Who Borrows from the Lender of Last Resort?

Evidence from the European Financial Crisis*

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Abstract

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) insolvency, (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. The results strongly support the insolvency explanation, both outside the Periphery countries, where it appears to be the main driver, and within the Periphery, where it seems that illiquidity, and possibly political economy, are also at work.

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1 Introduction

The role of the Lender of Last Resort (LOLR) has been at the center of attention during the financial crisis of 2007-2010. Following the bankruptcy of Lehman Brothers in 2008, central banks around the world engaged in large-scale LOLR interventions to provide funding to struggling banks. The motivation for these interventions is the belief that private market participants withdraw lending from sound financial institutions during times of crises, which is potentially very damaging to the 'real' economy since it creates a 'credit crunch'. The standard policy prescription is to contain such crises by providing direct LOLR financing to banks.

The European Central Bank (ECB) has closely followed this prescription since the onset of the financial crisis by engaging in large-scale LOLR lending to banks.[1] As of December 2011, total ECB loans outstanding to banks were close to €1 trillion. The ECB provides such loans against collateral at an above-market interest rate. Since October 2008, the ECB has provided unlimited loans as long as a bank can provide sufficient collateral. The maximum loan a bank can take is the value of its collateral times one minus the ECB's required haircut. This arrangement mimics lending in private repo markets. The main benefit of borrowing from the ECB is that for some risky assets it requires lower haircuts than do private repo markets.

For example, as shown in Panel A of Figure 1, the ECB has provided loans against Greek sovereign bonds at a haircut of 8% (or less) throughout the entire financial crisis. At the same time, Greek sovereign credit risk steadily increased and most private market participants stopped accepting Greek sovereign bonds as collateral by March 2010 (implying a market haircut of 100%). As shown in Panel B of Figure 1, the use of Greek sovereign bonds as collateral migrated from private markets to the ECB. Greek sovereign bonds pledged as collateral in private markets decreased from €80 billion in mid-2008 to less than €10 billion

[1] In a speech on December 8th 2011, Vitor Constancio, Vice-President of the ECB, concluded by remarking "...the key messages that I want to convey today ... Fourth, the ECB is able and willing *to continue fulfilling central banks's classical role as financial lender of last resort*, handling liquidity problems in a financial system without endangering price stability. [emphasis added]"

in mid-2010, while Greek sovereign bonds pledged with the ECB increased from €10 billion to €70 billion over the same time period.

Hence, by applying below-market haircuts to risky collateral, the ECB effectively provides a collateral-based subsidy to banks. The size of the implied subsidy is increasing in the difference between the ECB's and the market's haircut. Since ECB haircuts are less sensitive to asset quality than are market haircuts, the subsidy is in general largest for the riskiest assets. This implies that the largest subsidy is captured by banks that engage in a high level of borrowing *and* do so against the riskiest collateral.

Panel A of Figure 2 examines whether there is a relationship between the two components of the subsidy, the level of borrowing and the riskiness of collateral, across banks. We sort banks into five quintiles based on their ECB borrowing as of July 2010. We compute a bank's collateral risk as the average credit rating of its collateral and average collateral risk across banks within the quintiles. As shown in the Figure, the collateral risk of the banks in the lowest borrowing quintile remains constant from January 2009 to December 2011. In contrast, the collateral risk of the banks in the highest borrowing quintile increases over time. By the end of 2011, the average collateral risk of high-borrowing banks is almost 3 notches higher than the average collateral risk of low-borrowing banks. Panel B of Figure 2 finds a qualitatively similar result using as an alternative measure of collateral risk the share of a bank's collateral that was originated by periphery country governments (Greece, Ireland, Italy, Spain, Portugal).

Figure 2 shows a correlation in the take-up of the two components of ECB subsidies; banks which borrow a lot also tend to pledge the riskiest collateral. Moreover, the relationship grows stronger over time. The implication is that not only are there large differences between banks in the subsidies they receive, but this take-up of subsidies diverges over time. This evidence raises the research question that we address in this paper: *Why does the take-up of ECB subsidies by banks diverge over time, and what can one learn from this about the leading theories of the LOLR?* We propose and subsequently evaluate four broad explanations: (i) illiquidity, (ii) insolvency, (iii) differences in private valuation, and (iv) political economy.

1.1 Theories

The *illiquidity* explanation is that banks are forced to use LOLR funding to finance risky assets. The idea is that private market participants stop funding banks and therefore banks cannot roll over their short-term debt. In the absence of a LOLR banks would be forced to liquidate risky assets at fire sale discounts, reducing the value of bank equity and hence leading to debt overhang and a credit crunch. This explanation is at the heart of LOLR theory going back to at least Bagehot (1873). The theory suggests that the LOLR can help banks to avoid value-destroying fire sales by providing them with direct funding, thereby containing the financial crisis. This theory could explain Figure 2 if over time high-borrowing banks suffered a series of negative liquidity shocks that forced them to pledge increasingly risky collateral with the ECB.

The *insolvency* explanation is that banks actively use LOLR funding to purchase risky assets. The idea is that some banks suffer from debt overhang because of a permanent decline in the value of their assets, even though the presence of a LOLR allows them to avoid fire sales. The banks with the greatest debt overhang have a strong incentive to extract a large collateral-based subsidy from the ECB by buying risky assets that they can then pledge as collateral at below-market haircuts. Their heightened probability of default makes low haircuts an attractive opportunity to take risk, since they do not internalize any downside risk that is realized in states of the world where they default. This theory could explain Figure 2 if over time high-borrowing banks increasingly pledged riskier assets in order to actively use ECB funds to finance these assets.

The *differences in private valuation* explanation captures reasons other than insolvency why banks would actively use LOLR funding to finance investment in risky assets. Specifically, some banks may specialize in investing in certain types of risky assets. For example, if there are large fire sale discounts for mortgage-backed securities, one may expect mortgage specialists to use LOLR facilities to finance such assets. Alternatively, some banks may be more optimistic than others, or have private information about the valuation of certain risky assets. This theory could explain Figure 2 if the banks with the highest borrowing are those

that have the highest private valuations of risky assets.[2]

The *political economy* explanation is that banks buy risky assets because they are encouraged (or forced) to do so by their respective governments. In particular, some periphery countries experienced high sovereign borrowing costs and may have encouraged national banks to use LOLR funding to buy sovereign bonds of their home country, thereby reducing their cost of borrowing. Alternatively, since the ECB is not allowed to directly recapitalize weak banks, regulators may have attempted to do so indirectly by encouraging banks in the periphery countries to use LOLR funds to finance risky assets. This explanation could explain Figure 2 if banks increasingly financed their home country sovereign debt because of political economy pressure.

Understanding banks' motivation for borrowing is central to understanding the economic impact of the LOLR intervention. Providing funding to illiquid but solvent banks can be hugely welfare improving since it allows banks to avoid fire sales and avoids a credit crunch. In stark contrast, providing LOLR funding to insolvent banks can be greatly welfare destroying. Due to their distorted incentives, insolvent banks desire excessively high levels of risky-asset exposure, and prefer to avoid liquidating their non-performing assets rather than fund profitable new investments. Lending to banks with high private valuations of risky assets can in principle be welfare improving if these banks beliefs are rational and their incentives are aligned with maximizing firm value. However, if these beliefs are not rational then lending to such banks will be welfare destroying. The political economy explanation suggests that LOLR lending is an indirect way to subsidize financing of risky sovereign debt when there is insufficient private demand. This is only optimal if there are large benefits to such subsidized purchases, and if there are costly restrictions on more direct financing mechanisms.

[2]We note that insolvency is actually a source of differences in private valuation. However, unlike the other reasons for differences in private valuation, insolvency is incompatible with firm value maximization and we therefore categorize it as a separate explanation.

1.2 Overview of Results

We evaluate these different explanations using a novel and proprietary dataset that includes weekly bank-level observations on all borrowing and collateral pledged with the European Central Bank (ECB) from January 2008 to December 2011. We match these data to information on bank characteristics, including total assets, equity, bank loans, equity returns, and credit default swap (CDS) prices. We also match the dataset to data on banks' holdings of periphery sovereign debt which were disclosed under the European bank stress tests. These data allow us to provide a complete picture of banks' LOLR borrowing and collateral pledged during the financial crisis.

Our analysis proceeds in several steps. First, we use standard regression analysis to examine the relationship between bank borrowing and collateral risk. We confirm the main findings from Figures 1 and 2: high-borrowing banks pledge lower quality collateral with the ECB than do low-borrowing banks, and this difference increases over time. These results are robust to using different proxies for collateral risk (credit ratings, share of periphery sovereign debt) and different measures of borrowing (borrowing relative to collateral, borrowing relative to assets, and an indicator variable for borrowing). The results are also robust to using different subsamples, including the universe of all banks, the set of banks with credit ratings, and the set of banks with publicly traded equity.

Second, we analyze whether banks are forced to use LOLR funding because of a deterioration in their funding situations ("illiquidity") or because they actively invest in risky assets. The unique prediction of the illiquidity explanation is that banks increasingly pledge risky assets as collateral due to loss of other funding *and not because this reflects their increasing investment in these assets*. We test this prediction by analyzing the relationship between banks' pledging and holdings of periphery sovereign debt. We find that a 1% increase in periphery sovereign bonds pledged with the ECB is associated with a 0.5% increase in periphery sovereign bond holdings, both across *and within* banks. This result is not predicted by illiquidity, and it implies that banks use ECB funding to finance their investment in periphery sovereign debt. Hence, illiquidity cannot fully account for the observed divergence

in the pledging of sovereign periphery debt, though it could explain up to half the effect.

As an alternative test of the illiquidity explanation, we attempt to control directly for sources of banks' illiquidity. The most plausible source of banks' illiquidity that can explain the gradual increase in risky collateral pledging is an ongoing deterioration in the macroeconomic health of a bank's home country. For example, banks may suffer gradual deposit flight due to a loss of confidence in the sovereign's creditworthiness. This implies that the correlation between a bank's borrowing and the risk of its collateral is driven by country-level variables. We therefore re-estimate the borrowing-collateral relationship using a full set of time dummies for *each* country. We find that this does weaken the relationship between bank's borrowing and collateral risk, but that it remains positive and statistically significant, implying that illiquidity cannot fully account for the pledging of increasingly risky assets by high-borrowing banks.

We then move on to evaluating the evidence on *insolvency* and *differences in private valuations*. To distinguish between these we examine the relationship between a bank's financial strength and its borrowing and collateral choices. If insolvency drives bank behavior then banks with lower financial strength, which are more likely to suffer from debt overhang, have a stronger incentive to use LOLR financing for risky investment. In contrast, the differences in private valuations explanation says that other factors besides financial strength drive banks' LOLR borrowing. As a proxy for bank's financial health we use the bank's credit rating. We find that a bank's rating predicts future increases in the riskiness of pledged collateral. This finding is robust to using different measures of collateral riskiness and to using different subsamples of banks. These findings support the insolvency explanation, whereas they are not predicted by the differences in private valuations explanation.

We further test the differences in private valuations explanation by controlling for bank observable characteristics such as asset size and reliance on deposit funding. These characteristics proxy for underlying differences in bank business models that may explain variation in private valuations. We find that our results on the relationship between borrowing and collateral riskiness are robust to using such controls across different subsamples. Since it is

unlikely that banks have private information about the value of sovereign debt, the private valuations explanation also appears to be inconsistent with the fact that the borrowing and collateral risk relationship holds when collateral risk is measured using periphery sovereign debt. In summary, we find no evidence in favor of a differences in private valuations explanation.

Finally, we test the political economy explanation. Since the financial crisis afflicted mostly the periphery countries, it is unlikely that countries outside the Periphery exerted pressure on their banks to buy periphery sovereign bonds. We therefore re-estimate our main tests for the set of banks headquartered in non-periphery countries. We find that the relationship between borrowing and collateral risk remains positive and statistically significant. This suggests that regulatory pressure alone cannot fully explain the relationship, though it may partially explain it for the periphery countries. Note that this result also provides further evidence against the illiquidity explanation, since funding problems were much less likely outside the Periphery and are therefore not likely to generate the observed relationship between borrowing and collateral risk for non-periphery banks.

We confirm the robustness of our results with some additional tests. First, we restrict the estimation by measuring collateral risk using only newly pledged collateral. We continue to find a strong relationship to bank borrowing, showing that banks actively increased the risk of their collateral. Second, we show that our results are robust to using alternative measures of banks' borrowing. Third, we show that our tests are robust to sampling the data at a quarterly rather than weekly frequency.

Overall, our results strongly support the insolvency explanation. This explanation seems to be the main driver of the divergence in banks' take-up of ECB subsidies for banks based outside the Periphery. Within the Periphery, insolvency appears to be even more important, though the evidence indicates that illiquidity, and possibly political economy, are also at work.

Lastly, we examine whether LOLR borrowing contains information beyond what is captured in public information. A basic tenet of much LOLR theory is that public information

is *not* sufficient to differentiate illiquid and insolvent banks, especially at the beginning of a crisis. As a proxy for public information we use banks' credit ratings, since they are available for a large set of banks. Following our earlier tests, we find that credit ratings do predict future increases in banks' collateral risk. However, LOLR borrowing continues to have significant predictive power even after controlling for credit ratings. This result is consistent with the assumption of LOLR theory, as it indicates that the LOLR (or investors) cannot simply use credit ratings, and perhaps public information more generally, to precisely differentiate between different types of banks.

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 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 original motivation for creating central banks in many countries was to contain financial crises.[3]

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

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

(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 insolvency 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.

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 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).[4].

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 have to be financially sound. 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.[5] 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 billion have access to ECB lending. Depending on the country, many banks with assets of less than €10 million also have access to ECB lending. This includes financial institutions that have subsidiaries in Eurozone member states but are not headquartered in the Eurozone. In practice, this provision provides access to ECB lending for most large banks headquartered outside 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

[4]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.*

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

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.[6]

Banks need to provide adequate collateral against ECB borrowing. 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. Since the start of the financial crisis in August 2007, the ECB has modified the collateral framework several times to widen the pool of assets eligible as collateral. There is anecdotal evidence that the ECB eligibility criteria are less stringent and haircuts are lower for low-quality assets relative to private repo markets. The ECB maintains a list of current eligible assets on its website.[7]

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 January 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.

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

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

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 listed

banks. 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 358 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.[8]

Panel A of Figure 3 shows total lending by the European Central Bank in the period 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

[8]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.

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 3 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 4 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 with 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

Panel A of Table 1 provides summary statistics for the listed bank sample. Our sample contains 76 unique banks and 11,307 bank-week observations in the period from January 2009 to December 2011. As shown in column (1), average bank size is €402 billion, average book equity is €19.9 billion, and average market equity is €12.1 billion. The average bank is relatively risky with market leverage of 43.4, a CDS price of 239 basis points, and an average

credit rating of A.[9]

About 70% of banks borrow from the ECB in a given week. Conditional on borrowing, banks on average borrow €4.1 billion. Borrowing is large relative to bank equity, accounting for 70.9% of book equity. There is significant variation across banks with a standard deviation of 137.7%. In terms of collateral, banks on average pledge €12.7 billion with the ECB. As a result, the average bank is only using 35.7% of its collateral capacity, or conditional on borrowing, 50.1% of its collateral capacity. Similar to total borrowing, there is significant variation across banks in the use of their collateral capacity.

About 98% 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 financial institutions therefore 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 a financial institution cannot pledge unused collateral with other market participants. About 67.8% of collateral is rated by at least one of the three rating agencies. The average rating is 2.9, or equivalently, AA. The assets without credit ratings are non-marketable assets or assets that were not matched to ratings by the ECB. About 22.1% of collateral is sovereign debt originated in periphery countries.

Next, we split the sample based on whether a financial institution is borrowing in a given week. We find that banks that borrow are slightly larger than banks that do not borrow with average total assets of €418 billion and €350 billion, respectively. Banks that borrow have similar book leverage to banks that do not with leverage of 19 and 18.9, respectively. However, banks that borrow are riskier than banks that do not borrow. Specifically, they have a higher average market leverage of 45.8 relative to 37.7, a higher average CDS price of 279 basis points compared to 134 basis points, and a lower average credit rating of 6.4, compared to 5.4.

Banks that borrow pledge more collateral, €15.3 billion on average, relative to €6.6

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

billion for banks that do not borrow. Banks that borrow on average pledge collateral of lower quality, with a lower rated share, 66% relative to 72.2%, lower credit ratings, 3.2 relative to 2.2, and a lower share rated AA or above, 63.5% relative to 80.5%. Banks that borrow also pledge a higher share of periphery sovereign debt, 24.1%, relative to 16.5%. Overall, this comparison suggests that banks that borrow are generally of lower quality and post lower-quality collateral relative to bank that do not borrow.

Panel B of Table 1 provides summary statistics for the Bankscope sample. This sample includes 358 banks and 55,848 bank-week observations. We find that 56.6% of banks borrow in a given week. This share is lower than for the listed bank sample, which suggests that smaller banks are less likely to borrow from the ECB. We find a similar pattern as in the listed bank sample regarding collateral quality. Banks that borrow pledge lower rated collateral, 2.8 relative to 2.6, and have a lower share of assets rated AA or higher, 65% relative to 67.7%. Similar to the listed banks sample, banks that borrow also pledge more periphery sovereign bonds, 10.1% relative to 3.5%.

Panel C of Table 1 provides summary statistics for all banks that borrow at least once during the analysis period. The sample contains 1,826 banks and 289,694 bank-week observations. We find that 40.2% of banks borrow in a given week. Similar to the other samples, banks that borrow pledge lower-quality collateral. Relative to the other samples, banks hold fewer periphery sovereign bonds, which suggest that periphery sovereign debt holdings are concentrated in large banks.

4 Empirical Strategy and Results

Our tests require empirical proxies for banks' borrowing and collateral riskiness. We use two main measures for the riskiness of the collateral pledged by a bank. The first measure is the average rating of the collateral. We assign a numerical value to each rating: '1' for AAA, '2' for $AA+$, and so on. We compute the average collateral rating as the value-weighted mean of the individual asset ratings for each bank in each week. A higher value for our

average rating measure corresponds to greater collateral riskiness (lower collateral quality). The second measure is the share of total collateral pledged that is due to sovereign debt originated in the periphery countries (Greece, Italy, Ireland, Portugal, Spain). We use this measure since buying high-yielding sovereign debt originated in periphery countries was a well-known, capital-efficient way for banks to increase risk-taking during the financial crisis.

Panels A and B of Figure 5 plot the two collateral riskiness measures at the aggregate level for the period September 2008 to December 2011. As shown in Panel A, the average rating of collateral pledged with the ECB is relatively stable throughout this period. It is only at the end of the sample that the average aggregate collateral risk starts to increase. The increase is probably related to the first round of the three-year LTRO in December 2011. Panel B plots the average share of collateral due to periphery sovereign debt and the average share of collateral due to all assets originated in periphery countries. The two shares track each other closely and are fairly stable throughout the period, averaging 4% and 9%, respectively. In the analysis below we focus on the periphery sovereign debt share since this corresponds to the data available on banks' holdings from the European bank stress tests.

Next, we construct a measure of bank borrowing. We want our measure of bank borrowing to have the following characteristics: (1) it should be invariant to the scale of the bank so that it is equally appropriate for large and small banks, (2) it should be available for the broadest cross-section of banks, and (3) it should be higher for banks that draw more aggressively on their capacity for borrowing from the ECB. Consequently, we choose as our primary borrowing measure the ratio of a bank's borrowed funds to its total pledged collateral. This measure satisfies our three criteria. First, since larger banks have both more collateral and a greater need for loans, their ratio should be invariant to bank size. Second, we can calculate this measure for all banks in our dataset, in whereas this is not possible for measures of borrowing that depend on accounting data.

Third, since banks want to ensure access to ECB lending at short notice, they tend to pledge up-front most of their stock of collateral which receives a haircut subsidy, *even* if they do not fully borrow against it (as discussed in Section 3). This is consistent with Figure 4,

which shows that there is little variation over time in aggregate collateral pledged with the ECB. Hence, total collateral pledged is a proxy for a bank's total borrowing capacity with the ECB, and the ratio of borrowing to pledged collateral is then a proxy for how intensively a bank utilizes this capacity. In robustness tests we show that our main results hold if we use alternative borrowing measures, such as borrowing relative to bank size or an indicator variable for whether a bank borrows from the ECB.

Figure 6 plots borrowing from the ECB relative to collateral pledged for the period from September 2008 to December 2011. The figure shows that both equal- and value-weighted aggregate borrowing measures are relatively stable throughout the period. The only exceptions are the marked increase during the one-year LTRO from July 2009 to July 2010 and during the first-round of the three-year LTRO at the end of December 2011.

4.1 The Take-up of ECB Subsidies

As discussed in Section 1, a bank's take-up of the ECB's implicit subsidies has two components. The first component is how much the bank borrows. The second component is the riskiness of the bank's collateral. We use regression analysis to examine the relationship between these two components. Specifically, we test whether high-borrowing banks pledge increasingly risky collateral over time. Since a bank can increase its borrowing much more quickly than it can adjust the composition of its assets, we examine whether banks' borrowing predicts subsequent changes in the riskiness of its collateral. There are two advantages of looking at the correlation of borrowing with future *changes*, rather than with the contemporaneous level, of collateral risk: (1) changes captures actions by banks to change the riskiness of their collateral riskiness, and (2) looking at changes controls for pre-existing variation (including initial conditions) in the level of collateral risk.

We therefore estimate the following OLS regression:

$$\Delta Risk_{i,t+1} = \alpha + \delta_t + \beta Borrowing_{it} + \gamma X_{it} + \varepsilon_{it} \tag{1}$$

where $\Delta Risk_{i,t+1}$ is the change in the collateral risk of bank i from time t to $t+1$, $Borrowing_{it}$ is bank i's borrowing at time t, X_{it} are controls, and δ_t are time fixed effects. As a control, we use the lagged value of collateral risk. It controls for any mechanical changes in collateral credit rating not due to active changes by banks, including the possibility of autocorrelation in ratings due to measurement (or recording) errors. We cluster standard errors at the bank level to account for the correlation of error terms within banks.

Table 2 presents the results in two panels. Panel A uses average collateral rating as the measure of collateral risk, while Panel B uses the share of periphery sovereign debt in total collateral. In each panel, we present separate results for two time periods and three bank subsamples. The first time period is for the year 2009 while the second time period is for the years 2010 and 2011. This breakdown allow us to assess the evolution of the borrowing-collateral relationship over time. We present the results for three subsamples of banks: a sample covering all banks in our dataset ("full sample"), a sample covering all banks with credit ratings ("Bankscope sample"), and a sample of all banks with publicly listed equity ("listed sample"). The use of three different samples allows us to assess whether the results are robust across different types of banks.

Panel A analyzes the relationship between borrowing and subsequent changes in collateral riskiness. As shown in Columns (1) to (3), there is little evidence of a positive relationship between borrowing and changes in collateral risk in 2009. The coefficients for the full sample (column 1) and the Bankscope sample (column 2) are close to zero and statistically insignificant. The coefficient for the listed sample is positive but only marginally significant. In contrast, Columns (4) to (6) show a positive and statistically significant relationship between borrowing and future changes in collateral risk for all three samples. For the listed bank sample, an increase in borrowing by 50% predicts an increase (i.e., worsening) in collateral risk by 1.23 notches over the subsequent one year. The effect is 0.64 notches in the Bankscope sample and 0.31 notches in the full sample.[10]

[10]We compute these estimates by multiplying the coefficients from Columns (4) to (6) by 0.5 for the change in borrowing and by 52 to normalize for the one-year period. The outcome variable is measured in basis points, so that a value of 100 represents one notch.

Panel B analyzes the relationship between borrowing and subsequent changes in the share of total collateral originated by periphery country governments. Similar to Panel A, Columns (1) to (3) find no statistically significant relationship between borrowing and collateral in 2009. However, as shown in Columns (4) to (6), the relationship is positive and statistically significant for the years 2010 and 2011 across all subsamples. For the listed bank sample, an increase in borrowing relative to collateral by 50% increases the share of periphery sovereign debt pledged in total collateral by 5.4 percentage points over a one-year period. The effect is 4.3 percentage points in the Bankscope sample and 2.0 percentage points in the full sample.

These findings show that the riskiness of collateral pledged by high-borrowing banks increased significantly relative to low-borrowing banks in the years 2010 and 2011. Hence, the take-up of ECB subsidies diverged across banks as the two components of ECB subsidies, borrowing and collateral risk, became more concentrated within banks over time. We next examine which theory of the LOLR can account for these results.

4.2 Do Banks Actively Invest in Risky Assets?

As discussed in Section 1, 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 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 financing.[11]

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

[11]We note that the insolvency explanation also predicts a decline in funding liquidity. However, the difference relative to the illiquidity explanation is that the insolvency 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 bank asset quality. The classical example of an illiquidity situation is a Diamond and Dybvig (1983) type bank run.

proprietary. However, as part of the European bank stress tests, bank regulators published information on bank holdings of sovereign periphery debt. European banks conducted three separate rounds of bank stress tests (March 2010, December 2010, and September 2011), which allows us to analyze the time-series of bank holdings. 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 periphery sovereign bonds. We estimate the following OLS regression:

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

where $Holdings_{it}$ is bank i's total holdings of periphery sovereign debt at time t relative to bank size, $Pledged_{it}$ is bank i's periphery sovereign debt pledged as collateral with the ECB at time t relative to bank size and δ_t are time fixed effects. We measure bank size using bank assets of of December 2008 to avoid endogeneity with respect to changes in bank size. 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 periphery sovereign debt pledged with the ECB is associated with 1.19% increase in periphery sovereign debt holdings. As shown in Column (2), the coefficient is almost unchanged if we control for time fixed effects. This result suggests that banks with larger holdings of sovereign periphery debt also pledge more periphery sovereign debt. The coefficients suggest that there is effectively a one-to-one relationship between holdings and collateral pledged.

We further examine whether the increase in holdings of periphery sovereign debt is associated with higher borrowing. We do so by replacing the variable $Pledged_{it}$ in equation (2) with the ratio of total borrowing relative to total collateral pledged. As shown in Columns (3) and (4) of Table 3, we find that an increase in borrowing by 50% is associated with an

increase in periphery sovereign debt holdings of 2.05 percentage points. Again, this result is robust to including time fixed effects. This shows that banks with higher periphery sovereign debt holdings borrow more from the ECB.

As a direct test of the insolvency explanation, we analyze the association between periphery sovereign debt holdings and a bank's financial strength. We implement this test by replacing $Pledged_{it}$ in equation (2) with a bank's credit rating. We note that our sample drops to 52 (from 54) banks because two banks do not have credit ratings. We measure bank credit ratings by assigning increasing numerical values to each rating ('1' for AAA, '2' for $AA+$, and so on). As shown in Columns (5) and (6), we find that banks with lower ratings have larger holdings of periphery sovereign debt, consistent with the insolvency explanation. A one-notch decrease in a bank's credit rating is associated with a 0.27% percentage point increase in periphery sovereign debt holdings.

Next, we examine if changes in the periphery sovereign debt collateral holdings of a bank are associated with changes in its pledged collateral. This allows us to focus on the time-series dimension *within* banks, and controls for pre-existing variation in the pledging of periphery sovereign debt collateral and in periphery sovereign debt holdings. We therefore estimate the following regression:

$$\Delta Holdings_{it} = \alpha + \delta_t + \beta \Delta Pledged_{it} + \varepsilon_{it} \tag{3}$$

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 periphery 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.

As shown in Columns (7) and (8), we find that a 1% point increase in periphery sovereign debt pledged with the ECB is associated with a 0.54% percentage point increase in periphery sovereign debt holdings. This result is robust to including time fixed effects. This suggests that banks actively increase their holdings of periphery sovereign debt at about 50% of the rate at which they increase their use of periphery sovereign debt as collateral. This result is

inconsistent with the illiquidity explanation and indicates that illiquidity can account for at most half the increase in periphery sovereign debt pledged as collateral.

We also examine whether the increase in holdings of periphery sovereign debt is associated with increased borrowing. We do so by replacing $\Delta Pledged_{it}$ with the change in borrowing relative to collateral pledged in equation (3). As shown in Columns (9) and (10), the increase in periphery sovereign debt holdings is associated with an increase in borrowing. This is inconsistent with illiquidity, and suggests that banks are increasing their use of LOLR funding to increase their holdings of periphery sovereign debt. Hence, it appears again that the illiquidity explanation cannot fully account for the divergence in the use of periphery sovereign debt collateral with the ECB.

4.3 Are the Results Driven by Cross-Country Differences?

As an alternative test of the illiquidity explanation, we also test directly for the main source of bank illiquidity. As discussed in Section 1, the most likely source of illiquidity that can account for the gradual increase in collateral riskiness among high-borrowing 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 funding liquidity can potentially explain the observed relationship between bank borrowing and future changes in collateral risk. We test this explanation by including a full set of time dummies for each country in our main regression. 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.

We therefore estimate the following OLS regressions:

$$\Delta Risk_{i,t+1} = \alpha_{it} + \beta Borrowing_{it} + \gamma X_{it} + \varepsilon_{it} \tag{4}$$

where $\Delta Risk_{i,t+1}$ and $Borrowing_{it}$ are the same as in equation (1) and α_{it} are country-time fixed effects. We cluster standard errors at the bank level to account for the correlation of

error terms within banks.

Table 4 presents the results. As shown in Columns (1) to (3) of Panel A, there is no evidence of a positive relationship between borrowing and changes in collateral risk in the year 2009. However, Columns (4) to (6) find a positive and statistically significant relationship between bank borrowing and increases in collateral risk in the years 2010 to 2011. For the listed bank sample, a 50% increase in borrowing raises collateral risk by 0.35 notches over a one-year period, 0.24 notches for the Bankscope sample, and 0.09 notches for the full sample. The magnitude of the coefficients is about two thirds smaller than the estimates without country-time fixed effects in Table 2. Panel B presents results for periphery sovereign debt and finds qualitatively similar results to Panel A.

Overall, these results suggest that the borrowing-collateral relationship is robust to using only *within*-country variation. This implies that country-level changes in illiquidity cannot fully account for the observed changes in banks' collateral risk.

4.4 Do Riskier Banks Pledge Risker Collateral?

We next evaluate the evidence on the *insolvency* and *differences in private valuation* explanations. We distinguish these explanations by examining the relationship between a bank's financial strength and its collateral riskiness. If banks pledge riskier collateral because of insolvency, then banks with lower financial strength, which are more likely to suffer from debt overhang, have a stronger incentive to use LOLR financing for risky investment. In contrast, the differences in private valuations explanation says that factors other than financial strength drive banks' collateral choices.

We use a bank's credit rating as a proxy for a bank's financial strength. For the purpose of our empirical exercise, we assign a numerical value to each rating: '1' for AAA, '2' for $AA+$, and so on. We note that a higher number denotes higher bank risk (lower financial strength). We restrict the estimation to the sample of rated banks ("Bankscope sample").

We estimate the following OLS regression:

$$\Delta Risk_{i,t+1} = \alpha + \delta_t + \beta BankRating_{it} + \gamma X_{it} + \varepsilon_{it} \tag{5}$$

where $\Delta Risk_{i,t+1}$ is the same as in equation (1), $BankRating_{it}$ is bank i's credit rating at time t, X_{it} are controls, and δ_t are time fixed effects. We cluster standard errors at the bank level.

Table 5 presents the results. As shown in Column (1) and (2) of Panel A, we find little evidence that lower rated banks pledge increasingly risky collateral in 2009. In contrast, Columns (3) and (4) show that in 2010 and 2011 there is a positive and statistically significant relationship between high bank risk (low financial strength) and subsequent increases in collateral risk. These results are similar to the results in Tables 2 and 4. In terms of economic magnitudes, a one-notch increase in bank risk predicts an increase of 0.17 notches in future collateral risk in the Bankscope sample and 0.38 notches in the listed sample. As shown in Panel B, the results are similar for the share of periphery sovereign debt. These results show that banks with lower financial strength increasingly pledge riskier collateral, which is evidence in favor of the insolvency explanation.

Next, we test the differences in private valuation explanation by including additional control variables to our analysis. Specifically, we add controls for the natural logarithm of bank size and the share of retail deposit funding to regression equation (5). The idea is that these control variables capture differences in bank business models (other than financial strength) that may cause differences in private valuation.

Table 6 reports the results. As shown in Panel A, the coefficients on bank rating remain robust and almost unchanged in terms of magnitude after adding controls. The coefficients on the control variables are always statistically insignificant. These results suggest that differences in business models captured by bank size and deposit funding cannot account for the relationship between a bank's financial strength and collateral risk. As shown in Panel B, we find qualitatively similar results for periphery sovereign debt although some coefficients lose statistical significance after adding controls. We note that the coefficient on

asset size is statistically significant in some regressions but the sign changes across samples, which suggests that there is no clear effect on collateral risk. Overall, we find no evidence in favor of the private valuation explanation.

We further note that it is unlikely that banks have private information on the value of sovereign debt, which is one of our two risk measures. Hence, this is further evidence against the private valuation explanation. Overall, our results provide strong support for the insolvency explanation.

4.5 Are the Results Driven by Regulatory Pressure?

The *political economy* explanation says that high-borrowing banks increase collateral risk because they are encouraged (or forced) to do so by their national regulators. This may be the case because periphery country 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 Periphery, since that is where sovereigns experienced high costs of borrowing.[12]

We therefore test for the political economy explanation by estimating our main regression equation (1) *only* for the sample of banks headquartered *outside* the Periphery. 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 sovereign periphery debt to disappear because this is the main focus of the political economy explanation.

Table 7 presents the results. The results are qualitatively similar to the ones in Table 2. For collateral ratings, there is no effect in 2009 but there is a positive and statistically significant relationship between borrowing and changes in collateral riskiness in 2010 and

[12]We note that the political economy explanation interacts with the insolvency 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.

2011. For listed banks, an increase in borrowing relative to collateral by 50% predicts an increase in the average collateral rating by 0.66 notches over the subsequent one year period in 2010 and 2011. The effect is 0.27 notches in the Bankscope sample and 0.11 notches in the full sample. In terms of magnitudes, the coefficients are about two thirds smaller than in Table 2. As shown in Panel B, we find qualitatively similar results for periphery sovereign debt. For the listed bank sample, an increase in borrowing by 50% raises the share of periphery sovereign debt by 6.9 percentage points over a one-year period. The effect is 1.4 percentage points in the Bankscope sample and 0.3 percentage points in the full sample.

These results show that the borrowing-collateral-risk relationship is not simply driven by banks headquartered in the periphery countries. Even amongst bank based outside of the Periphery we find a statistically significant correlation between borrowing and the future increase in collateral risk. Moreover, this relationship exists even for periphery sovereign debt. These finding imply that there remains an important role for the insolvency explanation even after controlling for political economy considerations.

Next, we evaluate the importance of illiquidity for explaining the borrowing-collateral risk relationship outside of the periphery countries. As discussed in section 4.3, illiquidity is likely to be driven by country-level deterioration in macroeconomic health. We thus control for such changes by including a full set of time fixed effects for each country. Hence, we estimate the regression equation (4) restricted to banks headquartered in the periphery countries.

Table 8 presents the results. We find that the coefficients across both panels and across all samples are almost identical to Table 7. This shows that country-level variables have no effect on the borrowing-collateral-risk relationship for banks headquartered outside the periphery countries. Moreover, this implies that there is no role for illiquidity in terms of explaining the increase in collateral risk outside the Periphery.[13] Hence, these results suggest that the insolvency explanation is the main driver for the take-up of ECB subsidies outside the periphery countries.

[13]A potential concern may be that we cannot control for within-country variation in illiquidity. However, it is unlikely that there was significant within-country illiquidity outside the Periphery given that the crisis centered in periphery countries, and given the results on bank asset holdings of periphery sovereign debt.

4.6 Are the Results Robust to Alternative Specifications?

4.6.1 Measuring Borrowing

We use borrowing relative to collateral pledged as the main borrowing measure in Tables 2 to 8. This measure has the advantage that it is normalized by a bank's borrowing capacity and that it can be computed solely based on ECB data and hence applied to banks that are not matched to other datasets.

Nevertheless, we want to ensure that our results are robust to using other borrowing measures. We therefore compute two alternative measures. The first measure is total borrowing divided by bank equity. This variable scales borrowing by bank size rather than collateral pledged. The advantage of this measure is that it does not use the endogenous choice of collateral in the denominator. However, it is only a noise proxy of a bank's usage of its borrowing capacity with the ECB because available collateral may differ across banks. The second variable is an indicator variable for whether a bank borrows at all from the ECB. The advantage of this measure is that no scaling is necessary. However, this measure is only a noise proxy of borrowing because it does not use any information on the intensive margin of borrowing. We restrict the analysis to the Bankscope sample because we need data on bank characteristics to compute borrowing relative to bank equity.

Table 9 presents the results. Panel A presents the regressions corresponding to Table 2 (all banks) and Panel B presents the regressions corresponding to Table 7 (non-periphery banks). Columns (1) and (2) of Panel A find no statistically significant relationship between borrowing and changes in collateral risk in 2009. In contrast, Columns (3) and (4) of Panel A find a positive and statistically significant relationship between borrowing and increases in collateral risk in 2010 and 2011. As shown in Panel B, the results are qualitatively similar for non-periphery banks. Columns (5) to (8) present the estimates for periphery sovereign debt. In both panels these results are qualitatively similar to the ones using collateral ratings. These finding show that our results are robust to using alternative borrowing measures.

4.6.2 Estimation Frequency

All of the results in Tables 2 to 8 are estimated at a weekly level. The advantage of this approach is that we can control for week-to-week changes that affect all banks in a similar way. However, one concern with this approach is that it may suffer from measurement (or recording) error. One way to address this concern is to estimate our results at a lower frequency. If measurement error is serially uncorrelated, we expect that a lower frequency attenuates the impact of measurement error on coefficient estimates. For robustness, we therefore estimate the main results from Tables 2 and 7 at a quarterly frequency.[14]

Table 10 presents the results. The estimates are both quantitatively and qualitatively similar to Tables 2 and 7. As shown in Panel A, the estimates for 2009 are statistically insignificant (Columns (1) to (3) and (7) to (9)) and the ones for 2010/11 are positive and statistically significant (Columns (4) to (6) and (10) to (12)). The estimates imply economic magnitudes similar to those based on Table 2. For example, in the listed bank sample a 50% increase in borrowing is associated with a decrease in ratings by 1.51 notches over the subsequent year and an increase in the periphery sovereign debt share of 8.5 percentage points. This compares to implied values of 1.23 notches and 5.4 percentage points based on the weekly estimates. The increase in magnitudes is consistent with a downward bias in the weekly coefficient estimates due to measurement error. The results in Panel B also have similar signs and comparable magnitudes to the weekly estimates shown in Table 7. Overall, these result show that our findings are robust, and in fact strengthen, when estimated at the quarterly frequency.

4.6.3 Pledging of Lower-Quality Collateral

The results in Tables 2 to 8 document the relationship between borrowing and an increase in collateral risk. Since there was an increase in the dispersion of asset ratings over the financial crisis, it is possible that the divergence in banks' collateral risk could arise just by banks passively hold onto the same collateral. The analysis of the illiquidity explanation, including

[14]We also estimated the results at a monthly frequency. The results are similar to the ones reported here.

the analysis of banks' holdings, already provides strong evidence against this view. Moreover, the results which use periphery sovereign debt's share of total collateral already suggest that banks actively manage their collateral risk. The reason is that periphery sovereign debt suffered a relative decrease in its market value over the analysis period. Hence, a bank which passively holds a constant (nominal) amount of this collateral would see a drop in its share of total collateral over time. This biases the tests against the results we find.[15]

Here we provide another, direct test of whether banks actively pledge lower-quality collateral over time. We analyze active pledging of lower-quality collateral by examining the ratings of newly pledged collateral. We define newly pledged collateral as assets with ISIN codes that have not been pledged by the same bank in the previous week. This definition allows us to focus narrowly on active changes in collateral. We drop bank-week observations if banks do not pledge new collateral. We estimate regression equation (1) using the average rating of newly pledged collateral as the outcome variable.

Table 11 presents the results. Panel A reports the results for the full sample. Columns (1) to (3) of Panel A find a positive and marginally statistically significant relationship between borrowing and risk-taking in 2009. Columns (4) to (6) of Panel A find a positive and statistically significant relationship between borrowing and risk taking in the years 2010 and 2011. For the listed bank sample, an increase in borrowing by 50% reduces average collateral rating by 0.47 notches over a one-year period.[16] The effect is 0.17 notches in the Bankscope sample and 0.03 notches in the full sample.

Panel B reports the results for banks headquartered outside the periphery countries. Columns (1) to (3) find no statistically significant relationship between borrowing and rating quality in 2009. Columns (4) to (6) finds a positive and statistically significant relationship between borrowing and newly pledged collateral. Again, the effect is largest for listed banks.

[15]We indeed find that the regression coefficients are slightly larger if we use nominal values instead of market values to measure the share of Periphery sovereign debt in total collateral.

[16]There are 6,992 observations in Column (6) of Panel A, Table 2, and 2,886 observations in Column (6) of Panel A, Table 11. Hence, listed banks pledge new collateral about 41% of bank-week observations. On average, newly pledged ISINs represents 2% of total collateral. Thus, the one-year effect is 52*0.41*0.02*1.1136=0.47 notches).

An increase in borrowing by 50% reduces average collateral rating by 0.64 notches over a one-year period. The effect is 0.16 notches in the Bankscope sample and 0.02 notches in the full sample.

Overall, these results suggest that banks actively pledge lower quality collateral as they increase their borrowing, and support explanations based on active risk-taking by banks.

4.7 Does Public Information Fully Capture Risk Taking?

The traditional theory of LOLR assumes that the central bank cannot fully determine which banks have strong risk-taking incentives. The standard policy prescription is that if a LOLR is able to do so, it should only lend to illiquid *but* solvent banks and force insolvent ones to unwind or recapitalize. It is therefore interesting to use public information on bank's solvency and examine whether borrowing information has information over and above publicly available information.

Following the analysis in Tables 5 and 6, we use bank credit ratings as our measure of public information on bank solvency. We choose ratings because they are widely used as a measure of banks' credit risk and they are available for the entire Bankscope sample. We estimate the main regression equation (1) using both bank risk and borrowing as explanatory variables. Panel A of Table 12 examines the full sample, while Panel B examines the sample of banks headquartered outside the Periphery. Columns (1) to (6) of Table 12 use the average collateral rating, while Columns (7) to (12) use the share of periphery sovereign debt in total collateral.

Columns (1) to (3) of Panel A find no statistically significant relationship between the change in average collateral ratings and either borrowing or bank risk in 2009. Columns (4) to (6) of Panel A find a positive and statistically significant effect of both borrowing and bank rating on collateral rating. The coefficient on borrowing remains stable and statistically significant even after including the control for bank rating. This result suggests that borrowing contains independent information over and above the public information incorporated in bank ratings. In contrast, the coefficient on bank rating is only marginally significant after

controlling for borrowing. Columns (7) to (12) of Panel A present the regressions using the share of periphery sovereign debt. Again, there is no statistically significant relationship between risk-taking and either borrowing or bank rating in 2009. In 2010 and 2011, both variables are individually statistically significant but bank rating loses significance after including borrowing while borrowing remains significant. Panel B finds qualitatively similar, but quantitatively smaller, effects for the non-periphery banks.

Overall, these results suggest that borrowing contains independent information on bank's risk-taking over and above the public information contained in bank ratings. These results indicate that the LOLR has proprietary information in making the determination about banks' risk taking that is not incorporated in public information.[17]

5 Conclusion

Since the advent of central banks, one of their key capacities has been to act as Lender of Last Resort during financial crises. The LOLR role is usually motivated by the idea to provide temporary funding to illiquid but solvent 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, some of which are more likely to 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

[17]This result may raise the question of why the ECB is not using this information in making decisions about LOLR lending. There are number of possible explanations. First, the ECB has to act under immense time pressure and may not have sufficient time to conduct this analysis. Second, the ECB is generally required to lend to all banks on the same terms. It is the national bank supervisor, not the ECB, that decides whether a bank is sufficiently solvent to borrow from the ECB. Third, bank behavior and the resulting equilibrium would change if the ECB would use this information to make decisions about access to LOLR lending. It is not obvious whether the new equilibrium would necessarily be welfare improving.

this divergence: (1) illiquidity, (2) insolvency, (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 bank with lower financial strength increasingly pledge riskier collateral. This result strongly supports insolvency as an important driver of the divergence in banks's take-up of ECB subsidies. In periphery 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 periphery countries and political economy considerations may also be at work. Outside the periphery countries, we find no evidence that explanations other than insolvency can explain the increase in collateral risk.

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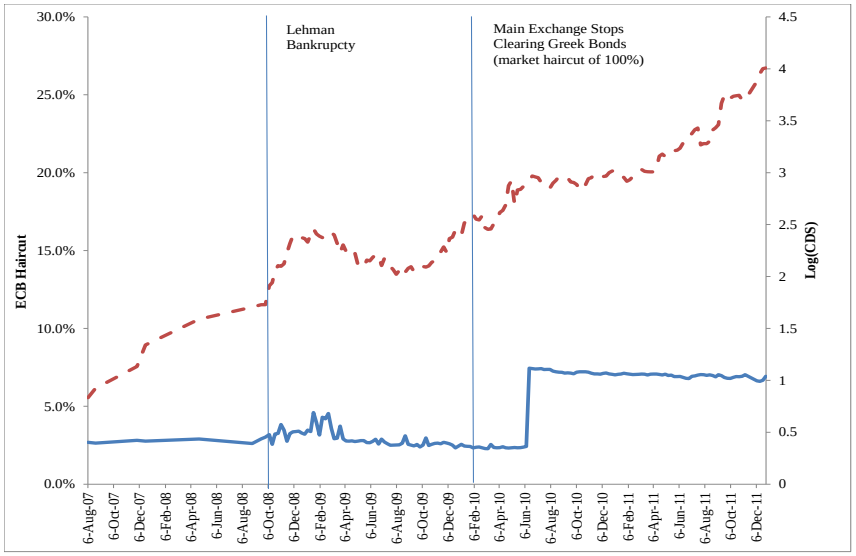
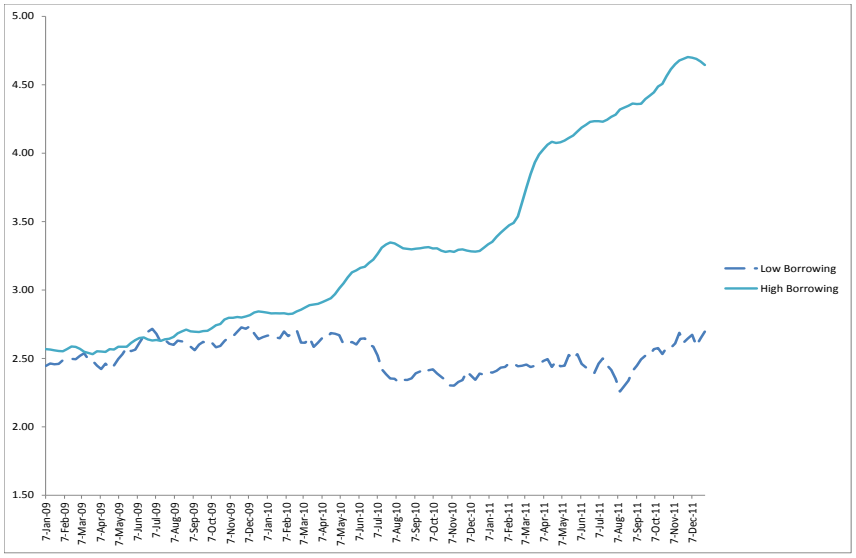
Figure 1: (A) Greek Sovereign Risk and ECB Haircut



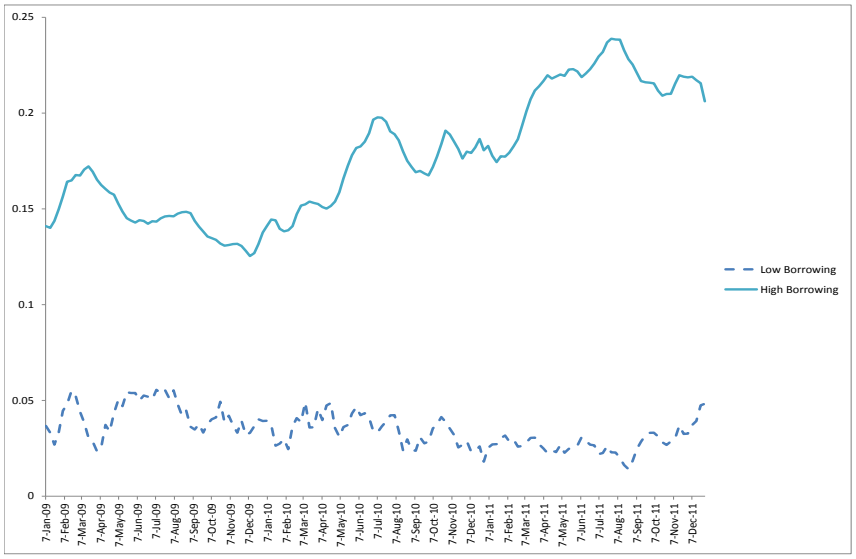
(B) Collateral Use of Greek Sovereign Bonds

Panel A of Figure 1 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 2: (A) Average Rating by Borrowing Quintile

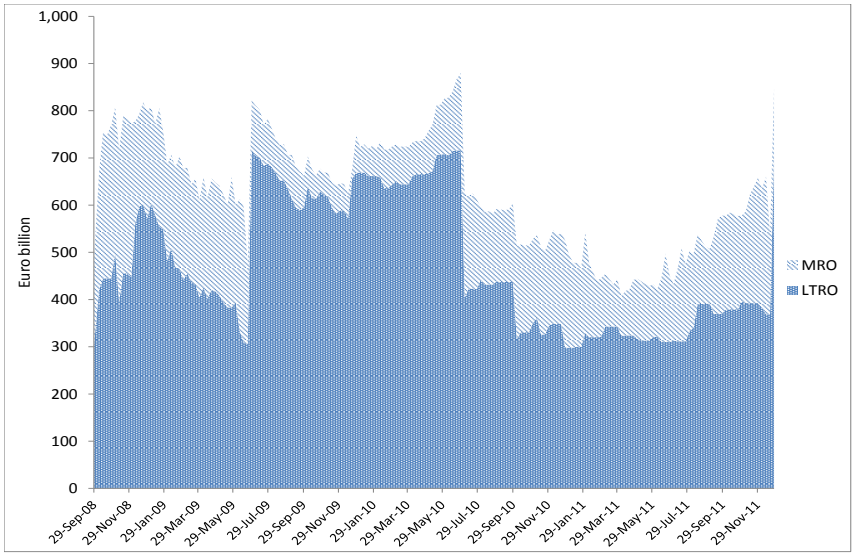


(B) Share of Periphery Sovereign Debt by Borrowing Quintile

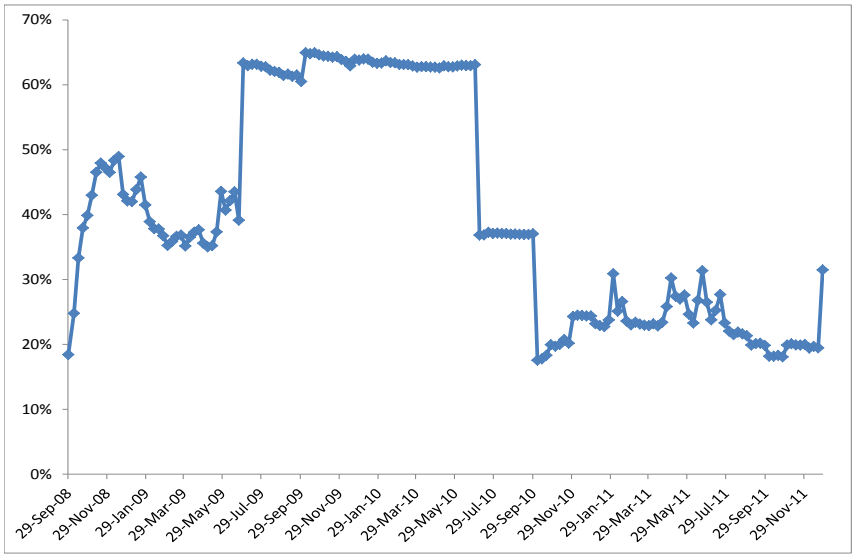


Panel A of Figure 2 plots the average collateral credit rating of banks in the highest borrowing quintile (dashed line) and banks in the lowest borrowing quintile (dotted line). Panel B plots Periphery sovereign debt as share of total collateral pledged for banks in the highest borrowing quintile (dashed 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 3: (A) Total Borrowing

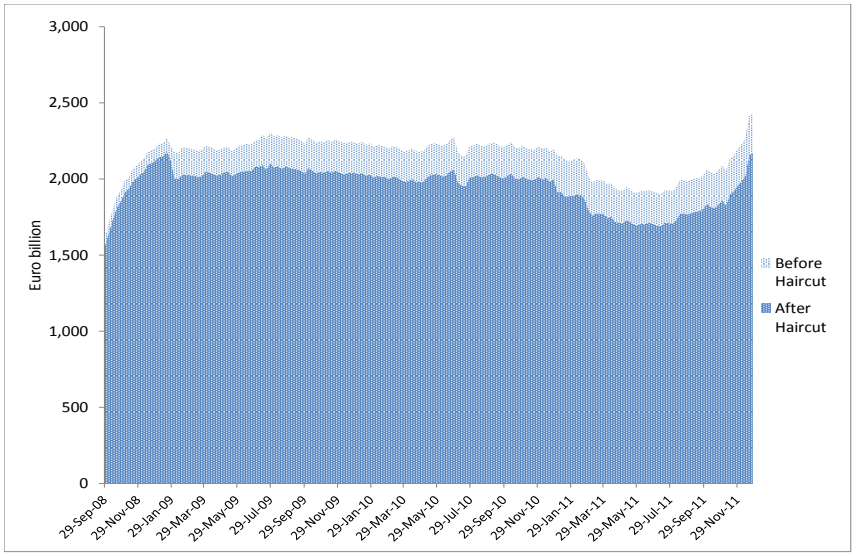


(B) Fraction of Banks that Borrow

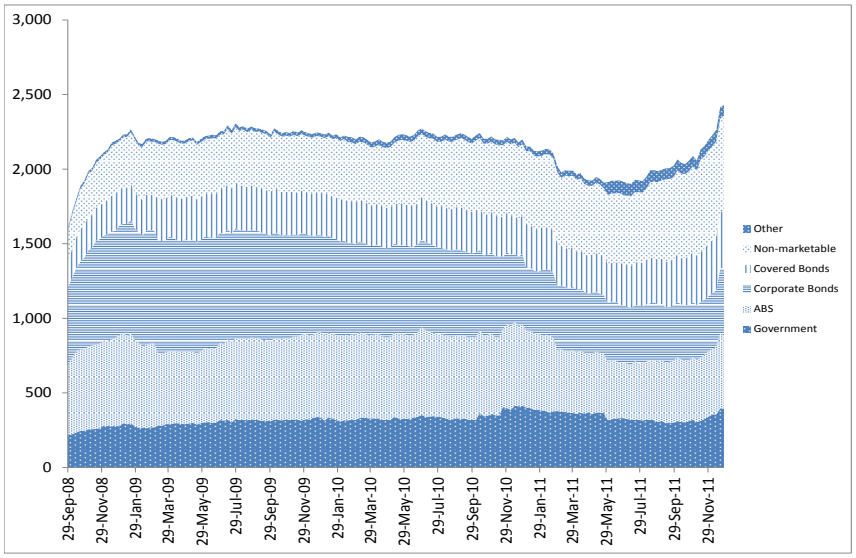


Panel A of Figure 3 plots the time series of borrowing from the ECB under long-term refinancing operations (LTRO) and main refinancing operations (MRO) in € billion. Panel B shows the time series of the fraction of banks which borrow from the ECB.

Figure 4: (A) Total Collateral

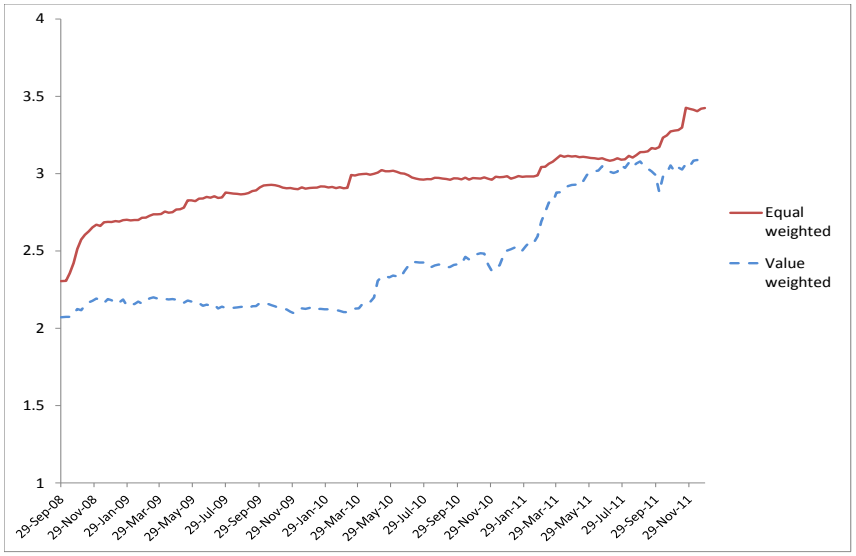


(B) Collateral by Type

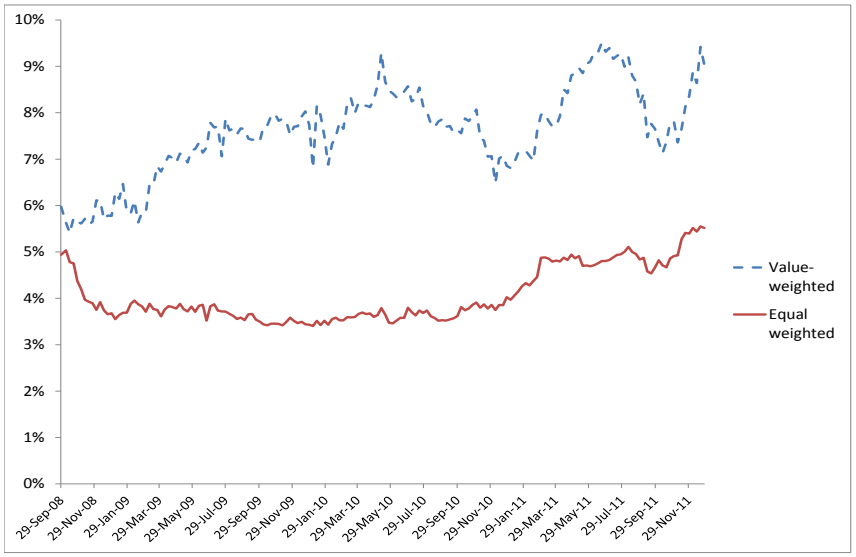


Panel A of Figure 4 plots the time series of total collateral pledged to the ECB before and after ECB haircuts in € billion. Panel B shows the time series of total collateral pledged broken down by the type of asset in € billion.

Figure 5: (A) Average Collateral Rating



(B) Periphery 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 periphery 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: Borrowing Relative to Collateral

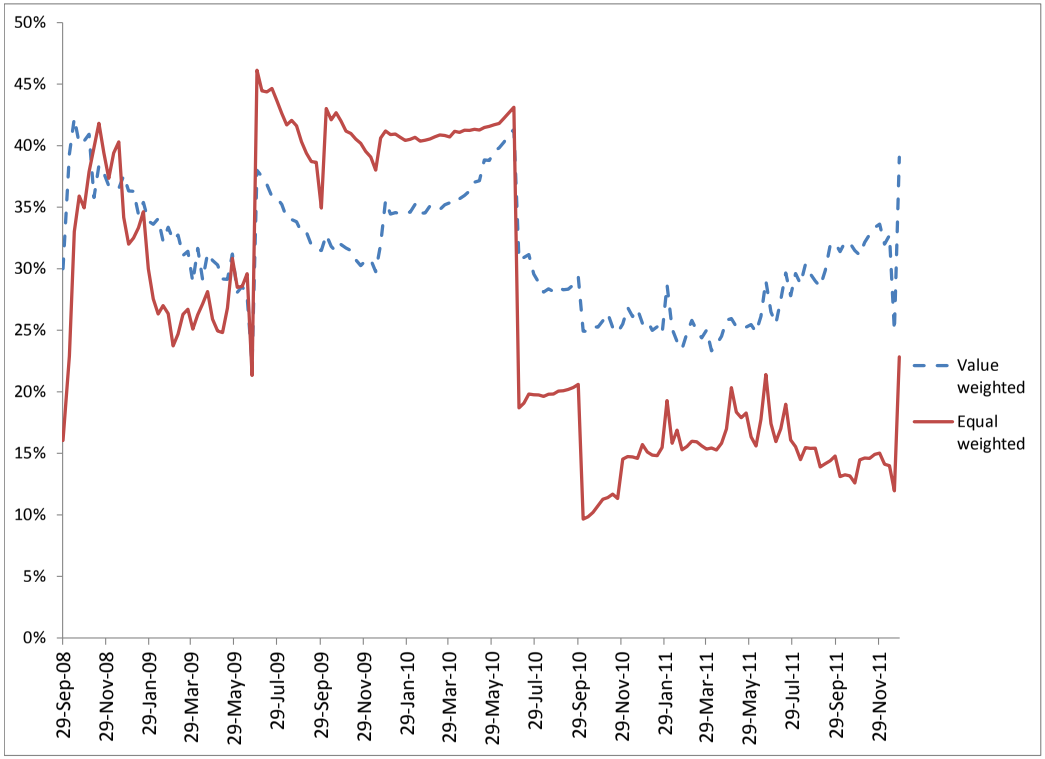


Figure 6 plots the time series of borrowing relative to total collateral. The figure plots both the equal-weighted average (solid line) and the value-weighted average (dashed line).

Table 1: Summary Statistics of European Banks

This table provides weekly summary statistics for European Banks from January 2009 to December 2011. *Panel A* includes all listed banks (76 banks). *Panel B* includes all banks with credit ratings (358 banks). *Panel C* includes all banks that borrow at least once from the ECB from January 2009 to December 2011 (1,826 banks). The variable definitions and data sources are listed in the Appendix.

	Panel A: Listed Banks (N=76)					
	All (N=11,307)		Borrowing >0 (N=7,898)		Borrowing =0 (N=3,409)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
	(1)	(2)	(3)	(4)	(5)	(6)
Bank Characteristics						
Total Assets (Euro bil)	402.1	549.4	418.4	567.5	350.6	484.2
Book Equity (Euro bil)	19.9	26.3	20.8	26.8	17.1	24.2
Market Equity (Euro bil)	12.1	20.1	19.2	20.4	13.7	22.1
Book Leverage	19.0	8.3	19.0	8.8	18.9	6.9
Market Leverage	43.4	55.5	45.8	60.2	37.7	42.0
CDS	239.4	296.1	278.5	335.7	133.6	67.5
Bank Rating	6.2	2.5	6.4	2.7	5.4	1.6
Loan Share	58.1%	15.4%	58.8%	15.1%	56.1%	15.9%
Deposit Share	50.4%	14.1%	51.0%	13.8%	48.6%	14.8%
Equity/Assets	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Periphery Bank	45.9%	49.8%	53.8%	49.9%	27.7%	44.8%
Central Bank Borrowing						
Any borrowing (Yes=1)	69.9%	45.9%	100.0%	0.0%	0.0%	0.0%
Total Borrowing (Euro bil)	4.1	6.7	5.9	7.4		
Borrowing/Book Equity	70.9%	137.7%	93.4%	151.2%		
Borrowing/Collateral	35.7%	34.9%	50.1%	31.4%		
MRO-Borrowing/Collateral	7.7%	16.6%	10.8%	18.8%		
LTRO-Borrowing/Collateral	28.0%	30.1%	39.3%	28.7%		
Collateral						
No collateral (Yes=1)	2.0%	14.0%	0.0%	0.0%	6.6%	24.8%
Collateral Pledged (Euro bil)	12.7	17.2	15.3	18.3	6.6	12.2
Collateral/Book Equity	130.5%	159.5%	152.1%	171.4%	62.4%	83.1%
Haircut	8.9%	6.8%	9.4%	6.8%	7.6%	6.8%
Rated share (%)	67.8%	28.7%	66.0%	27.3%	72.2%	31.3%
Average Rating	2.9	2.1	3.2	2.3	2.2	1.1
Share rated AA or higher (%)	68.2%	32.0%	63.5%	33.8%	80.5%	22.3%
Periphery Sovereign Debt	22.1%	27.7%	24.1%	26.4%	16.5%	30.4%

Panel B: Bankscope Sample (N=358 banks)						
	All (N=55,848)		Borrowing >0 (N=31,612)		Borrowing =0 (N=24,236)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
	(1)	(2)	(3)	(4)	(5)	(6)
Bank Characteristics						
Total Assets (Euro bil)	92.9	274.9	124.6	323.9	51.5	185.1
Book Equity (Euro bil)	4.4	13.3	5.9	15.5	2.5	9.2
Bank Rating	5.7	2.2	6.1	2.4	5.1	1.8
Loan Share	57.4%	17.1%	57.7%	17.2%	56.9%	17.0%
Deposit Share	68.7%	23.3%	65.8%	22.5%	72.4%	23.7%
Equity/Assets	6.1%	3.3%	6.0%	3.5%	6.3%	3.0%
Periphery Bank	17.6%	38.1%	25.0%	43.3%	7.9%	27.0%
Central Bank Borrowing						
Any borrowing (Yes=1)	56.6%	49.6%	100.0%	0.0%	0.0%	0.0%
Total Borrowing (Euro bil)	1.5	5.5	2.7	7.1		
Borrowing/Book Equity	72.9%	353.5%	128.7%	462.2%		
Borrowing/Collateral	49.8%	28.8%	49.8%	28.8%		
LTRO-Borrowing/Collateral	6.2%	16.8%	10.2%	20.6%		
MRO-Borrowing/Collateral	24.0%	29.5%	39.6%	28.7%		
Collateral						
No collateral (Yes=1)	6.5%	24.6%	0.0%	0.0%	14.9%	35.6%
Collateral Pledged (Euro bil)	4.6	11.8	6.8	14.5	1.9	5.5
Collateral/Book Equity	177.7%	493.3%	233.8%	631.8%	104.4%	175.3%
Haircut	8.1%	5.9%	8.5%	6.0%	7.5%	5.5%
Rated share (%)	81.2%	24.3%	80.7%	23.5%	82.1%	25.5%
Average Rating	2.7	1.5	2.8	1.6	2.6	1.2
Share rated AA or higher (%)	66.1%	29.7%	65.0%	29.3%	67.7%	30.2%
Periphery Sovereign Debt	7.5%	18.9%	10.1%	20.8%	3.5%	14.7%

Panel C: Full Sample (N=1,826 banks)						
	All (N=289,694)		Borrowing >0 (N=115,560)		Borrowing =0 (N=173,114)	
	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
	(1)	(2)	(3)	(4)	(5)	(6)
Bank Characteristics						
Periphery Bank	10.3%	30.4%	13.3%	33.9%	8.3%	27.6%
Central Bank Borrowing						
Any borrowing (Yes=1)	40.2%	49.0%	100.0%	0.0%	0.0%	0.0%
Total Borrowing (Euro bil)	0.3	2.5	0.8	3.9		
Borrowing/Collateral	54.0%	27.1%	54.0%	27.1%		
LTRO-Borrowing/Collateral	4.8%	15.9%	9.8%	21.5%		
MRO-Borrowing/Collateral	21.8%	30.4%	44.2%	29.7%		
Collateral						
No collateral (Yes=1)	18.7%	39.0%	0.0%	0.0%	31.3%	46.4%
Collateral Pledged (Euro bil)	1.1	5.6	2.0	8.2	0.4	2.6
Rated share (%)	84.4%	25.6%	84.1%	24.2%	84.6%	26.8%
Average Rating	3.0	1.5	3.1	1.5	2.9	1.5
Share rated AA or higher (%)	58.2%	34.6%	56.1%	32.3%	60.3%	36.6%
Periphery Sovereign Debt	5.1%	18.4%	6.5%	19.8%	3.8%	16.8%

Table 2: Borrowing and Collateral Risk

This table examines the correlation between central bank borrowing and the change in collateral riskiness in the period from January 2009 to December 2011. The unit of observation is a bank-week. In Panel A the proxy for collateral riskiness is the average collateral credit rating. We construct this measure by assigning numerical values to each rating (AAA=1, AA+=2, AA=3, etc.) and compute the value-weighted average rating of collateral per bank-week. In Panel B the proxy for collateral risk is the share of periphery sovereign debt out of total collateral. *Borrowing/Collateral* is the ratio of borrowing relative to total collateral. All columns include week fixed effects and a control for the lagged level of collateral rating or periphery sovereign debt share, respectively. Columns (1) to (3) cover the year 2009 and Columns (4) to (6) cover the years 2010 and 2011. Columns (1) and (4) use the full sample, (2) and (5) use the Bankscope sample, and (3) and (6) use the sample of listed banks. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

Panel A: Ratings						
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating					
Period	2009			2010 & 2011		
Sample	All	Bankscope	Listed	All	Bankscope	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_{it}$	0.080	-0.100	1.498*	1.199***	2.494***	4.758***
	(0.129)	(0.308)	(0.771)	(0.130)	(0.312)	(0.689)
Time Fixed Effects	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Observations	75,174	16,909	3,493	148,961	34,048	6,992
R2	0.009	0.011	0.018	0.022	0.02	0.042
Panel B: Periphery Sovereign Debt						
Dependent Variable	$\Delta_{t+1,i}$ Share Periphery Sovereign Debt					
Period	2009			2010 & 2011		
Sample	All	Bankscope	Listed	All	Bankscope	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_{it}$	0.007	0.024	0.092	0.077***	0.167***	0.206**
	(0.008)	(0.022)	(0.095)	(0.012)	(0.034)	(0.089)
Time Fixed Effects	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Observations	76,687	16,743	3,567	152,310	33,736	7,041
R2	0.003	0.006	0.023	0.004	0.01	0.024

Table 3: Periphery Sovereign Debt Pledged and Periphery 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. *Periphery Sovereign Debt Pledged$_{it}$/Assets$_{i,08}$* and *Periphery Sovereign Debt Holdings$_{it}$/Assets$_{i,08}$* are collateral pledged and holdings of periphery sovereign debt divided by banks assets as of December 2008, respectively. *Borrowing/Collateral* is the ratio of total borrowing relative to collateral. *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	Periphery Sovereign Debt Holdings$_{it}$/Assets$_{i,08}$						$\Delta_{t+1,i}$ Periphery Sovereign Debt Holdings$_{it}$/Assets$_{i,08}$			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Periphery Sovereign Debt Pledged$_t$/Assets$_{i,08}$	1.191***	1.201***								
	(0.247)	(0.246)								
Borrowing/Collateral$_{it}$			4.097***	4.174***						
			(0.905)	(0.771)						
Bank Rating$_{it}$					0.275*	0.286*				
					(0.153)	(0.160)				
$\Delta_{t+1,i}$ Periphery Sovereign Debt Pledged$_t$/Assets$_{i,08}$							0.538***	0.537***		
							(0.174)	(0.193)		
$\Delta_{t+1,i}$ Borrowing$_t$/Collateral$_{it}$									0.594*	0.714*
									(0.315)	(0.414)
Time Fixed Effects	N	Y	N	Y	N	Y	N	Y	N	Y
Obs	162	162	162	162	156	156	108	108	108	108
Banks	54	54	54	54	52	52	54	54	54	54
R2	0.241	0.246	0.249	0.252	0.052	0.057	0.109	0.171	0.051	0.062

Table 4: Borrowing and Collateral Risk (after country-week fixed effects)

This table examines the correlation between central bank borrowing and the change in collateral riskiness in the period from January 2009 to December 2011. We replicate Table 2 and include country-time fixed effects (a full set of time fixed effects for each country). All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

Panel A: All Banks						
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating					
Period	2009			2010 & 2011		
Sample	All	BS	Listed	All	BS	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_{it}$	0.125	-0.03	1.197	0.375***	0.904***	1.355
	(0.133)	(0.321)	(1.216)	(0.100)	(0.250)	(0.949)
Country-Time FE	Y	Y	Y	Y	Y	Y
Obs	75,165	16,909	3,492	148,946	34,045	6,987
R2	0.033	0.088	0.206	0.094	0.173	0.335
Panel B: Periphery Sovereign Debt						
Dependent Variable	$\Delta_{t+1,i}$ Share Periphery Sovereign Debt					
Period	2009			2010 & 2011		
Sample	All	BS	Listed	All	BS	Listed
	(7)	(8)	(9)	(10)	(11)	(12)
Borrowing/Collateral$_{it}$	0	-0.005	-0.033	0.024***	0.066**	0.082
	(0.007)	(0.020)	(0.107)	(0.009)	(0.028)	(0.119)
Country-Time FE	Y	Y	Y	Y	Y	Y
Obs	76,687	16,743	3,567	152,310	33,736	7,041
R2	0.052	0.117	0.213	0.073	0.139	0.225

Table 5: Bank Risk and Collateral Risk

This table examines the correlation between bank risk and the change in collateral riskiness in the period from January 2009 to December 2011. The unit of observation is a bank-week. In Panel A the proxy for collateral riskiness is the average collateral credit rating. We construct this measure by assigning numerical values to each rating (AAA=1, AA+=2, AA=3, etc.) and compute the value-weighted average rating of collateral per bank-week. In Panel B the proxy for collateral risk is the share of periphery sovereign debt out of total collateral. *Bank Risk* is the bank's credit rating (AAA=1, AA+=2, AA=3, etc.). All columns include week fixed effects and a control for the lagged level of collateral rating or periphery sovereign debt share, respectively. Columns (1) to (2) cover the year 2009 and Columns (3) to (4) cover the years 2010 and 2011. Columns (1) and (3) use the Bankscope sample, and (2) and (4) use the sample of listed banks. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

Panel A: Rating				
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating			
Period	2009		2010 & 2011	
Sample	Bankscope	Listed	Bankscope	Listed
	(1)	(2)	(3)	(4)
Bank Rating$_{it}$	0.020	0.370*	0.341***	0.729***
	(0.052)	(0.217)	(0.046)	(0.105)
Time Fixed Effects	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Observations	13,161	2,975	32,061	5,926
R2	0.007	0.022	0.019	0.043
Panel B: Periphery Sovereign Debt				
Dependent Variable	$\Delta_{t+1,i}$ Periphery Sovereign Debt			
Period	2009		2010 & 2011	
Sample	Bankscope	Listed	Bankscope	Listed
	(1)	(2)	(3)	(4)
Bank Rating$_{it}$	0.006	-0.001	0.016***	0.012
	(0.005)	(0.026)	(0.005)	(0.015)
Time Fixed Effects	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Observations	12,995	2,927	31,752	5,842
R2	0.007	0.026	0.01	0.03

Table 6: Bank Risk and Collateral Risk (after controls)

This table examines the correlation between bank risk and the change in collateral riskiness in the period from January 2009 to December 2011. We replicate Table 5 and add controls for asset size and deposit share. We measure asset size as the natural logarithm of total banks assets and deposit share as the ratio of deposits to total bank assets. We restrict the estimation to the samples for which bank characteristics are available. Columns (1) and (3) use the Bankscope sample, and (2) and (4) use the sample of listed banks. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

Panel A: Rating				
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating			
Period	2009		2010 & 2011	
Sample	Bankscope	Listed	Bankscope	Listed
	(1)	(2)	(3)	(4)
Bank Rating$_{it}$	-0.061	-0.095	0.347***	1.058***
	(0.047)	(0.169)	(0.046)	(0.105)
Log(Assets) $_{it}$	-0.018	-0.023	0.105	0.025
	(0.051)	(0.153)	(0.064)	(0.199)
Depositshare$_{it}$	0.377	1.771	0.797	0.764
	(0.553)	(1.951)	(0.529)	(1.910)
Time Fixed Effects	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Observations	12,907	2,923	20,129	5,579
R2	0.007	0.022	0.020	0.49
Panel B: Periphery Sovereign Debt				
Dependent Variable	$\Delta_{t+1,i}$ Periphery Sovereign Debt			
Period	2009		2010 & 2011	
Sample	Bankscope	Listed	Bankscope	Listed
	(1)	(2)	(3)	(4)
Bank Rating$_{it}$	0.013	0.024	0.014*	0.016
	(0.009)	(0.049)	(0.007)	(0.028)
Log(Assets) $_{it}$	0.019**	0.015	0.015**	-0.060**
	(0.008)	(0.033)	(0.008)	(0.026)
Depositshare$_{it}$	0.065	0.151	-0.042	0.335
	(0.073)	(0373)	(0.072)	(0.290)
Time Fixed Effects	Y	Y	Y	Y
Controls	Y	Y	Y	Y
Observations	12,642	2,871	31,752	5,842
R2	0.007	0.024	0.01	0.03

Table 7: Borrowing and Collateral Risk (outside Periphery)

This table examines the correlation between central bank borrowing and the change in collateral riskiness in the period from January 2009 to December 2011. We replicate Table 2 for the sample of banks headquartered outside periphery countries. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

Panel A: Rating						
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating					
Period	2009			2010 & 2011		
Sample	All	Bankscope	Listed	All	Bankscope	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_{it}$	0.116	-0.230	1.525	0.433***	1.041***	2.542*
	(0.134)	(0.334)	(1.215)	(0.107)	(0.273)	(1.329)
Time Fixed Effects	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Observations	68,847	13,937	1,866	135,752	28,064	3,693
R2	0.011	0.015	0.04	0.025	0.018	0.048
Panel B: Periphery Sovereign Debt						
Dependent Variable	$\Delta_{t+1,i}$ Share Periphery Sovereign Debt					
Period	2009			2010 & 2011		
Sample	All	Bankscope	Listed	All	Bankscope	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_{it}$	-0.004	-0.005	-0.008	0.010*	0.054***	0.266***
	(0.004)	(0.017)	(0.105)	(0.006)	(0.021)	(0.088)
	11					
Time Fixed Effects	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Observations	70,317	13,887	1,940	138,452	27,780	3,765
R2	0.004	0.009	0.035	0.004	0.008	0.029

Table 8: Borrowing and Collateral Risk (outside Periphery and country-week fixed effects)

This table examines the correlation between central bank borrowing and the change in collateral riskiness in the period from January 2009 to December 2011. We replicate Table 2 for the sample of banks headquartered outside periphery countries and include country-time fixed effects (a full set of time fixed effects for each country). All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

Panel A: Collateral						
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating					
Period	2009			2010 & 2011		
Sample	All	BS	Listed	All	BS	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_{it}$	0.182	-0.095	1.612	0.334***	0.655***	1.231
	(0.137)	(0.336)	(1.589)	(0.098)	(0.219)	(1.122)
Country-Time FE	Y	Y	Y	Y	Y	Y
Obs	68,838	13,937	1,865	135,745	28,064	3,688
R2	0.032	0.094	0.304	0.06	0.129	0.346
Panel B: Non-Periphery Banks						
Dependent Variable	$\Delta_{t+1,i}$ Share Periphery Sovereign Debt$_{it}$					
Period	2009			2010 & 2011		
Sample	All	BS	Listed	All	BS	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_{it}$	0	-0.012	0.114	0.009*	0.036**	0.350**
	(0.004)	(0.016)	(0.118)	(0.005)	(0.016)	(0.133)
Country-Time FE	Y	Y	Y	Y	Y	Y
Obs	70,317	13,887	1,940	138,452	27,780	3,765
R2	0.055	0.14	0.278	0.09	0.161	0.295

Table 9: Correlation between Borrowing and Risk-Taking (Alternative Measures of Borrowing)

This table estimates the same regressions as in Tables 2 and 7 but uses alternative proxies for borrowing. *Borrowing/Equity*$_t$ is the ratio of central bank borrowing to bank equity (as of December 2008) and *Anyborrowing*$_t$ is an indicator variable whether a bank borrows from the Central Bank. The sample is the Bankscope sample. All columns include week fixed effects and a control for the level of Collateral Rating. Columns (1), (2), (5) and (6) cover the year 2009 and Columns (3), (4), (7) and (8) cover the years 2010 and 2011. *Panel A* includes banks headquartered in European countries and *Panel B* includes banks headquartered in non-periphery European countries. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

Panel A: All Banks								
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating				$\Delta_{t+1,i}$ Share Periphery Sovereign Debt			
Period	2009		2010 & 2011		2009		2010 & 2011	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Borrowing/Equity$_{i,08}$	-0.018		0.348***		-0.009*		0.019***	
	(0.035)		(0.104)		(0.005)		(0.006)	
Anyborrowing$_{it}$		-0.355		1.036***		0.015		0.073***
		(0.216)		(0.153)		(0.017)		(0.015)
Observations	16,909	16,909	34,045	34,045	16,743	16,743	33,736	33,736
R2	0.011	0.011	0.017	0.017	0.006	0.006	0.01	0.01
Panel B: Non-Periphery Banks								
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating				$\Delta_{t+1,i}$ Share Periphery Sovereign Debt			
Period	2009		2010 & 2011		2009		2010 & 2011	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Borrowing/Equity$_t$	-0.035		0.126**		-0.007		0.011***	
	(0.035)		(0.052)		(0.005)		(0.003)	
Anyborrowing$_t$		-0.369*		0.354***		0.014		0.023**
		(0.199)		(0.127)		(0.011)		(0.011)
Observations	13,937	13,937	28,064	28,064	13,887	13,887	27,780	27,780
R2	0.015	0.015	0.018	0.018	0.009	0.009	0.008	0.008

Table 10: Borrowing and Risk Taking (Quarterly Frequency)

This table examines the correlation between central bank borrowing and the change in collateral riskiness in the period from January 2009 to December 2011. We replicate the regressions from Tables 2 and 7. The only difference to Tables 2 and 7 is that the regressions are estimated at the quarterly level instead of the weekly level. The samples and variables are the same as in Tables 2 and 7. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

Panel A: All Banks												
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating						$\Delta_{t+1,i}$ Share Periphery Sovereign Debt					
Period	2009			2010 & 2011			2009			2010 & 2011		
Sample	All	BS	Listed	All	BS	Listed	All	BS	Listed	All	BS	Listed
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Borrowing/Collateral$_{it}$	-2.043	-7.746*	7.985	16.263***	38.663***	75.413***	0.068	0.396	0.575	0.936***	2.440***	4.223***
	(2.119)	(4.439)	(10.080)	(2.271)	(5.285)	(10.624)	(0.145)	(0.432)	(1.372)	(0.192)	(0.487)	(1.235)
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Obs	5,650	1,291	265	9,125	1,891	248	5,769	1,276	271	10,229	2,273	474
R2	0.037	0.034	0.024	0.016	0.021	0.101	0.035	0.028	0.038	0.031	0.074	0.103
Panel B: Non-Periphery Banks												
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating						$\Delta_{t+1,i}$ Share Periphery Sovereign Debt					
Period	2009			2010 & 2011			2009			2010 & 2011		
Sample	All	BS	Listed	All	BS	Listed	All	BS	Listed	All	BS	Listed
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Borrowing/Collateral$_{it}$	-0.170	-7.301	22.52	7.111***	18.594***	44.641**	-0.095	0.048	0.314	0.274**	1.057***	4.282**
	(2.210)	(4.801)	(16.315)	(2.063)	(5.165)	(21.911)	(0.078)	(0.239)	(1.268)	(0.114)	(0.369)	(1.796)
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Obs	5,168	1,063	141	9,125	1,891	248	5,290	1,058	147	9,324	1,871	253
R2	0.038	0.033	0.063	0.016	0.021	0.101	0.055	0.064	0.08	0.03	0.041	0.073

Table 11: Correlation between Borrowing and Active Risk-Taking (Newly Pledged Collateral)

This table examines the correlation between central bank borrowing and the change in collateral riskiness in the period from January 2009 to December 2011. The unit of observation is a bank-week. The proxy for risk-taking is the variable *Newly Pledged Collateral Rating*. We construct *Newly Pledged Collateral Rating* by computing the value-weighted rating of newly pledged securities (i.e., ISIN codes that were not pledged by the same bank in the previous week). By construction, we restrict the sample to observations with new ISIN codes. "*Borrowing/Collateral*" is the ratio of total borrowing relative to collateral. All columns include week fixed effects and a control for the lagged level of Collateral Rating$_t$. Columns (1) to (3) cover the year 2009 and Columns (4) to (6) cover the years 2010 and 2011. Columns (1) and (4) use the full sample, (2) and (5) use the Bankscope sample, and (3) and (6) use the sample of listed banks. *Panel A* includes banks headquartered in European countries and *Panel B* includes banks headquartered in Non-periphery European countries. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

Panel A: All Banks						
Dependent Variable	Newly Pledged Collateral Rating$_{it}$					
Period	2009			2010 & 2011		
Sample	All	Bankscope	Listed	All	Bankscope	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_{it}$	33.845**	47.493*	93.968*	51.181***	83.912***	111.360***
	(13.525)	(25.676)	(53.072)	(11.566)	(17.549)	(22.906)
Time Fixed Effects	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Observations	8,269	3,820	1,452	12,930	6,906	2,886
R2	0.317	0.209	0.206	0.316	0.282	0.376
Panel B: Non-Periphery Banks						
Dependent Variable	Newly Pledged Collateral Rating					
Period	2009			2010 & 2011		
Sample	All	Bankscope	Listed	All	Bankscope	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_{v}$	21.249	39.997	89.612	33.996**	85.654***	146.148***
	(13.484)	(25.996)	(55.556)	(16.193)	(20.973)	(24.487)
Time Fixed Effects	Y	Y	Y	Y	Y	Y
Controls	Y	Y	Y	Y	Y	Y
Observations	6,679	2,854	848	9,459	4,999	1,655
R2	0.32	0.222	0.18	0.283	0.238	0.31

Table 12: Public Information and Risk-Taking

This table examines the correlation between central bank borrowing and the change in collateral riskiness in the period from January 2009 to December 2011. We replicate the regressions from Tables 2 and 7. The only difference is that we add *Bank Rating*$_t$ as an independent variable in some regressions as a proxy for public information. The sample is all banks with a credit rating from at least one rating agency. Columns (1) to (3) and (7) to (9) cover the year 2009 and Columns (4) to (6) and (10) to (11) cover the years 2010 and 2011. *Panel A* includes banks headquartered in European countries and *Panel B* includes banks headquartered in Non-periphery European countries. All regressions are clustered at the bank-level *** significant at 1% level, ** significant at 5% level, and * significant at 10%-level.

Panel A: All Banks												
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating$_{it}$						$\Delta_{t+1,i}$ Share Periphery Sovereign Debt$_{it}$					
Period	2009			2010 & 2011			2009			2010 & 2011		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Borrowing/Collateral$_{it}$	-0.04	0.024		1.984***	2.540***		0.021	0.028		0.160***	0.178***	
	(0.355)	(0.335)		(0.311)	(0.322)		(0.025)	(0.027)		(0.035)	(0.035)	
Bank Rating$_{it}$	0.038		0.036	0.204***		0.321***	0.005		0.006	0.006		0.015***
	(0.053)		(0.051)	(0.040)		(0.044)	(0.004)		(0.005)	(0.005)		(0.005)
Observations	13,797	13,797	13,797	33,452	33,452	33,452	13,631	13,631	13,631	33,143	33,143	33,143
R2	0.007	0.007	0.007	0.021	0.02	0.019	0.007	0.007	0.007	0.011	0.011	0.01
Panel B: Non-Periphery Banks												
Dependent Variable	$\Delta_{t+1,i}$ Collateral Rating$_{it}$						$\Delta_{t+1,i}$ Share Periphery Sovereign Debt$_{it}$					
Period	2009			2010 & 2011			2009			2010 & 2011		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Borrowing/Collateral$_{it}$	-0.038	-0.044		0.734***	0.877***		-0.009	-0.011		0.055**	0.056***	
	(0.375)	(0.361)		(0.277)	(0.275)		(0.019)	(0.021)		(0.023)	(0.021)	
Bank Rating$_{it}$	-0.004		-0.005	0.070*		0.102***	-0.002		-0.002	0.000		0.003
	(0.050)		(0.048)	(0.038)		(0.038)	(0.004)		(0.004)	(0.003)		(0.003)
Observations	10,907	10,907	10,907	27,292	27,292	27,292	10,857	10,857	10,857	27,008	27,008	27,008
R2	0.009	0.009	0.009	0.019	0.019	0.019	0.01	0.01	0.01	0.009	0.009	0.009

Appendix

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
Equity Return$_{t+1,t}$	Weekly equity return	Datastream
$\Delta_{t+1,i}$ Log(CDS)	Weekly log change in CDS	Datastream
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		
No 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
Periphery Sovereign debt	Sovereign Debt issued by Periphery Countries (Greece, Ireland, Italy, Spain, Portugal)	ECB
$\Delta_{t+1,i}$ Collateral Rating	Weekly change in average rating of collateral	ECB
$\Delta_{t+1,i}$ Share Periphery Sovereign Debt	Weekly change in Periphery sovereign debt	ECB