Who Borrows From the Lender of Last Resort?

Evidence from the European Financial Crisis*

Itamar Drechsler
NYU-Stern

Thomas Drechsel
ECB

David Marques-Ibanez
ECB

Philipp Schnabl
NYU-Stern, CEPR, and NBER

September 2012

Abstract

We ask a central question of the theory of Lender of Last Resort (LOLR): *to what extent is LOLR lending taken up by banks that are insolvent rather than illiquid?* We address this question using a proprietary dataset containing all bank-level borrowing and collateral information from the European Central Bank, specified down to the security level, for the period from January 2007 to December 2011. We differentiate between insolvent and illiquid banks by analyzing the dynamics of their borrowing and collateral choices. Insolvent institutions have strong incentives to borrow intensively from the LOLR and accumulate risky collateral, whereas illiquid banks aim to reduce borrowing and improve collateral quality. We therefore test for correlations between LOLR borrowing and future increases in collateral risk. We find strong, robust results that point to the presence of insolvent borrowing beginning in January 2010. We further find that LOLR borrowing information cannot be substituted for by public information on credit ratings, and that it predicts future equity and CDS prices.

*The views expressed herein are those of the authors and do not necessarily represent the position of the European Central Bank or the Eurosystem. We thank seminar participants at the Federal Reserve Board and the New York Federal Reserve for helpful comments and suggestions. All errors are our own. Corresponding authors: Philipp Schnabl (schnabl@stern.nyu.edu) and Itamar Drechsler (itamar.drechsler@stern.nyu.edu).

1 Introduction

Since the creation of central banks, one of their most important functions has been to contain financial crises. Their main instrument for doing so is by acting as a Lender of Last Resort (LOLR) to financial institutions when private market funding is unavailable. The motivation behind such central bank intervention is that in times of crisis private market participants may withdraw lending from a broad swath of financial institutions, including many that are inherently solvent. This sudden withdrawal of funding is potentially very damaging to the 'real' economy since it creates a 'credit crunch' and leads to fire sales by banks and corporations.

Going back to at least Bagehot (1873), the theory of LOLR has recommended that the central bank alleviate a financial crisis by lending to illiquid, but inherently solvent, banks. A bank is considered illiquid (but solvent) if giving it access to LOLR financing, and thereby allowing it to avoid significant fire sales, implies that the expected payoff from its assets will exceed the face value of its debt. As a result, if such a bank is given access to LOLR funding, then its equityholders' incentives are aligned with maximizing firm value since they are able to avoid value-destroying fire sales. In contrast, a bank is considered insolvent if the expected payoff from its assets would fall short of the face value of its debt *even if the bank could avoid significant fire sales* (through LOLR assistance). As a result, the equityholders of an insolvent bank have strong incentives to use LOLR financing to increase risk, especially by buying (and overpaying) for assets whose payoffs are correlated with their survival.

Knowing the extent to which illiquid and insolvent banks borrow from the LOLR is paramount to understanding the impact of a LOLR intervention. Providing funding to illiquid but solvent institutions can be hugely welfare improving. The theory posits that LOLR funding serves as bridge financing, buying time for illiquid banks to change the composition of their assets and liabilities while avoiding fire sales and a resulting credit crunch. In stark contrast, providing LOLR funding to insolvent banks can be greatly welfare destroying. Due to their distorted incentives, insolvent banks want to maintain high levels of risky-asset ex-

posure and to avoid liquidating their non-performing assets (i.e., "zombie lending"), rather than funding the most profitable investments. Providing them with LOLR funding diverts resources towards inefficient uses and can distort asset prices. Hence, LOLR interventions may exacerbate financial crises if a significant part of them is taken up by insolvent banks.

LOLR theory has long recognized that it is difficult (perhaps even impossible) for the LOLR to accurately tell apart illiquid and insolvent institutions when they come to borrow. Banks have better information about their assets than the LOLR and this information asymmetry between banks and outsiders is perhaps the main reason why private investors are unwilling to lend in the first place. Moreover, even if the LOLR could tell illiquid and insolvent banks apart, he may not have the time or expertise to carry out this determination in the midst of a financial crisis.

In this paper we thus ask whether it is *at all* possible to distinguish between illiquid or insolvent banks. A key insight of our analysis is that while it may not be possible to determine whether banks are illiquid or insolvent when they come to borrow from the LOLR, it should be possible to do so *after* they borrow. A LOLR should be able to make this determination for the same reason that it is important to make the distinction in the first place: insolvent banks borrow from the LOLR to finance assets whose payoffs are correlated with their survival, while illiquid banks need temporary bridge financing for illiquid assets to avoid fire sales. LOLR lending to illiquid banks is therefore inherently temporary, while LOLR lending to insolvent banks is indefinite.

This intuition leads us to examine the *dynamics* of banks borrowing and collateral choices and to propose a simple empirical test for the presence of insolvent banks. Illiquid banks borrow to avoid temporary fire sales, and therefore their borrowing should decline, and their collateral quality should improve, as liquidity shocks dissipate. Hence, if all LOLR borrowing is coming from illiquid banks, we should find no correlation–or a negative correlation–between current borrowing and future increases in collateral risk. In contrast, insolvent institutions have an incentive to borrow from the LOLR to finance risky collateral. Rather than rebalance over time towards safer collateral and reduce LOLR dependence, insolvent banks maintain

or even increase the risk of their collateral. If all LOLR borrowing is coming from insolvent banks, we should find a positive correlation between current borrowing and future increases in collateral risk. Hence, we can use the dynamics of borrowing and collateral to test for the presence of insolvent banks among LOLR borrowers.

We implement our empirical test using a proprietary dataset which covers the universe of financial institutions that borrow from the European Central Bank (ECB) in the period from January 2007 to December 2011. It contains weekly bank-level data on central bank lending and information on collateral pledged with the central bank at the level of specific securities. We match these data to information on bank characteristics, including total assets, equity, bank lending, equity returns, and credit default swap (CDS) prices. These data allow us to provide a complete picture of central bank lending over the analysis period.

Our empirical test requires measures of bank borrowing and collateral risk. We measure bank borrowing as the ratio of a bank's LOLR borrowing to its pledged collateral. This ratio is a good measure of how aggressively a bank is utilizing its total capacity for LOLR borrowing, since banks tend to pledge most of their eligible collateral to ensure access to ECB lending at short notice.

We measure collateral risk using proxies for the quality of a bank's pledged collateral. This is the right thing to look at since the LOLR intervention consists of accepting illiquid collateral from counterparties at below-market (i.e., subsidized) haircuts. Hence, banks use (or abuse) the LOLR facility by adjusting their portfolio of collateralized assets. Our first risk-taking measure is the value-weighted average credit rating of a bank's collateral. We use this measure because credit ratings are widely used to evaluate collateral quality. Our second measure is the proportion of a bank's pledged collateral due to sovereign debt originated in the Periphery countries (Greece, Ireland, Italy, Portugal, and Spain). We use this measure because buying high-yielding sovereign debt originated in Periphery countries was a well-known way for banks to increase exposure to risky assets during this time period.

Our results show a strong and robust positive correlation between current borrowing and future increases in collateral risk, starting in January 2010 and continuing until the end of

our analysis period in December 2011. Importantly, we run our tests in a number of different subsamples: (i) the universe of all banks, (ii) the set of banks present in Bankscope, for which we have detailed accounting information, and (iii) the set of banks that are publicly traded. Moreover, we also present results of all of our tests using only banks headquartered outside of Periphery countries. We find that our results are strongly robust across the different subsamples and, in particular, that they hold for the set of banks outside the Periphery countries. These findings shows that the results hold across different types of banks and that they are not driven solely by banks in Periphery countries. Hence, our empirical test indicates that insolvent banks were present among LOLR borrowers starting in January 2010.

We conduct a number of robustness tests of our main results. First, we show that our results are robust to restricting the estimation to newly pledged collateral. This finding suggests that increases in collateral risk represent active decision by banks. Second, we find that our results are robust to controlling for country-specific time fixed-effects. This means only comparing banks within the *same* country. This finding shows that variation in insolvency across banks cannot simply be explained by cross-country differences. Third, we estimate our main test using two alternative borrowing measures. The first measure is the ratio of total borrowing relative to bank equity. The second measure is an indicator variable for whether a bank borrows from the LOLR at all. We find that our main results are robust to these alternative borrowing measures. Fourth, we show that our test is robust to using quarterly data instead of weekly data. Fifth, we confirm that that the changes in collateral risk are consistent with changes in holdings risk based on European bank stress data.

We then examine whether LOLR borrowing contains information beyond that captured in public information. We proxy for public information with banks' credit ratings, as they are available for a large set of banks. First, we do find that by themselves credit ratings, like the LOLR borrowing information, predict future increases in collateral riskiness. However, the borrowing information continues to have strongly significant predictive power even after controlling for credit rating. These results suggest that, consistent with the assumption of

the LOLR theory, the central bank (or investors) cannot simply use credit ratings, or public information more generally, to precisely differentiate between illiquid and insolvent banks at the onset of a crisis.

Assuming that borrowing information is predictive of insolvency and that this information eventually becomes known, we would also expect that borrowing information is predictive of future asset prices. Indeed, we find that more borrowing predicts a future decline in stock prices and a future increase in CDS prices. These results are robust to controlling for bank-specific betas on general bank risk. Overall, these findings suggest that the LOLR has proprietary information not available to private market participants that can be used to differentiate between insolvent and illiquid banks.

The remainder of the paper is organized as follows. Section 2 discusses the data and presents an overview of bank borrowing from the ECB. Section 3 describes our empirical test. Section 4 presents the test results. Section 5 concludes.

2 Setting and Data

2.1 Setting

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).[1].

The ECB engages in lending to a large number of financial institutions. These institutions

[1]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.*

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.[2] 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 EUR 10 billion have access to ECB lending. Depending on the country, many banks with assets of less than EUR 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 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.[3]

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

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

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

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.[4]

2.2 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.

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

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

agencies. In our analysis, we use the median asset rating if more than one rating is available.

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 at least EUR 10 billion in assets. 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.[5]

Panel A of Figure 1 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 EUR 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 EUR billion. Total borrowing peaked at EUR 900 billion prior to the expiration of the one-year LTRO in June 2010. After July 2010, total borrowing dropped by 300 billion and declined gradually thereafter. Starting in June 2011, this trend reversed and ECB borrowing increased again. The last observation in 2011 indicates the take-up of the first round of three-year LTRO offered at the end of December 2011. The net increase in borrowing due to the first round of three-year LTRO was about 300 EUR billion.

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

[5]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.

30%.

2.3 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 EUR billion, average book equity is 19.9 EUR billion, and average market equity is 12.1 EUR 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.[6]

About 70% of banks borrow from the ECB in a given week. Conditional on borrowing, banks on average borrow 4.1 EUR 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 EUR 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.

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

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 EUR 418 billion and EUR 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, EUR 15.3 billion on average, relative to EUR 6.6 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 3 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 holdings are concentrated in

large banks.

3 Testing for Insolvency

3.1 Methodology

A large literature in economics has recognized that equilibrium models of adverse selection predict that an agent's actions can reveal his risk-taking incentives. This insight has been used extensively in empirical work on insurance markets to test for the presence of asymmetric information. This work relies on the idea that asymmetric information is present if there is a positive correlation between insurance coverage and the experience of the insured risk. For example, Chiappori and Salanie (2000) test for asymmetric information in the car insurance market by testing for a positive correlation between the level of insurance and the likelihood of an accident. Finkelstein and Poterba (2008) test for asymmetric information by testing for a positive correlation between the purchase of life annuities and the length of life.

In this paper, we use a similar test to examine whether insolvent banks borrow from the LOLR. As the theory of LOLR has long recognized, central banks cannot accurately discriminate between illiquid and insolvent borrowers when they first come to borrow. The main reason is that banks know more about their assets than the LOLR, which makes it almost impossible to distinguish between illiquid and insolvent banks. Moreover, a LOLR usually does not have the time (or expertise) to thoroughly analyze bank balance sheets in the midst of a financial crisis. The LOLR thus faces a situation of asymmetric information in which borrowers have better information about their risk-taking behavior than the lender.

The main idea of our test is that the LOLR can use information on the *dynamics* of borrowers' borrowing and collateral composition to distinguish between illiquid and insolvent banks. LOLR lending is made available following a large negative asset price shock that gives rise to widespread illiquidity and perhaps also insolvency. The LOLR lending is intended as bridge financing that allows borrowers to rebalance their assets after the shock while

minimizing fire sales. This means reducing the now (following the shock) too high holdings of low-quality, risky and illiquid assets, allowing the bank to transition back to private-market borrowing while reducing its reliance on the LOLR. LOLR lending provides the financing a bank needs to hold onto assets while carrying this process out. While the process may go on for a while, it is expected to culminate within a reasonable time frame, at which point the LOLR will end its intervention.

We can represent this idea with a simple statistical model to explain the test design and demonstrate a setup under which we can test for insolvency. We start with the benchmark case of pure illiquidity among banks. This will help us to understand the borrowing and collateral dynamics in the absence of insolvent banks. We will later introduce insolvent banks into this framework and examine how the presence of insolvent banks changes the dynamics of borrowing and collateral.

Let l_t^j denote the level of illiquidity of bank j's assets at time t. It evolves as follows,

$$l_{t+1}^j = \rho l_t^j + \epsilon_{t+1}^j \qquad (\rho < 1). \tag{1}$$

where ϵ_{t+1}^j represents a mean-zero error term that is uncorrelated with illiquidity at time t. The assumption of $\rho < 1$ means that the level of illiquidity dissipates over time (i.e., reverts to zero), though potentially slowly (if ρ is close to 1). This occurs as banks rebalance their portfolios to reduce illiquid assets and as overall liquidity conditions improve and the pressure for fire sales decreases (in part due to banks' actions). In other words, $\rho < 1$ captures the idea that illiquidity is a temporary phenomenon (as should be the need for LOLR intervention).[7]

Let b_t^j represent total borrowing from the LOLR. We assume the bank's demand for borrowing from the LOLR is driven by its degree of illiquidty (inability to attain private-

[7]If we assume $\rho = 1$, then this implies that liquidity shocks never dissipate. In this case, there is no meaningful distinction between illiquidity and insolvency because there is no distinction between temporary fire sale discounts (illiquidity) and a permanent decline in bank asset values (insolvency). In this case, it is neither possible nor conceptually meaningful to distinguish between illiquidity and insolvency.

market funding for its assets). To reflect this let borrowing be given by

$$b_t^j = l_t^j + v_t^j \tag{2}$$

where v_t^j represents noise (including measurement error) that is uncorrelated with illiquidity. Let y_t^j represent the risk of the collateral portfolio of bank j at time t. As in the empirics, we follow the convention of having higher numbers denote higher risk (lower credit ratings). We further assume y_t^j is also related to a bank's illiquidty. Since a shock that increases collateral risk is likely to make the bank less liquid, we allow that a higher l_t^j is associated with a higher y_t^j (i.e. higher collateral risk). Hence, we have

$$y_t^j = kl_t^j + u_t^j \qquad (k_l \geq 0) \tag{3}$$

where u_t^j represents noise (including measurement error) that is uncorrelated with illiquidity or v_t^j. This implies that the change in y_t^j from t to $t+1$, denoted Δy_t^j, is given by

$$\Delta y_t^j = k(\rho - 1)l_t^j + k\epsilon_{t+1}^j + u_{t+1}^j - u_t^j.$$

Now we can see how insolvency impacts the coefficient β_b from a regression of Δy_t^j on b_t^j. To see this consider the covariance between Δy_t^j and b_t^j,

$$\text{cov}(\Delta y_t^j, b_t^j) = k(\rho - 1)\text{var}(l_t^j) \leq 0. \tag{4}$$

In words, high borrowing predicts a future decline in collateral risk (i.e., the covariance is negative). The intuition for this result is that banks want to borrow to smooth temporary liquidity shocks. Hence, if an illiquid bank takes a large loan from the LOLR and pledges low-quality collateral, then it must be that the bank suffered a large liquidity shock. Given the assumption that liquidity shocks are temporary and dissipate over time, it must be that large borrowing predicts a future decline in collateral risk. We summarize this finding as our first result:

Result 1: If borrowing is due to pure illiquidity, then higher borrowing predicts a bigger future improvement in collateral quality.

Next, we introduce insolvent banks. Since insolvent borrowers seek to maintain or increase risk, then relative to illiquid borrowers they should both (a) borrow more intensively, and (b) have more persistent holdings of risky collateral or even increasingly risky collateral. More formally, we assume that I^j is the state of insolvency of bank j at time t. We can think of it as either an indicator variable or continuously-valued. For simplicity. let I^j be constant for bank j. Also for simplicity, assume that I^j and l_t^j are orthogonal.[8]

Now assume that bank j's demand for borrowing from the LOLR, b_t^j, is driven by both its degree of illiquidty (inability to attain private-market funding for its assets) and, if it is insolvent, by the desire to use LOLR financing to increase risk. To reflect borrowing in the presence of insolvent bank let borrowing b_t^j be given by

$$b_t^j = I^j + l_t^j + v_t^j. \tag{5}$$

Next, assume that banks need time to adjust their portfolio risk to the desired level after the liquidity shock. This may be because risk-taking occurs through rolling over of non-performing assets ("zombie lending"), which is inherently staggered over time, or because banks need time to purchase risky assets due to price impact or regulatory scrutiny. Thus, we expect that changes in risk taking occur gradually such that collateral risk evolves as follows:

$$\Delta y_t^j = cI^j + k(\rho - 1)l_t^j + k\epsilon_{t+1}^j + u_{t+1}^j - u_t^j \tag{6}$$

where $c > 0$.

Now we can see how insolvency impacts the coefficient β_b from a regression of Δy_t^j on b_t^j.

[8]It is more intuitive perhaps to assume that they are positively correlated and we can do so without problem. However, this represents a built-in bias against the null hypothesis of pure illiquidity, since it implies that where there is illiquidty there is also likely to be insolvency. Hence, we treat these as orthogonal bank characteristics.

To see this consider the covariance between Δy_t^j and x_t^j,

$$\text{cov}(\Delta y_t^j, b_t^j) = c\,\text{var}(I^j) + k(\rho - 1)\text{var}(l_t^j). \tag{7}$$

The second term on the right hand side is the same as in equation (4) and represents the collateral-risk dynamics of illiquid banks. This term is weakly negative. The first term on the right hand side is new and represents the collateral-risk dynamics due to insolvency. This term is strictly positive. Hence, a positive β_b coefficient unambiguously points to the presence of insolvent banks among LOLR borrowers. In other words, if we observe a positive coefficient we can reject the null hypothesis of pure illiquidity. We summarize this finding as our second result:

Result 2: A positive correlation between borrowing and future changes in collateral risk is only possible in the presence of insolvency.

Note, however, that even if there is insolvency it is possible to find a zero or negative coefficient, since there are two forces at work. To give the test more power, we can run a bivariate regression for Δy_t^j that controls (at least partly) for the level of illiquidity l_t^j by including as a second regressor the lagged value of y_t^j, and then testing for a positive coefficient on b_t^j.

3.2 Implementation

In this section, we describe the implementation of the positive correlation test for the presence of insolvent financial institutions in LOLR borrowing. The implementation requires us to choose empirical proxies for bank borrowing b_t^j and collateral risk y_t^j. We discuss the choice of each variable in detail.

We use two separate measures for collateral risk. First, we use the average rating of collateral pledged by bank i at time t. Our dataset provides us with ratings of up to three ratings agencies. We assign the median rating if there is more than one rating. We create a

numerical value and assign '1' for AAA, '2' for $AA+$, and so on. We compute rating as the value-weighted mean of collateral ratings for each bank i at time t. Hence, a higher value for our ratings measure means greater collateral risk. Second, we use sovereign debt originated in Periphery countries (Greece, Italy, Ireland, Portugal, Spain) as a share of total collateral. 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 this time period.

Figure 3 plots both risk measures in the period from September 2008 to December 2011. As shown in Panel A, the average rating across all banks of collateral pledged with the ECB is relatively stable throughout the analysis period. It is only at the end of the sample that the aggregate average collateral quality starts to decrease. The decrease is probably related to the first round of the three-year LTRO in December 2011. As shown in Panel B, the average share of Periphery assets and Periphery sovereign debt is relatively stable throughout the analysis period, with a share of about 9% and 4%, respectively.

We measure bank borrowing as the ratio of a bank's LOLR borrowing to its pledged collateral. This ratio is a good measure of how aggressively a bank is utilizing its total capacity for LOLR borrowing since banks tend to pledge most of their eligible collateral to ensure access to ECB lending at short notice. As discussed below, our results are robust to using alternative borrowing measures such as borrowing relative to bank size and an indicator variable for whether a bank borrows from the ECB.

Figure 4 plots borrowing relative to collateral pledged in the period from September 2008 to December 2011. The value-weighted measure is the ratio of total ECB borrowing relative to total collateral pledged with the ECB. The equally-weighted measure is the average for the full sample conditional on positive borrowing. The borrowing intensity is relatively stable throughout the analysis period with the exception of a marked increase during the one-year LTRO from July 2009 to July 2010 and during the first-round of three-year LTRO at the end of December 2011.

Figure 5 provides a non-parametric analysis of the relationship between borrowing and

risk-taking. We use the Bankscope sample and group banks into five quintiles based on their borrowing intensity. To ensure that our results are not driven by banks changing across groups, we fix the grouping based on borrowing intensity in the middle of our analysis period (July 2010). The results are qualitatively similar if we resort quintiles every period.

Panel A plots average collateral rating of the highest and lowest borrowing quintile. Average ratings are about 2.5 for both the low and high borrowing quintile in the period from January 2009 to December 2009. Starting January 2010, the average rating of the highest borrowing quintile gradually starts to increase, while the average rating of the lowest quintile remains flat. By the end of the analysis period, the average rating of the highest quintile is about 2 notches higher (i.e., lower quality) than the average rating of the lowest quintile.

Panel B plots the average share of Periphery sovereign debt for the highest and lowest borrowing quintile. As of January 2009, the share of the high borrowing quintile is about 8 percentage points larger than the share of the low borrowing quintile. Importantly, the shares remain flat for both borrowing quintiles from January 2009 to December 2009. Starting in January 2010, the share of the highest borrowing quintile gradually increases, while the share of the lowest borrowing quintile remains steady. By the end of the analysis period, the share of Periphery sovereign debt of highest borrowing quintile is about 15 percentage points higher than the share of the lowest borrowing quintile.

Overall, these results suggest that borrowing predicts an increase in collateral risk starting in January 2010, which is consistent with the presence of insolvent banks among ECB borrowers. To test this relationship more formally, we estimate the following OLS regression:

$$\Delta Risk_{it} = \alpha_i + \delta_t + \beta Borrowing_{it} + \gamma Risk_{it} + \varepsilon_{it} \tag{8}$$

where $Risk_{it}$ is a measure of collateral risk of bank i at time t, $Borrowing_{it}$ is a measure of the borrowing from the central bank by bank i at time t, and α_i and δ_t are bank and time fixed effects. In some robustness regressions, we also add country-time fixed effects to this specification. To account for the correlation of error terms within banks, we cluster standard

errors at the bank level. We note that we add the level of collateral risk $Risk_{it}$ as control variable. As discussed above, we introduce this control to enhance the statistical power of our test by in part capturing the extent of illiquidity at time t. As discussed below, our results are robust to excluding this variable.

We also test for the importance of public information in explaining changes in collateral risk. In this case, we estimate the OLS regression:

$$\Delta Risk_{it} = \alpha_i + \delta_t + \beta Borrowing_{it} + \eta PublicInfo_{it} + \gamma Risk_{it} + \varepsilon_{it} \tag{9}$$

where $PublicInfo_{it}$ is a measure of public information of bank i's credit risk at time t. Again, to account for the correlation of error terms within banks, we cluster standard errors at the bank level.

Finally, we also test whether borrowing is predictive of future equity and CDS prices. We estimate the OLS regression:

$$\Delta Price_{it} = \alpha_i + \delta_t + \beta Borrowing_{it} + \eta_i \Delta IndexRet_t + \varepsilon_{it} \tag{10}$$

where $\Delta Price_{it}$ is bank i's stock return or log change in CDS price from time t to $t+1$ and $IndexRet_t$ is the average of bank stock returns or log changes in CDS price from time t to $t+1$. We note that we allow for bank-specific coefficients η_i to capture different loadings on the bank index return. Again, to account for the correlation of error terms within banks, we cluster standard errors at the bank level.

4 Results

Our results are presented in Tables 2 to 11. For most tables, we present two panels with results. The top panel presents results for all banks headquartered in European countries. The bottom panel presents results for banks headquartered in European countries other than the Periphery. We always present both panels to assess whether the results are qualitatively

robust to the exclusion of banks headquartered in the Periphery.

Within each panel, we generally present separate results for two time periods. The first time period covers the year 2009 and the second time period covers the years 2010 and 2011. This breakdown allow us to assess the evolution of borrowing and risk-taking over time.

For most tables, we present results for three samples: 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 publicly listed banks ("listed bank sample"). The use of three different samples allow us to assess whether the results are robust across different types of banks.

4.1 Borrowing and Collateral Rating

We present our main empirical test of the relationship between LOLR borrowing and risk taking in Table 2. Our proxy for risk-taking is the change in the quality of collateral from week t to week $t+1$. Recall from the summary statistics that we measure collateral quality as the value-weighted average of collateral's credit ratings, where we assign a numerical score to each rating with a AAA rating having a value of 1, AA+ a value of 2, AA a value of 3, and so on.

The proxy for borrowing is total borrowing relative to collateral ("borrowing intensity") of bank i in week t. We choose this measure because it scales borrowing by a bank's borrowing capacity with the ECB. Also, this variable is available for the entire sample independent of whether observations are matched to other datasets. We consider alternative borrowing measures in our robustness analysis.

Panel A presents estimates for all banks headquartered in Europe. The first three columns present estimates for year 2009 and the next three columns provide estimates for the years 2010 and 2011. For each time period, we present estimates for all three sample: the full sample ("All"), the Bankscope sample ("BS"), and the listed bank sample ("Listed").

As shown in Columns (1) to (3), we find no statistically significant correlation between borrowing and collateral quality across samples in 2009. In contrast, in Columns (4) to (6)

we find a positive and statistically significant relationship between borrowing and collateral quality across all samples in the years 2010 and 2011. The estimates are statistically significantly different from the 2009 estimates. For the listed bank sample an increase in borrowing intensity by 50% predicts an increase (i.e., worsening) of average collateral credit rating 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.[9]

These findings suggest that there was little borrowing by insolvent banks in the first year of the financial crisis. However, insolvent banks emerged as significant borrowers in the subsequent years. The correlation is strongest among the listed bank sample. Given that the listed banks are also the largest and economically most important banks, these results suggests that borrowing by insolvent banks was also economically important.

Panel B presents the results for banks headquartered in European countries outside the Periphery. Similar to Panel A, Columns (1) to (3) find no statistically significant correlation between borrowing and collateral in 2009. As shown in Columns (4) to (6), the estimates for 2010 and 2011 are all positive and statistically significant but the magnitudes are smaller than in Panel A. 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. The effect is 0.27 notches in the Bankscope sample and 0.11 notches in the full sample.

These findings suggest that the financial crisis evolved qualitatively similarly across Europe. During the first year, banks borrowed from the ECB primarily for liquidity reasons. In the subsequent two years, insolvent banks started to emerge as significant borrowers from the ECB, in particular in Periphery countries. Overall, the results are consistent with a worsening of the financial crisis starting in 2010 and with a stronger effect in Periphery relative to non-Periphery countries.

[9]We compute these estimates by multiplying the coefficients from Columns (3) to (6) with 0.5 for the change in borrowing intensity and 52 to normalize to a one-year period. The outcome variable is measured in basis points, so that a value of 100 represents one notch.

4.2 Borrowing and Periphery Sovereign Debt

We also implement the correlation test using the change in the share of a bank's collateral in Periphery sovereign debt as our measure of risk taking. We choose this measure because Periphery sovereign debt had been considered to have almost no default risk prior to the financial crisis. Periphery sovereign debt therefore required no capital for regulatory purposes and banks invested in sovereign debt as a buffer against liquidity shocks.

However, as the financial crisis progressed, it became clear that Periphery sovereign debt carried substantial liquidity and credit risks, which made it costly to use them as collateral in private repo markets relative to the ECB. As a result, Periphery sovereign debt emerged as a form of risk-taking among banks. There is substantial anecdotal evidence of such risk taking in the financial press. Hence, even though Periphery sovereign debt does not necessarily measure all of a bank's risk-taking, we can use it as an indicator of a bank's risk-taking. Importantly, this measure is not independent of credit ratings because Periphery sovereign debt was downgraded on several occasions during the financial crisis. However, it is complementary because this measure does not rely on ratings at all. Instead, it is based on differential pricing between private repo markets and the ECB, which creates the a risk-taking opportunity via the LOLR. Moreover, this measure captures active decision by banks because it relies on changes in the share of collateral pledged, which is zero if all banks are passive.

Table 3 reports the results for all banks headquartered in Europe. Columns (1) to (3) of Panel A find no 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 and the estimates are statistically significant different from the 2009 estimates. For the listed bank sample, increasing borrowing relative to collateral by 50% increase the share of Periphery sovereign debt pledged as collateral by 5.4 percentage points over the period of one year. The effect is 4.3 percentage points in the Bankscope sample and 2.0 percentage points in the full sample.

These results on Periphery sovereign debt are qualitatively similar to the ones for collat-

eral ratings. In the first year of the crisis, there is no evidence of insolvent banks across all samples. However, in the subsequent two years, insolvent banks start borrowing significantly. Similar to collateral ratings, the effect is strongest in the listed bank sample, intermediate in the Bankscope sample, and smallest in the full bank sample.

Panel B presents results for banks headquartered in Europe countries other than the Periphery. Similar to Panel A, we find no statistically significant relationship in year 2009 and positive and statistically significant relationships in the years 2010 and 2011. An increase in borrowing intensity by 50% increases the share of Periphery sovereign debt pledged as collateral by 6.9 percentage points over the period of one year. 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 correlation between borrowing and Periphery sovereign debt is not simply driven by banks headquartered in the Periphery. Even among bank outside of the Periphery, we find a strong correlation between borrowing and using Periphery sovereign debt as collateral. This finding suggests that our test does not simply pick up other factors, such as home bias or pressure by local regulators or politicians, which may induce Periphery banks to purchase sovereign debt of their home country. Overall, these results suggest that insolvent banks emerged as borrowers from the LOLR in 2010/11.

4.3 Do Bank Actively Pledge Lower-Quality Collateral?

The results in Tables 2 and 3 document the emergence of insolvent banks borrowers in 2010/11. We next examine whether the results are caused by banks actively pledging lower-quality collateral over time. We note that the results in Table 3 already suggest that banks actively manage their collateral by changing the share of Periphery sovereign debt.[10] To analyze this issue more closely, we next examine average ratings of newly pledged collateral.

[10]Our collateral measures are based on market values. Strictly speaking, changes in the share of sovereign debt can occur as a result of changes in market values rather than active decisions by banks. In theory, this should bias the estimation against finding an effect because the share of Periphery sovereign assets declines as these assets become riskier. Empirically, we find that the result are slightly larger if we use nominal values instead of market values, which is further evidence that changes in Periphery sovereign debt represent active decisions by banks.

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.

Table 4 presents the results. Columns (1) to (3) of Panel A find a positive and marginally statistically significant relationship between borrowing and risk-taking. 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. The 2010/11 estimates are are statistically significant different from the 2009 estimates for the full bank and the Bankscope sample. For the listed bank sample, an increase in borrowing intensity by 50% reduces collateral ratings of newly pledged collateral by 0.47 notches over a one-year period.[11] The effect is 0.17 notches in the Bankscope sample and 0.03 notches in the full sample.

We now turn to the results without Periphery banks. Columns (1) to (3) of Panel B finds 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 actively pledged collateral. Again, the effect is largest for listed banks. An increase in borrowing intensity by 50% reduces collateral ratings of newly pledged collateral 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.

These results suggest that banks actively pledge lower quality collateral as they increase their borrowing. We already find some evidence of such risk-taking in 2009 for the sample including Periphery banks but the results are only marginally statistically significant. In 2010/11, the results become stronger and statistically significant at the 1%-level, consistent with the results in Tables 2 and 3. The economic magnitude of changes in collateral ratings is comparable to estimates in Table 2.

[11]There are 6,992 observations in Column (6) of Panel A, Table 2, and 2,886 observations in Column (6) of Panel A, Table 4. Hence, listed banks pledge new collateral about 41% of bank-week observations. On average, new collateral represents 2% of total collateral. Thus, the one-year effect is 52*0.41*0.02*1.1136=0.47 notches).

4.4 Are Results Driven by Cross-Country Differences?

The results in Tables 2 to 4 compare banks across different European countries. We are also interested in knowing to what extent the results are caused by differences in insolvency across banks within the same country. We therefore estimate the regressions in Tables 2 and 3 adding a full set of week dummies for *each* country. The country-week fixed effects control for any country-specific changes that affect banks' risk-taking. We present the test corresponding to Table 2 in Columns (1) to (6) of Table 5 and the test corresponding to Table 3 in Columns (7) to (12) of Table 5.

We find that the estimates in Columns (1) to (6) of Panel A are qualitatively similar to the estimates in Table 2. The main difference is that the full sample estimate in Column (6) is not statistically significant, which may be due to the large number of controls. In terms of magnitudes, the coefficients are about 60% smaller than the ones in Table 2. Next, we find that the estimates in Columns (1) to (6) of Panel B are almost identical to ones in Table 2. The economic magnitude is the same as in Table 2.

The results suggest that our main results are robust to controlling for country-specific time trends. In other words, only comparing banks within the same country, we find the emergence of insolvent banks in 2010/11. For non-Periphery banks, country-specific trends have no effect on the economic magnitude of the estimates. Interestingly, the economic magnitudes in Panel A mostly match Panel B after controlling for country-week fixed effects. This finding suggests that the stronger effects for the full sample observed in Panel A of Table 2 are largely driven by cross-country differences between Periphery and non-Periphery banks.

We find similar results for the Periphery sovereign debt in Columns (7) to (12). The estimates in Panel A are qualitatively similar to the ones in Panel B of Table 3 but quantitatively smaller. The estimates for Panel B are qualitatively and quantitatively similar to the ones in Panel A of Table 2. Again, this evidence suggests that the higher estimates for the full sample in Panel A of Table 2 are caused by cross-country differences between Periphery and non-Periphery banks.

4.5 Do Results Differ by Bank Characteristics?

We examine whether the results differ by bank characteristics. We focus on characteristics that have been used as measures for insolvency: asset size, equity ratio, and retail deposit funding. We focus on years 2010 and 2011 because we find in Table 2 to 5 that insolvent banks emerged as borrowers during this period. Consistent with the earlier results, we find that estimates for 2009 are generally not significant. Moreover, we find in Tables 2 to 5 that our results are consistent across the three samples. For simplicity, we therefore focus on the Bankscope sample. The result for the listed bank sample are qualitatively similar. We do not conduct the analysis for the full bank sample because we only have characteristics for the Bankscope sample.

Panel A reports result for the all banks headquartered in European countries. Columns (1) to (4) reports sample splits by asset size. One may expect to find more insolvency for larger banks because they tend to have too-big-to fail guarantees given that regulators are reluctant to close large banks, even if they are deemed insolvent. Indeed, we find that the estimates are significantly larger for banks with above-median asset size for both average ratings and Periphery sovereign debt. A 50% increase in borrowing intensity increases ratings by 1.01 notches and raises Periphery sovereign debt by 12.9 percentage points over a one-year period for large banks, but only 0.15 notches and 0.1 percentage points, respectively, for small banks. The differences are statistically significant. As shown in Panel B, the results are qualitatively similar for non-Periphery banks. These results show that most of the risk-taking is concentrated among larger banks. This finding suggests that larger banks may either be more affected by insolvency or are more likely to stay in business even if they are insolvent.[12]

Columns (5) to (8) reports sample splits by the book equity ratio. If book equity ratios are a good indicator of bank insolvency, one may expect to find more insolvency among banks with a low book equity ratio. As shown in Panel A, we find that the estimates are almost

[12]These results are also supported by earlier results in Tables 2 and 3, which show that the estimates are larger for samples that include a higher share of large banks.

identical for banks with high and low equity ratios. A 50% increase in borrowing intensity reduces ratings by 0.67 notches and raises Periphery sovereign debt by 6.8 percentage points over a one-year period for high-equity banks and by 0.64 notches and 7.1 percentage points, respectively, for low-equity banks. As shown in Panel B, the estimates are qualitatively smaller for non-Periphery banks. These results suggest book equity ratios are not a good indicator of solvency. This may be because insolvent banks can delay realizing book losses on assets that declined in value. Indeed, there is anecdotal evidence that banks reclassify assets that require market-to-market writedowns. This also suggests that the LOLR cannot use book equity ratios to determine bank insolvency.

Columns (9) to (12) reports sample splits by the share of liabilities financed with retail deposits. Here the idea is that retail deposit financing is more stable than other sources of financing. Under this assumption, banks with a high share of deposit financing are less likely to become insolvent as a result of a negative liquidity shock. As shown in Panel A, we find less insolvency among banks with more deposit financing relative to banks with low deposit financing. A 50% increase in borrowing intensity reduces ratings by 0.30 notches and raises Periphery sovereign debt by 3.4 percentage points over a one-year period for high-deposit banks but only 0.96 notches and 11.5 percentage points, respectively, for low-deposit banks. These result suggests that retail deposit financing is indeed a buffer against insolvency.

Overall, the estimates shows that insolvency had a larger impact on risk-taking for large banks and banks with a low share of deposit-financing. There is no difference in insolvency across banks with different levels of book equity ratios. The observed patterns are similar for Periphery and non-Periphery banks. These result also suggest that regulators might be able to use observable characteristics as proxies for insolvency. We conduct an explicit test of the use of public information as an identifier for insolvency in Table 10.

4.6 Are Results Robust to Alternative Specifications?

4.6.1 Measuring Borrowing

We use borrowing intensity as a proxy for borrowing in Table 2 to 6. This measure has the advantage that it is normalized by a bank's borrowing capacity. It therefore comes closest to the measure of borrowing discussed in the methodology section. Another advantage is that this measure can be computed solely based on ECB data and can be applied to banks that are not matched to other datasets.

However, we want to ensure that our results are robust to using alternative borrowing measures. We therefore compute two other borrowing 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 borrowing intensity because available collateral for LOLR borrowing may differ across banks. The second variable is an indicator variable whether a banks 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.

Table 7 presents the results. We restrict the analysis to the Bankscope sample because we need data on bank characteristics to compute borrowing relative to bank equity. Columns (1) and (2) of Panel A find no statistically significant relationship between borrowing and risk-taking in 2009. In contrast, Columns (3) and (4) of Panel A find a positive and statistically significant correlation between borrowing and risk-taking in 2010 and 2011. The estimate suggests that a one-standard deviation increase in borrowing relative to equity increases collateral ratings by 0.66 notches over a one-year period. Moreover, compared to a non-borrowing bank, a bank that borrows experiences an increase of 0.52 notches in its average collateral rating over a one-year period. As shown in Panel B, the result are qualitatively similar but smaller for non-Periphery banks. Columns (5) to (8) present the estimates for

Periphery sovereign debt. The results are qualitatively similar to the ones in Columns (1) to (4). Overall, these finding suggest that the results in Table 2 and 3 are robust to using alternative borrowing measures.

4.6.2 Estimation Frequency

We estimate all our results in Tables 2 to 6 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 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 averages out measurement error. For robustness, we therefore estimate the main results from Tables 2 and 3 at a quarterly frequency.[13]

We present the results in Table 8. Columns (1) to (6) present the ratings results as in Table 2. Columns (7) to (12) present the Periphery sovereign debt results as in Table 3. The estimates are both quantitatively and qualitatively similar to Tables 2 and 3. As shown in Panel A, the estimates for 2009 are statistically insignificant (Columns (1) to (3) and (7) to (12)) and the ones for 2010/11 are positive and statistically significant (Columns (4) to (6) and (10) to (12)). The difference between the two time periods is statistically significant for all samples. The estimates also imply similar economic magnitudes. For example, in the listed bank sample a 50% increase in borrowing intensity in 2010/11 reduces ratings by 1.51 notches and increase the Periphery sovereign debt share by 8.5 percentage points. This compares to an estimate of 1.23 notches and 5.4 percentage points at the weekly frequency. This result is consistent with downward bias due to measurement error at the weekly frequency. The results for the other samples also have similar signs and comparable magnitudes to the weekly frequency. Overall, these result show that our findings are robust to using a quarterly frequency for estimation.

[13]We also estimated the results at a monthly level. The results are very similar to the ones reported here.

4.6.3 Holdings and Collateral

Our analysis focuses exclusively on collateral pledged with the ECB. The reason is that we are interested in marginal risk-taking because of the LOLR. Such risk-taking only occurs to the extent that banks use LOLR facilities to finance risk taking. If banks engage in risk taking using other sources of financing, then we do not attribute such risk taking to the LOLR.[14]

This does not imply that all risk taking financed with other sources is necessarily optimal. There may be frictions in market financing, for example due to explicit or implicit government subsidies, which allow banks to finance risk too cheaply relative to the first best. However, such risk taking occurs independent of whether the government provides LOLR facilities and should therefore not be included in the estimation of risk-taking due to the LOLR. Hence, our results hold independently of whether banks hold specific assets prior to pledging them with the ECB. From the LOLR perspective, the relevant decision is whether banks use LOLR financing to purchase or hold onto risky assets, not whether they generally hold risky assets.[15]

It is however possible that changes in risk taking due to LOLR financing may affect a bank's total holdings. Even though this is not required for our estimation, it would provide further support for our analysis. The main challenge in conducting this analysis is that banks do not provide detailed information on their holdings. Yet, during the financial crisis, national bank supervisors in Europe conducted bank stress tests for the largest European banks. The first stress test was conducted in March 2010, when the financial crisis was

[14]We are thinking of the counterfactual of *not* providing access to the LOLR to a given bank (or a small set of banks) while continuing to provide LOLR access for all other banks. This counterfactual is the relevant question in practice because LOLRs generally provide liquidity in case of financial crises. A different question is to ask about risk taking if there is no intervention by the LOLR at all. In that case, it is likely that risk taking would increase because illiquid banks would also face strong risk-taking incentives. However, it would be difficult to answer this question empirically because we do not observe a situation without a LOLR in our data. Hence, we would need to make strong structural assumptions on bank behavior to capture general equilibrium effects on asset prices.

[15]We make the simplifying assumption that the LOLR expects no recovery from bank assets other than the collateral pledged. This assumption seems reasonable in our context because banks are highly levered, other creditors usually have priority (e.g., deposit insurance fund), and bank values tend to decrease greatly in bankruptcy.

already well under way. Two subsequent stress tests were conducted in December 2010 and September 2011. As part of the stress tests, regulators published bank-level information on sovereign debt holdings. We use these data to compute total Periphery sovereign debt held by banks. To compare across banks, we scale total holdings of Periphery sovereign debt by bank equity. We then sort banks into quintiles based on CDS prices.[16]

We report the results in Table 9. The first row of Panel A shows equal-weighted and value-weighted holdings for all banks. Consistent with the collateral results, we find that holdings of Periphery sovereign assets are generally increasing in the CDS quintile. This finding shows that banks with higher credit risk hold more Periphery sovereign debt. The first row of Panel B is restricted to non-Periphery banks and finds qualitatively similar results. These results are suggestive that banks adjusted Periphery sovereign debt holdings based on their credit risk. However, given that we cannot observe holdings prior to March 2010, we caution that such differences may have existed even before the start of the financial crisis.

We therefore examine the evolution of Periphery sovereign debt holdings as the financial crisis progressed. As shown in Columns (1) to (3) of Panel A, banks in the lowest three CDS quintiles generally keep or decrease their holdings of Periphery sovereign debt. In contrast, as shown in Column (4) and (5), banks in the highest two quintile increase their holdings. As shown in Panel B, we find a qualitatively similar pattern for non-Periphery banks. Overall, these results suggest that we observe qualitatively similar changes in Periphery sovereign debt holdings as we observe in the collateral data. It is difficult to judge whether these changes are quantitatively similar because we only observe data from three stress tests and the first stress test was conducted well after the start of the financial crisis. Moreover, banks were aware that the results would be published and may have adjusted holdings prior to the reporting dates. Taking these caveats into account, these results provide further evidence that the observed pattern in collateral also reflects underlying pattern in holdings.

[16] We use CDS prices because we cannot use proprietary information due to the small sample size. However, we ensure that CDS prices are positively correlated with borrowing such that it can be interpreted as a proxy for our borrowing measure.

4.7 Does Public Information Fully Capture Risk Taking?

The traditional theory of LOLR assumes that the central bank cannot fully determine which potential borrowers are insolvent and which are illiquid at the onset of a crisis. Were it able to do so, it would lend only to illiquid solvent institutions and force insolvent ones to unwind or recapitalize. It is therefore interesting to use public information on bank's solvency and examine whether these data contain the same information as borrowing.

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 correlation test for our risk-taking measures using both bank credit ratings and borrowing intensity as explanatory variables. We estimate regressions with each variable separately to evaluate the marginal effect of adding public information. Columns (1) to (6) of Table 10 examine the effect on collateral ratings and Columns (7) to (12) of Table 10 examine the effect on Periphery Sovereign Debt.

Columns (1) to (3) of Panel A find no statistically significant relationship between collateral ratings and either borrowing intensity nor credit ratings in 2009. Columns (4) to (6) of Panel A find a positive and statistically significant effect of both borrowing intensity and bank rating on risk-taking. The coefficient on borrowing intensity 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 B present the corresponding regressions for Periphery sovereign assets. Again, there is no statistically significant relationship between risk-taking and either borrowing intensity or credit rating in 2009. In 2010, both variables are individually statistically significant but credit ratings loses significance after including borrowing intensity but borrowing intensity remains statistically significant. Panel B finds qualitatively similar, but quantitatively smaller, effects for Non-Periphery banks.

Overall, these result suggest that borrowing intensity contains independent information on bank insolvency over and above the public information contained in bank ratings. These results suggest that the LOLR has proprietary information in making the determination about insolvency that is not incorporated in public information.[17]

4.8 Does Borrowing Predict Future Asset Prices?

The results on public information suggest that the lender of last resort has some proprietary information that may not be contained in market prices. Assuming that the information eventually becomes known to market participants, we expect that borrowing measures predict future asset prices. We examine this hypothesis by estimating the effect of borrowing at time t on stock returns and changes in CDS prices from time t to $t+1$. We estimate the regressions at the weekly level.

Panel A of Table 11 presents the results for banks headquartered in Europe. Column (1) of Panel A finds no statistically significant relationship between borrowing intensity and equity returns in 2009. Column (2) controls for bank-specific betas on average bank returns and still finds no statistically significant relationship. Columns (3) and (4) show similar results for CDS changes in 2009. In contrast, Column (5) shows that borrowing intensity predicts equity returns in 2010/11. The estimate suggests that a 50% increase in borrowing intensity predicts a subsequent decline in the weekly stock return by 8 basis points. Column (6) shows that the estimate is robust to including bank-specific betas on average bank returns. This result suggests that the difference is not simply driven by differences in loadings on general bank risk. Columns (7) and (8) estimate similar regressions for log changes in CDS prices. The results are similar. A 50% increase in borrowing intensity predicts a subsequent weekly increase in CDS prices by 4.5 basis points. The result is robust to including bank-specific

[17]This result may raise the question 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.

betas on average changes in CDS prices.

Panel B presents the results for non-Periphery banks. As shown in Columns (1) to (4), there is no statistically significant relationship between borrowing intensity and equity returns or change in CDS prices in 2009. Column (5) finds a positive and statistically significant effect in 2010/11. The estimate is slightly smaller than for non-Periphery banks. A 50% increase in borrowing intensity predicts a decrease in weekly stock return by 6.5 basis points. The estimate is robust to allowing different betas on average bank returns. Columns (7) to (8) find a positive, but not statistically significant, relationship between borrowing intensity and changes in CDS prices. Hence, the results for non-Periphery banks are qualitatively similar but quantitatively smaller.

Overall, these results show that borrowing from the ECB predicts future asset prices. This finding suggests that information on bank borrowing is not completely known to market participants and gets priced in sover time.

4.9 Relation to the Literature

This paper relates to the literature on the role of the lender of last resort (LOLR). Most of 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 solve 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.[18].

A large theoretical literature has re-examined the question of whether and how central

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

banks should intervene during times of financial crises. For example, Goodfried and King (1988) argue that in developed economies solvent banks should always be able to obtain funding liquidity given the efficiency of money markets. They suggest that central banks should therefore restrict themselves to regular open market operations. Goodhart (1995) argues that the distinction between illiquidity and insolvency is a myth because banks requiring a lender of last resort 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.

On the empirical side, several authors argue that lenders of last resort have positive effects. For example, Miron (1986), Bordo (1990) and Eichengreen and Portes (1987) examine the effect of creating a lender of last resort in a country and argue 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. 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.

However, other studies point out that lender of last resort 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. Finally, 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 lender of last resort interventions, most of which focus on the financial crises of 2007 to 2011. Cassola, Hortacsu, and Kastl (2009) examines 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) examines 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 seems quantitatively small.

Overall, the differences in views on lender of resort lending can be traced to whether the central bank is dealing with illiquid or insolvent institutions. Proponents of lender of last resort 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 lender of last resort 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 propose and implement a methodology to distinguish between illiquid and insolvent banks in central bank borrowing data.

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. A troubling concern for a LOLR is that it may be impossible to accurately discriminate between illiquid, solvent borrowers, who are fundamentally sound but need temporary financing during the process of deleveraging, and insolvent borrowers, who would like to maintain a high level of leverage and risk taking. The question of who borrows from the LOLR is central to LOLR theory since lending to illiquid borrowers during a crisis is socially beneficial, but lending to insolvent institutions is likely to exacerbate the crisis.

Using data on all borrowing and collateral with the European Central bank during the 2008-2011 European financial crisis, we test for the presence of insolvent borrowers. A key insight of our paper is that, even though it may be impossible to accurately tell apart illiquid and insolvent institutions when they first borrow, we should be able to infer this afterwards from their actions. Insolvent institutions will borrow more aggressively from the central bank and invest more in risky assets. They will avoid or delay deleveraging. In contrast, illiquid banks will rebalance their portfolio towards safer, more liquid assets, using LOLR borrowing to buy the time necessary to do so without incurring fire sales. We therefore test for insolvent borrowing by looking at the correlation between banks' borrowing intensity and futures changes in the riskiness of the collateral they pledge.

We find that increases in borrowing intensity significantly predict future increases in the risk of banks' pledged collateral, strongly suggesting the presence of insolvent banks. The evidence is robust across different measures of borrowing and collateral risk, different subsamples of banks, and different sampling frequencies. It is particularly strong among the largest banks, where we expect our measures of risk taking to be the most relevant and where the economic impact is the largest. We show that our results hold separately for banks headquartered inside and outside the Periphery (Greece, Ireland, Italy, Portugal, and Spain). We further show that banks actively pledge riskier collateral, and that our results cannot be explained solely by cross-country differences.

LOLR theory assumes that the LOLR cannot precisely distinguish insolvent and illiquid borrowers before they borrow. More generally, we test the informativeness of public information for discriminating among these institutions. We use credit ratings, which are available for a large bank sample, and find that they do positively predict future changes in banks' risk taking. This indicates that public information does provide some ability to discriminate between illiquid and insolvent banks. However, we further show that the information in banks' borrowing intensity is *not* subsumed by credit ratings, as there remains a strongly positive relation to future risk taking even after controlling for credit ratings. The predictive power of borrowing information is consistent with the assumed *inability* of the LOLR (or outside investors) to precisely differentiate between illiquid and insolvent banks. Consistent with this evidence, we further find that borrowing information has predictive power for future stock returns and changes in CDS spreads.

References

Armantier, Olivier, Eric Ghysels, Asani Sarkar and Jeffrey Shrader, 2011, "Stigma in Financial Markets: Evidence from Liquidity Auctions and Discount Window Borrowing during the Crisis,"" Federal Reserve Bank of New York Staff Reports, Report 483

Bagehot, Walter, 1873, *Lombard Street: A Description of the Money Market*, London: Henry S. King and Co.

Bernanke, Ben, 1983, "Non-Monetary Effects of the Financial Crisis in the Propagation of the Great Depression," *American Economic Review*, 73, 257-76.

Bordo, M.D., 1990, "The lender of last resort: Alternative views and historical experience," Federal Reserve Bank of Richmond, *Economic Review*, 76(1), 18-29.

Caballero, Ricardo J., Takeo Hoshi and Anil K. Kashyap, 2008, "Zombie Lending and Depressed Restructuring in Japan," *American Economic Review*, 98(5), pages 1943-77.

Cassola, Nuno, Ali Hortacsu, and Jakub Kastl, 2009, "The 2007 Subprime Market Crisis Through the Lens of European Central Bank Auctions for Short-Term Funds," Stanford University Working Paper.

Chiappori, Pierre-Andre and Bernard Salanie, 2000, "Testing for Asymmetric Information in Insurance Markets," *Journal of Political Economy*, 108(1), 56-78.

Diamond, Douglas, and Raghu Rajan, 2005, Liquidity Shortages and Banking Crises, *Journal of Finance*, 60(2), 615-647.

Diamond, Douglas W., and Philip Dybvig, 1983, "Bank Runs, Deposit Insurance and Liquidity," *Journal of Political Economy*, 91, 401-419.

Eichengreen, Barry and Richard Portes, 1987, "The anatomy of financial crises," In: *Threats to international financial stability*, ed. Richard Portes and Alexander Swoboda, Cambridge: Cambridge University Press.

European Central Bank, 2011, "The Implementation of Monetary Policy in the Euro Area," European Central Bank, February.

Farhi, Emmanuel, and Jean Tirole, 2012, "Collective Moral Hazard, Maturity Mismatch and Systemic Bailouts", *American Economic Review*, forthcoming.

Finkelstein, Amy and James Poterba, 2004, "Adverse Selection in Insurance Markets: Policyholder Evidence from the U.K. Annuity Market," *Journal of Political Economy*, 112, 183-208.

Freixas, Xavier and Jean-Charles Rochet, 2008, *Microeconomics of Banking*, 2nd edition, Cambridge, Mass: MIT Press.

Friedman, Milton and Anna J. Schwartz, 1963, *A Monetary History of the United States*, 1867-1960, Princeton University Press.

Goodfried and King, 1988 "Financial deregulation, monetary policy, and central banking," In: *Restructuring banking and financial services in America*, eds. W. Haraf and R. M. Kushmeider, Washington: American Enterprise Institute .

Goodhart Charles, 1998, *The Evolution of Central Banks*, Cambridge, Mass.: MIT Press.

Goodhart Charles, 1995, *The Central Bank and the Financial System*, Cambridge, Mass: MIT Press.

Goodhart Charles and Dirk Schoenmaker, 1995, "Should the functions of monetary policy and banking supervision be separated?," *Oxford Eoconomic Papers*, 47, 539-560

Gorton, Gary and George Pennacchi, 1990, "Financial Intermediaries and liquidity creation," *Journal of Finance*, 45(1), 49-71.

Meltzer, Allan, 1986, "Financial failures and financial policies," *Deregulating Financial Services: Public Policy in Flux*, eds. G. Kaufman and R. Kormendia, Cambridge, Mass.: MIT Press.

Miron, Jeff, 1986, "Financial Panics, the seasonality of the nominal interest rate, and the founding of the Fed," *American Economic Review*, 76(1), 125-140.

Rochet, Jean-Charles and Xavier Vives, 2004, "Coordination Failures and the lender of last resort: Was Bagehot right after all," *Journal of the European Economic Association*, 2(6), 1116-1147.

Shleifer, Andrei, and Robert W. Vishny, 1992, "Liquidation Values and Debt Capacity: A Market Equilibrium Approach," *Journal of Finance*, 47.

Shleifer, Andrei, and Robert W. Vishny, 1997, "The Limits of Arbitrage," *Journal of Finance*, 52, 35-55.

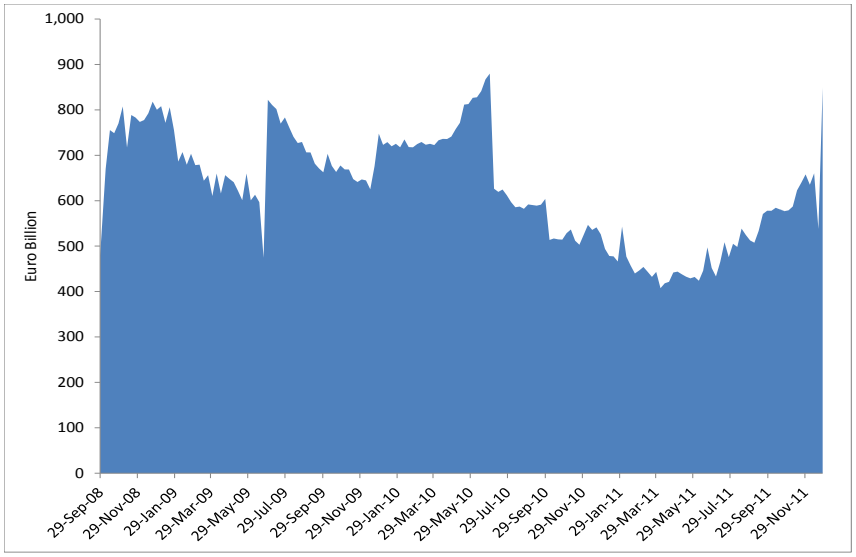
Shleifer, Andrei, and Robert W. Vishny, 2010, "Unstable Banking," *Journal of Financial Economics*, 97, 306318.

Stein, Jeremy, 1988, "Adverse Selection Model of Bank Asset and Liability Management with Implications for the Transmission of Monetary Policy," RAND Journal of Economics, 29, 466-486.

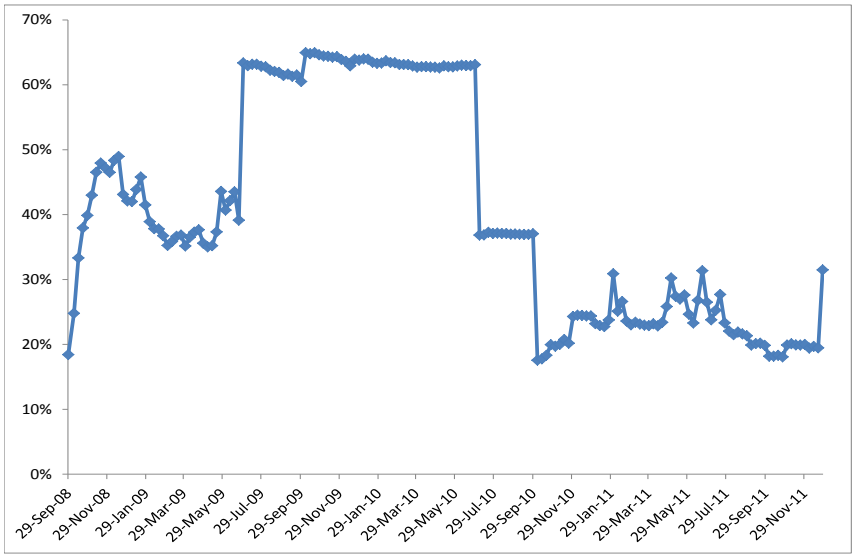
Stein, Jeremy, 2012, "Monetary Policy as Financial-Stability Regulation," Quarterly Journal of Economics, 127(1), 57-95.

Tucker, Paul, "The Repertoire of Official Sector Interventions in the Financial System: Last Resort Lending, Market-Making, and Capital, Remarks at Bank of Japan International Conference, May 27-28, 2009.

Figure 1: (A) Total Borrowing

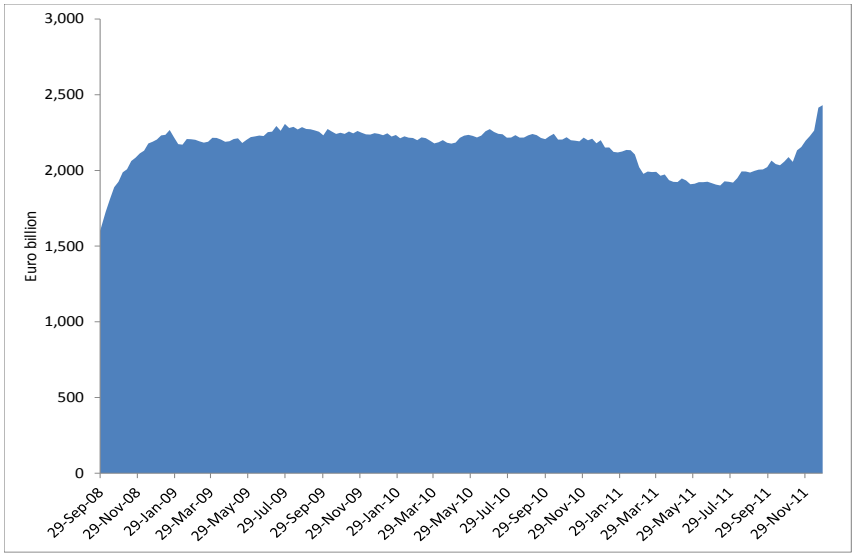


(B) Fraction of Banks that Borrow

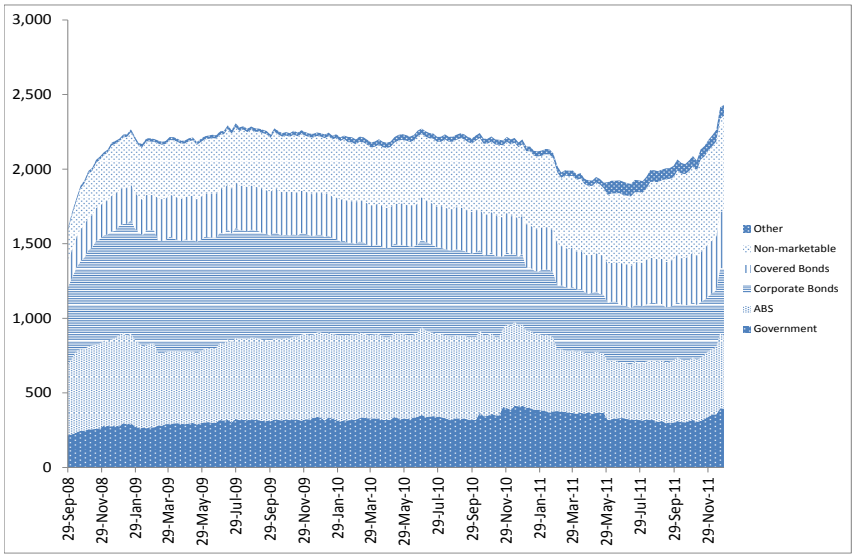


Panel A of Figure 1 plots the time series of total borrowing from the ECB by all banks in EUR billion. Panel B shows the time series of the fraction of banks which borrow from the ECB.

Figure 2: (A) Total Collateral

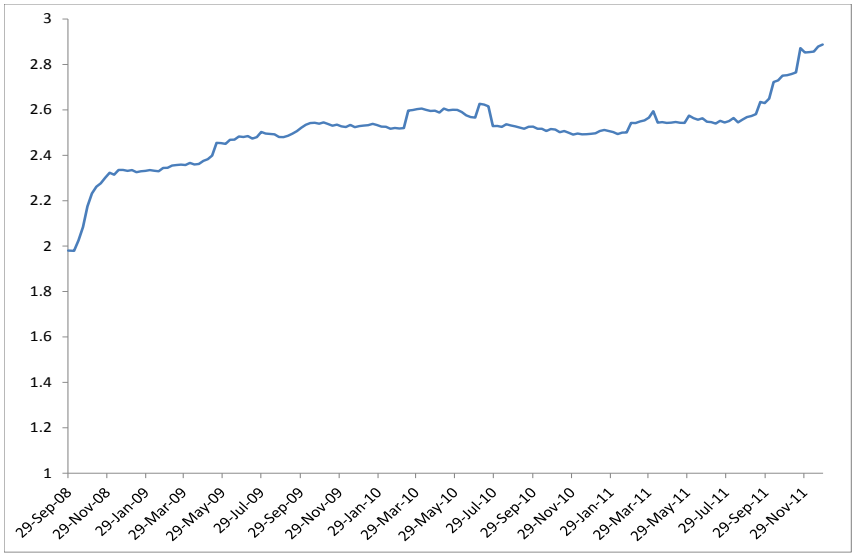


(B) Collateral by Type

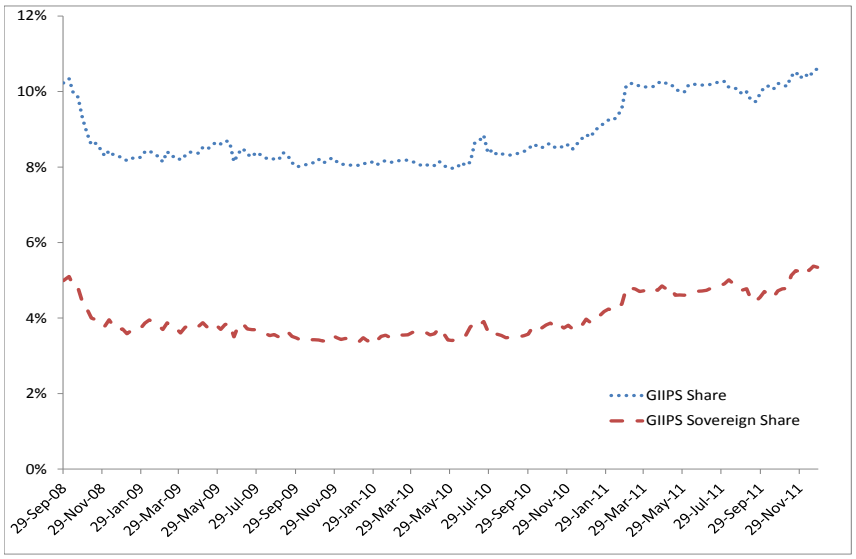


Panel A of Figure 2 plots the time series of total collateral pledged to the ECB in EUR billion. Panel B shows the time series of total collateral pledged broken down by the type of asset.

Figure 3: (A) Average Collateral Rating



(B) Periphery Assets as Share of Collateral



Panel A of Figure 3 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 assets originated in Periphery countries (blue dotted line) and to Periphery sovereign debt (red dashed line).

Figure 4: Borrowing Intensity

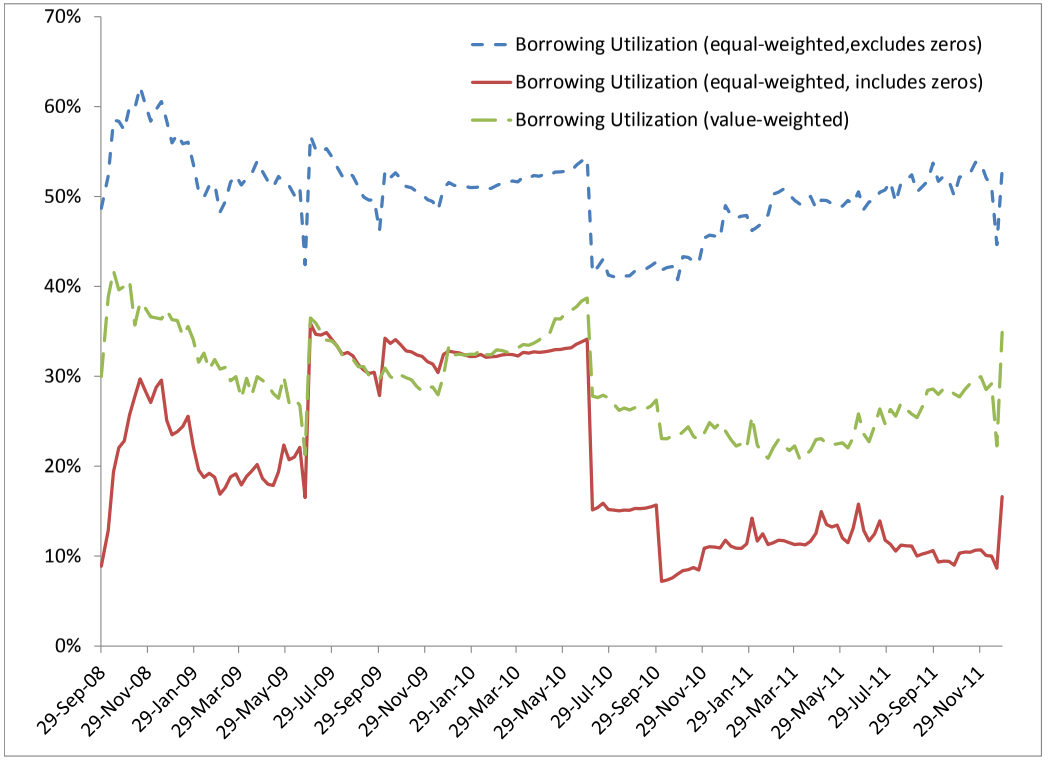
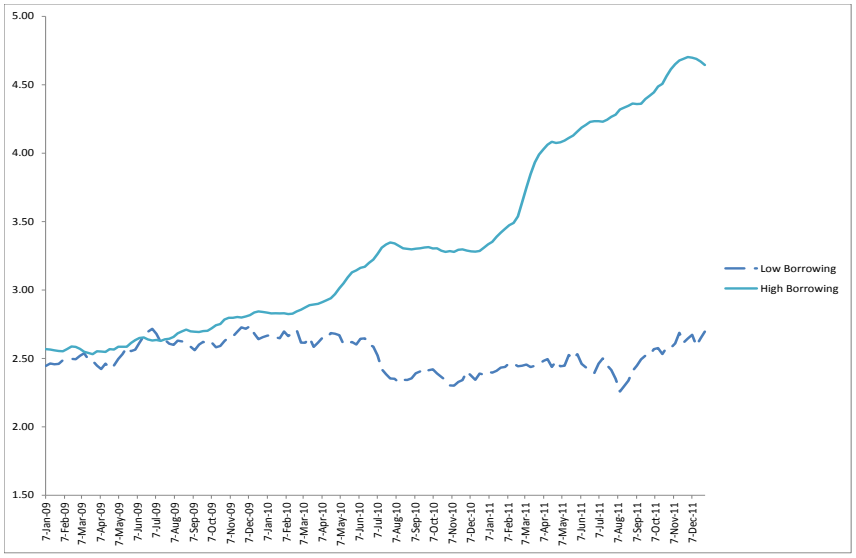
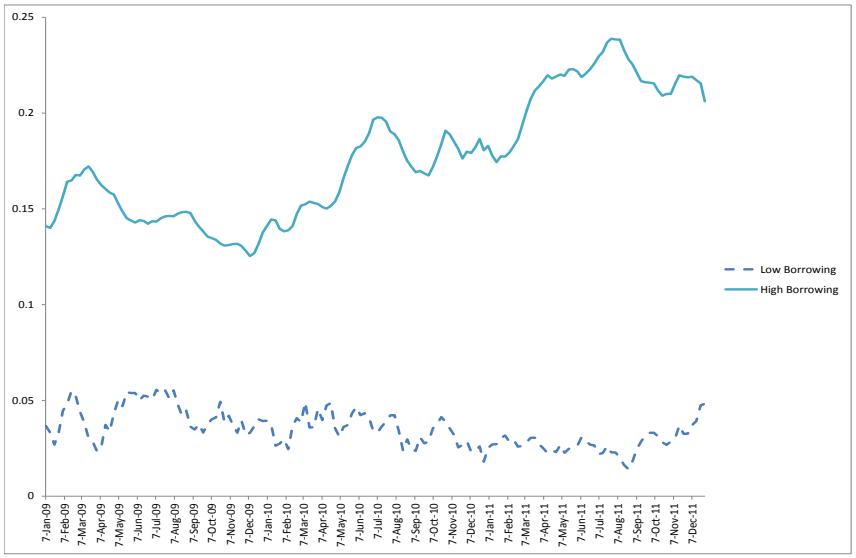


Figure 4 plots the time series of borrowing intensity (total borrowing divided by total collateral) for all banks in the ECB collateral registry. The solid red line shows the equal-weighted average of borrowing capacity utilization for all banks, including zeros for banks that do not borrow. The dashed blue line shows the equal-weighted average of borrowing capacity utilization for all banks that borrow (excluding the non-borrowers). The broken green line gives the value weighted average of borrowing capacity utilization for all banks, which is equivalent to aggregate borrowing divided by aggregate collateral pledged.

Figure 5: (A) Average Rating by Borrowing Quintile



(B) Share of Periphery Sovereign Debt by Borrowing Quintile



Panel A of Figure 5 plots the average collateral credit rating of banks in the highest quintile (dashed line) and banks in the lowest borrowing quintile (dotted line). Panel B plots Periphery sovereign debt as share of total collateral pledged n the highest quintile (dashed line) and banks in the lowest borrowing quintile (dotted line). The borrowing quintiles are based on borrowing intensity as of July 2011.

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: Correlation between Borrowing and Risk-Taking (Ratings)

This table examines the correlation between central bank borrowing and risk taking 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 $\Delta_{t+1,t}$ *Collateral Rating*. We construct $\Delta_{t+1,t}$ *Collateral Rating* by assigning numerical values to each rating (AAA=1, AA+=2, AA=3, etc.) and computing the change in value-weighted ratings of pledged collateral per bank-week. "*Borrowing/Collateral*" is the ratio of total borrowing relative to collateral. All columns include week fixed effects and a control for the 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	$\Delta_{t+1,t}$ Collateral Rating					
Period	2009			2010 & 2011		
Sample	All	Bankscope	Listed	All	Bankscope	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_t$	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: Non-Periphery Banks						
Dependent Variable	$\Delta_{t+1,t}$ Collateral Rating					
Period	2009			2010 & 2011		
Sample	All	Bankscope	Listed	All	Bankscope	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_t$	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

Table 3: Correlation between Borrowing and Risk-Taking (Periphery Sovereign Debt)

This table examines the correlation between central bank borrowing and risk taking 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 $\Delta_{t+1,t}$ *Share Periphery Sovereign Debt*. We construct $\Delta_{t+1,t}$ *Share Periphery Sovereign Debt* by computing the change in the share of Periphery Sovereign Debt pledged as collateral (in percentage points). *Borrowing/Collateral* is the ratio of total borrowing relative to collateral. All columns include week fixed effects and a control for the 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	$\Delta_{t+1,t}$ Share Periphery Sovereign Debt					
Period	2009			2010 & 2011		
Sample	All	Bankscope	Listed	All	Bankscope	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_t$	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
Panel B: Non-Periphery Banks						
Dependent Variable	$\Delta_{t+1,t}$ Share Periphery Sovereign Debt					
Period	2009			2010 & 2011		
Sample	All	Bankscope	Listed	All	Bankscope	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_t$	-0.004	-0.005	-0.008	0.010*	0.054***	0.266***
	(0.004)	(0.017)	(0.105)	(0.006)	(0.021)	(0.088)
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 4: Correlation between Borrowing and Active Risk-Taking (Newly Pledged Collateral)

This table examines the correlation between central bank borrowing and risk taking 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 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					
Period	2009			2010 & 2011		
Sample	All	Bankscope	Listed	All	Bankscope	Listed
	(1)	(2)	(3)	(4)	(5)	(6)
Borrowing/Collateral$_t$	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$_t$	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 5: Within-Country Correlation between Borrowing and Risk-Taking

This table examines the within-country correlation of central bank borrowing and risk taking in the period from January 2009 to December 2011. Columns (1) to (6) replicate Table 2 and Columns (7) to (12) replicate Table 3. The only difference to Table 2 and 3 is that the regressions also include country-time fixed effects. The samples and all other variables are the same as in Tables 2 and 3. 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	$\Delta_{t+1,t}$ Collateral Rating						$\Delta_{t+1,t}$ 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$_t$	0.125	-0.03	1.197	0.375***	0.904***	1.355	0	-0.005	-0.033	0.024***	0.066**	0.082
	(0.133)	(0.321)	(1.216)	(0.100)	(0.250)	(0.949)	(0.007)	(0.020)	(0.107)	(0.009)	(0.028)	(0.119)
Country-Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Obs	75,165	16,909	3,492	148,946	34,045	6,987	76,687	16,743	3,567	152,310	33,736	7,041
R2	0.033	0.088	0.206	0.094	0.173	0.335	0.052	0.117	0.213	0.073	0.139	0.225
Panel B: Non-Periphery Banks												
Dependent Variable	$\Delta_{t+1,t}$ Collateral Rating						$\Delta_{t+1,t}$ 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$_t$	0.182	-0.095	1.612	0.334***	0.655***	1.231	0	-0.012	0.114	0.009*	0.036**	0.350**
	(0.137)	(0.336)	(1.589)	(0.098)	(0.219)	(1.122)	(0.004)	(0.016)	(0.118)	(0.005)	(0.016)	(0.133)
Country-Time FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Obs	68,838	13,937	1,865	135,745	28,064	3,688	70,317	13,887	1,940	138,452	27,780	3,765
R2	0.032	0.094	0.304	0.06	0.129	0.346	0.055	0.14	0.278	0.09	0.161	0.295

Table 6: Correlation between Borrowing and Risk-Taking by Bank Characteristic

This table examines the correlation of central bank borrowing and risk taking in the period from January 2009 to December 2011 by bank characteristics. The unit of observation is a bank-week. We restrict the analysis to the Bankscope sample and the years 2010 & 2011. The variable Δ *Rat* is the variable $\Delta_{t+1,t}$ *Collateral Rating* as defined in Table 2. The variable Δ Sov is the variable $\Delta_{t+1,t}$ *Share Periphery Sovereign Debt* as defined in Table 3. All columns include week fixed effects and a control for the level of Collateral Rating$_t$. For each bank characteristic, we split the sample in observations above and below the median. Column (1) to (4) shows results for asset size, (5) to (8) for the equity ratio and (9) to (12) for the deposit share. *Panel A* includes banks headquartered in European countries and *Panel B* includes banks headquartered in Non-periphery European countries.

Panel A: All Banks												
Period	2010 & 2011				2010 & 2011				2010 & 2011			
Bank Type	Large		Small		Equity High		Equity Low		Deposit High		Deposit Low	
Dependent Variable	Δ Rat	Δ Sov	Δ Rat	Δ Sov	Δ Rat	Δ Sov	Δ Rat	Δ Sov	Δ Rat	Δ Sov	Δ Rat	Δ Sov
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Borrowing/Collateral$_t$	4.026***	0.499***	0.579*	0.004	2.614***	0.263***	2.463***	0.274***	1.173***	0.013*	3.727***	0.444***
	(0.459)	(0.113)	(0.340)	(0.003)	(0.448)	(0.081)	(0.451)	(0.074)	(0.437)	(0.008)	(0.479)	(0.111)
Observations	17,656	17,449	16,389	16,287	17,307	16,814	16,738	16,922	17,070	17,212	16,975	16,524
R2	0.03	0.02	0.04	0.02	0.02	0.02	0.03	0.01	0.04	0.02	0.03	0.02
Panel B: Non-Periphery Banks												
Period	2010 & 2011				2010 & 2011				2010 & 2011			
Bank Type	Large		Small		Equity High		Equity Low		Deposit High		Deposit Low	
Dependent Variable	Δ Rat	Δ Sov	Δ Rat	Δ Sov	Δ Rat	Δ Sov	Δ Rat	Δ Sov	Δ Rat	Δ Sov	Δ Rat	Δ Sov
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Borrowing/Collateral$_t$	2.064***	0.168**	0.484*	0.003	1.086***	0.068	0.958***	0.075*	0.712**	0.009**	1.642***	0.074
	(0.538)	(0.083)	(0.271)	(0.003)	(0.413)	(0.042)	(0.311)	(0.042)	(0.318)	(0.005)	(0.509)	(0.070)
Observations	12,037	11,894	16,027	15,886	13,741	13,265	14,323	14,515	16,903	17,006	11,161	10,774
R2	0.014	0.016	0.042	0.022	0.02	0.011	0.023	0.012	0.044	0.031	0.015	0.017

Table 7: Correlation between Borrowing and Risk-Taking (Alternative Measures of Risk-Taking)

This table estimate the same regressions as in Tables 2 and 3 but use other proxies for borrowing. *Borrowing/Equity*$_t$ is the ratio of central bank borrowing to bank equity 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$_t$. 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	$\Delta_{t+1,t}$ Collateral Rating				$\Delta_{t+1,t}$ Share Periphery Sovereign Debt			
Period	2009		2010 & 2011		2009		2010 & 2011	
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Borrowing/Equity$_t$	-0.018		0.348***		-0.009*		0.019***	
	(0.035)		(0.104)		(0.005)		(0.006)	
Anyborrowing$_t$		-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	$\Delta_{t+1,t}$ Collateral Rating				$\Delta_{t+1,t}$ 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 8: Borrowing and Risk Taking (Quarterly Frequency)

This table examines the robustness of correlation of central bank borrowing and risk taking in the period from January 2009 to December 2011. Columns (1) to (6) replicate Table 2 and Columns (7) to (12) replicate Table 3. The only difference to Table 2 and 3 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 3. 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	$\Delta_{t+1,t}$ Collateral Rating						$\Delta_{t+1,t}$ 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$_t$	-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)
Country-Time FE	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	$\Delta_{t+1,t}$ Collateral Rating						$\Delta_{t+1,t}$ 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$_t$	-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)
Country-Time FE	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 9: Correlation between Bank Holdings and Credit Risk

This table examines the holdings of Periphery sovereign debt by bank credit risk. We use data from the three European bank stress tests. We include all banks with a credit default swap price. We rank banks by CDS quintiles on the date of the bank stress test. We report average holdings of Periphery Sovereign Debt relative to equity for each data and quintile.

Panel A: All Banks										
Dependent Variable	Periphery Sovereign Debt/Bank Equity									
Weighting	Equal-weighted					Value-weighted				
Quintile	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
31-Mar-10	42.3%	49.2%	67.0%	38.7%	103.3%	33.8%	31.6%	47.0%	34.2%	120.1%
29-Dec-10	10.2%	27.7%	35.0%	71.0%	83.3%	0.4%	34.0%	41.4%	38.0%	90.9%
28-Sep-11	0.4%	17.2%	39.1%	75.5%	122.8%	5.2%	28.1%	48.7%	62.4%	84.1%
Panel B: Non-Periphery Banks										
Dependent Variable	Periphery Sovereign Debt/Bank Equity									
Weighting	Equal-weighted					Value-weighted				
Quintile	1st	2nd	3rd	4th	5th	1st	2nd	3rd	4th	5th
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
31-Mar-10	13.0%	30.8%	28.0%	74.5%	52.0%	18.4%	25.2%	13.3%	41.9%	23.4%
29-Dec-10	1.5%	25.6%	34.2%	12.8%	50.3%	1.0%	20.6%	32.2%	9.2%	25.3%
28-Sep-11	0.2%	9.2%	33.3%	11.9%	72.8%	0.1%	11.3%	34.7%	11.2%	31.1%

Table 10: Public Information and Risk-Taking

This table examines the correlation between central bank borrowing and risk taking in the period from January 2009 to December 2011. We replicate the regressions from Table 2 and 3. The only difference is that we add *Median Bank Rating*$_t$ as an independent variable in some regressions as a proxy for public information. The sample is the Bankscope sample for 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	$\Delta_{t+1,t}$ Collateral Rating						$\Delta_{t+1,t}$ Share Periphery Sovereign Debt					
Period	2009			2010 & 2011			2009			2010 & 2011		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Borrowing/Collateral$_t$	-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)	
Median Bank Rating	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	$\Delta_{t+1,t}$ Collateral Rating						$\Delta_{t+1,t}$ Share Periphery Sovereign Debt					
Period	2009			2010 & 2011			2009			2010 & 2011		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Borrowing/Collateral$_t$	-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)	
Median Bank Rating$_t$	-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

Table 11: Lender of Last Resort Borrowing and Future Returns

This table examines the relationship between borrowing and future equity returns and changes in credit default swap spread (CDS). The outcome variable in Columns (1), (2), (5), and (6) is the Equity Return and in Columns (1) to (3) and (7) to (9) the log change in CDS spreads. Columns (1) to (4) cover the year 2009 and Columns (5) to (8) cover the years 2010 and 2011. All regressions include week fixed effects. Columns (2), (4), (6), and (8) include bank-specific coefficients on average weekly bank returns or log CDS changes, respectively. *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								
Period	2009				2010 & 2011			
Dependent Variable	Equity Return$_{t+1,t}$		$\Delta_{t+1,t}$ Log(CDS)		Equity Return$_{t+1,t}$		$\Delta_{t+1,t}$ Log(CDS)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Borrowing/Collateral$_t$	0.002	-0.004	0.005	0.007	-0.016***	-0.015***	0.009***	0.009***
	(0.003)	(0.003)	(0.005)	(0.005)	(0.003)	(0.002)	(0.002)	(0.003)
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Bank Betas	N	Y	N	Y	N	Y	N	Y
Observations	3,639	3,639	2,269	2,269	7,238	7,238	4,666	4,666
R2	0.356	0.544	0.587	0.615	0.35	0.417	0.509	0.564
Panel B: Non-Periphery Banks								
Period	2009				2010 & 2011			
Dependent Variable	Equity Return$_{t+1,t}$		$\Delta_{t+1,t}$ Log(CDS)		Equity Return$_{t+1,t}$		$\Delta_{t+1,t}$ Log(CDS)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Borrowing/Collateral$_t$	0.002	-0.003	0.002	0.003	-0.013***	-0.013***	0.001	0.002
	(0.004)	(0.005)	(0.005)	(0.006)	(0.005)	(0.004)	(0.005)	(0.005)
Time Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y
Bank Betas	N	Y	N	Y	N	Y	N	Y
Observations	1,975	1,975	1,545	1,545	3,937	3,937	3,133	3,133
R2	0.387	0.531	0.595	0.619	0.458	0.566	0.586	0.647

Appendix

Table A.1: Variable Definitions

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
$\Delta_{t+1,t}$ 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
$\Delta_{t+1,t}$ Collateral Rating	Weekly change in average rating of collateral	ECB
$\Delta_{t+1,t}$ Share Periphery Sovereign Debt	Weekly change in Periphery sovereign debt	ECB