	Definition	Source
Bank Characteristics		
Total Assets	Total assets	Bankscope, SNL Financial
Book Equity (Euro bil)	Total book equity	Bankscope, SNL Financial
Market Equity (Euro bil)	Total market equity	Datastream
Book Leverage	(Bank assets-book equity)/book equity	Bankscope, SNL Financial
Market Leverage	(Bank assets-market equity)/market equity	Bankscope, Datastream
CDS	Credit default swap price	Datastream
Bank Rating	Median bank rating based on Moody's, S&P, and Fitch Ratings	ECB
Loan Share	Loans/Assets	Bankscope, SNL Financial
Deposit Share	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
Periphery Bank	Bank headquartered in a Periphery Country	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
Borrowing/Book Equity	Total borrowing/book equity	ECB, Bankscope
Borrowing/Collateral	Total borrowing/Collateral	ECB
LTRO-Borrowing/Collateral	LTRO-borrowing/Collateral	ECB
MRO-Borrowing/Collateral	MRO-borrowing/Collateral	ECB
Collateral		
Any collateral (Yes=1)	Indicator variable whether a bank does not pledge 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	Value-weighted rating of collateral (AAA=1, AA+=2, AA=3, …)	ECB
Share rated AA or higher (%)	Share of rated collateral that is rated AA or higher	ECB
Distressed Sovereign debt	Sovereign Debt issued by Distressed Countries (Greece, Ireland, Italy, Spain, Portugal)	ECB