School of Finance

University of St.Gallen

UNSECURED AND SECURED FUNDING

MARIO DI FILIPPO
ANGELO RANALDO
JAN WRAMPELMEYER

WORKING PAPERS ON FINANCE NO. 2016/16

SWISS INSTITUTE OF BANKING AND FINANCE (S/BF – HSG)

AUGUST 2016

Unsecured and Secured Funding*

Mario di Filippo
The World Bank†

Angelo Ranaldo
University of St. Gallen‡

Jan Wrampelmeyer
University of St. Gallen§

August 12, 2016

*The research presented in this paper was conducted when Mario di Filippo was at Banque de France, as a member of one of the user groups with access to TARGET2 information (which is one of the datasets used in this paper) in accordance with Article 1(2) of Decision ECB/2010/9 of 29 July 2010 on access to and use of certain TARGET2 data. The views expressed in this paper are solely those of the authors. Moreover, the authors are grateful to Eurex Repo GmbH for providing the repo data and to René Winkler and Florian Seifferer for helpful comments and insightful discussions. This work was supported by the Sinergia grant "Empirics of Financial Stability" from the Swiss National Science Foundation [154445].

†Mario di Filippo, The World Bank, 1818 H Street NW, Washington, DC 20433, USA. E-mail: mdifilippo@worldbank.org.

‡Angelo Ranaldo, University St. Gallen, Swiss Institute of Banking and Finance, Rosenbergstrasse 52, CH-9000 St. Gallen, Switzerland. E-mail: angelo.ranaldo@unisg.ch.

§Jan Wrampelmeyer, University of St. Gallen, Swiss Institute of Banking and Finance, Rosenbergstrasse 52, CH-9000 St. Gallen, Switzerland. Email: jan.wrampelmeyer@unisg.ch.

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ABSTRACT

We provide the first joint analysis of the secured and unsecured money markets of the euro area using bank-level data. After the Lehman crisis, two important substitution mechanisms emerge: banks with higher credit risk offset reductions of unsecured borrowing with secured funding. Riskier banks replace unsecured lending by granting more secured loans. However, high leverage and reliance on short-term funding hamper banks' ability to substitute. Moreover, banks enduring money market strains contribute to the credit crunch. Overall, our findings suggest that the secured segment of the euro money market contributes to financial stability, mitigating systemic effects such as short-term funding strains and contagion.

KEYWORDS: Money markets, bank funding, short-term debt, financial crisis, counterparty risk, liquidity

JEL CODES: E42, E43, E58, G01, G21, G28

Well-functioning money markets are crucial for the stability of the financial system. They contribute to an efficient allocation of short-term funding and risk sharing of liquidity shocks. Strains in money markets can turn into severe liquidity shortages or even bank runs with adverse consequences for the entire economy. Despite the importance of money markets, we lack a full understanding of several key issues: Are unsecured and secured borrowing substitutes or are they complementary sources of liquidity? In wake of a shock, do banks reduce interbank lending as a whole or only unsecured lending? How does an increase in credit risk affect banks' usage of the unsecured and secured money market?

This paper empirically addresses the questions above by conducting the first comprehensive study on how individual banks borrow and lend in the unsecured and secured euro money market. Using bank-level data, we uncover two important substitution mechanisms. On the borrowing side, banks with higher credit risk endure funding strains in terms of quantity rationing and relatively higher funding costs in the unsecured market. However, these banks offset the loss in liquidity from the unsecured market by borrowing more in the secured market. On the lending side, banks with higher credit risk reduce unsecured lending and charge higher interest rates. However, these banks actually increase their secured lending. We find that high leverage and dependence on short-term funding hamper banks ability to substitute unsecured with secured funding and unsecured with secured lending. Moreover, banks significantly reduce lending to non-financial customers in reaction to money market strains contributing to the credit crunch during the European sovereign debt crisis.

A number of theories provide explanations why funding problems arise in money markets. The liquidity hoarding hypothesis suggests that lenders are not willing to lend for precautionary reasons, e.g., due to anticipation of own liquidity needs (Acharya and Skeie, 2011; Acharya, Gale, and Yorulmazer, 2011), high aggregate liquidity demand (Allen, Carletti, and Gale, 2009), increases in Knightian uncertainty (Caballero and Krishnamurthy, 2008), credit constraints and limited participation because of incomplete markets (Ashcraft, McAndrews, and Skeie, 2011), or in anticipation of fire sales (Diamond and Rajan, 2011). Another set of models suggest that counterparty credit risk is responsible for the reduction in funding liquidity. The reason can either be asymmetric information and adverse selection (e.g., Stiglitz and Weiss, 1981; Freixas and Jorge, 2008; Heider, Hoerova, and Holthausen, 2015) or lenders reacting to changes in credit quality, which they learn through monitoring (Calomiris and Kahn, 1991; Rochet and Tirole, 1996).

While all these theories suggest lower volumes in the unsecured money market, they have different implications for the secured money market, because the market infrastructure plays a crucial role for fragility (Martin, Skeie, and von Thadden, 2014a,b) and collateral makes loans less informational sensitive (Dang, Gorton, and Holmström, 2012; Gorton and Ordoñez, 2014). The liquidity hoarding hypothesis suggests that lenders reduce lending in both the secured and unsecured money market. In contrast, according to the credit risk hypothesis, the reduction should only occur in the unsecured money market, if the secured money market is relatively safe as in Europe (Mancini, Ranaldo, and Wrampelmeyer, 2016). Moreover, theories based on asymmetric information have different implications than theories based on monitoring of credit quality. In the former, banks with low credit risk would be disincentivized to borrow in the unsecured market, because lenders do not know the borrowers' credit quality and thus overcharge low-risk borrowers. In the latter, banks with high credit risk are excluded from the unsecured market and have to find an alternative funding source, leading to a substitution from unsecured to secured borrowing as long as borrowers have sufficient collateral. Thus, two opposite patterns emerge and can be tested in our analysis, that is, banks with lower (higher) credit risk substitute unsecured with secured borrowing according to the asymmetric information (monitoring) hypothesis. However, the model of Ranaldo, Rupprecht, and Wrampelmeyer (2016) shows that banks' ability to substitute between secured and unsecured funding is limited and depends on banks leverage, with highly leveraged banks being more likely to face funding constraints in both components of the money market at the same time. With our unique data, we can test this theoretical prediction.

Understanding which market frictions contributed most to the financial crisis is crucial for policy makers and central bankers as the optimal policy responses are different depending on whether liquidity hoarding or credit risk concerns are key. To comprehensively test which of these theories best describes reality, it is crucial to investigate individual banks' borrowing and lending behavior in both the unsecured and secured money market at the same time. No previous empirical study has provided such a joint analysis. Using a unique bank-level data set, this paper fills this gap. Our data of overnight transactions[1] captures more than 60% of unsecured volume and 87% of volume on Eurex Repo, a major CCP-based electronic trading platform for funding-driven general

[1]Our data includes transactions with a maturity of one day (overnight, tomorrow-next, and spot-next).

collateral repos.[2]

Four main results emerge from our empirical study. First, our joint analysis of the unsecured and secured money market supports a credit risk-based explanation for the dry-up of unsecured funding markets rather than liquidity hoarding. While banks with higher credit risk tend to reduce unsecured borrowing and lending, these banks tend to increase secured borrowing and lending, consistent with the resilient features of the euro repo market (Mancini, Ranaldo, and Wrampelmeyer, 2016). Second, our finding that banks with higher credit risk are able to offset a reduction of unsecured borrowing with secured loans is consistent with theories of lenders monitoring credit quality rather than theories of adverse selection. Third, a bank's ability to substitute a loss of unsecured funding by more secured funding is impaired by high leverage and dependence on short-term funding prior to a crisis, in line with the theory that highly leveraged borrowers are more likely to become funding-constrained in both the unsecured and secured money market. Fourth, banks that suffer money market funding problems contribute most to credit crunches inside and outside the money market, that is, banks that have to reduce their borrowing in both the unsecured and secured money market during the financial, reduce total lending to other banks and to non-financial customers in the subsequent years. In all of our analysis we control for central bank liquidity provision and other market factors, finding that an increase in public liquidity provision reduces activity in both the unsecured and secured private money market.

We contribute to the existing literature by jointly analyzing unsecured and secured borrowing and lending at the bank level. We extend the recent empirical literature focusing on unsecured money markets in the United States (Ashcraft and Duffie, 2007; Afonso, Kovner, and Schoar, 2011), in the euro area (Brunetti, di Filippo, and Harris, 2011; Angelini, Nobili, and Picillo, 2011; Garcia-de-Andoain, Hoffmann, and Manganelli, 2014; Garcia-de-Andoain et al., 2016), and in the United Kingdom (Acharya and Merrouche, 2013) and that on secured money markets in the United States Gorton and Metrick (2012); Krishnamurthy, Nagel, and Orlov (2014); Copeland, Martin, and Walker (2014) and in Europe (Mancini, Ranaldo, and Wrampelmeyer, 2016; Boissel et al., 2015). None of the previous papers provides a joint analysis of secured and unsecured money markets to comprehensively assess short-term funding conditions on aggregate and on a bank-

[2]A repo is essentially a collateralized loan based on a simultaneous sale and forward agreement to repurchase securities at the maturity date. Repo transactions are typically used for funding purposes via general collateral (GC) repos or to obtain specific securities via special repos (specials). Thus, GC repos are mainly cash driven and the collateral can be any security from a predefined basket of securities, whereas special repos are security driven; that is, collateral is restricted to a single security.

specific level. Moreover, only a joint analysis allows to empirically test the different theoretical hypotheses discussed above, and to highlight the crucial factors that prevent banks from replacing unsecured funding with secured loans or cause banks to refrain from lending.

The remainder of the paper is organized as follows. Section 1 presents the main institutional features of the unsecured and secured euro money markets, introduces the data, and analyzes various measures of money market activity. Sections 2 contains our joint empirical analysis of unsecured and secured borrowing and lending. Section 4 investigates which characteristics make banks most vulnerable to money market strains. Section 5 concludes.

1. The unsecured and secured interbank markets in the euro area

1.1. Institutional background

The unsecured money market considered in this study is the market for uncollateralized loans of reserve balances held by Eurosystem banks. On a daily basis, banks may access this market to meet reserve requirements set by the ECB and to satisfy their liquidity needs. Most interbank loans have an overnight maturity, with some transactions having longer duration (up to one year). The unsecured money market is an over-the-counter market. Trades may be negotiated directly (for instance through the use of electronic platforms such as e-MID) or indirectly through a broker. Transactions in this market are based on relationships and on the periodic assessment of credit lines and credit merit among market participants. Trades are entered bilaterally and lenders are directly exposed to the borrowers' credit risk.

In addition to the unsecured market, banks in Europe may access the secured money market, which is also known as the repo market, to meet their short-term funding needs. This market has a unique infrastructure which has proven to be remarkably resilient during crisis periods. The key market features ensuring resilience are anonymous central counterparty (CCP)-based trading, safe collateral, and the absence of an "unwind" mechanism (Mancini, Ranaldo, and Wrampelmeyer, 2016).[3] Trading anonymously via a CCP eliminates direct counterparty exposures between borrowers and lenders, so credit risk concerns are far less important than in the unsecured market.

[3]Prior to the ongoing U.S. triparty repo market reform, an unwinding of the repo trade occurred every morning; that is, collateral was returned to borrowers and lenders received back their cash. This gave borrowers the opportunity to substitute collateral and to adjust for price fluctuations. Until the repo agreement was rewound in the afternoon, the triparty clearing bank was lending to the repo borrower between this 8:008:30 a.m. unwind and the rewind after 3:30 p.m. Nowadays, much less intraday credit is extended by the clearing bank.

1.2. Money market data

We use daily data of collateralized and uncollateralized lending activity in Europe between June 2, 2008 and December 31, 2014, a period which spans 1,688 trading days. For the unsecured money market, we rely on data from TARGET2, the real-time gross settlement (RTGS) payment system owned and managed by the Eurosystem. Unsecured interbank loans with a maturity of one-day are extracted from TARGET2, relying on the methodology developed by Frutos et al. (2016).[4] This algorithm identifies interbank loans by matching cash flows between banks on different days, matching an initial payment from bank i to bank j at time t, with its re-payment from bank j to bank i at time $t+1$. The algorithm requires the repayment to be equal the initial payment plus a plausible amount, corresponding to the prevalent one-day interest rate. We do not distinguish different one-day term types (overnight, tomorrow-next, spot-next).

For the secured market, we use a repo data set consisting of all trades executed on Eurex Repo. Established in 2001, Eurex Repo GmbH is the leading electronic trading platform for euro General Collateral (GC) repos. For the analysis, we exclude all special repos, which tend to be driven by the demand for a particular collateral security rather than funding. Moreover, in line with our data for the unsecured market we focus on one-day repos. The Eurex Repo data set does not include any information about the identity of banks. However, it includes anonymous participant identifiers, which allows us to track the behavior of a given participant over time.

To merge the information from the secured and unsecured market, we use TARGET2 flows between individual banks and the CCP, Eurex Clearing, to match the participants in the unsecured and secured money market. This allows us to investigate how much and at what interest rate banks borrow and lend in the unsecured and secured market at any point in time. We aggregate daily market data by reserve maintenance period (RMP). The final sample consists of 79 banks over 80 RMPs.

1.3. Money market activity

We depict volumes, rates, number of transactions, and shares of the unsecured and secured money markets in Figures 1 to 4. For the remainder of our analysis, solid lines depict borrowing activity and dotted lines depict lending activity, while black lines denote the Unsecured market and blue

[4]The algorithm for identifying interbank loans with payment data is a refinement of the methodology originally developed by Furfine (2000).

lines refer to the secured market. Figure 1 shows the average daily trading volume, obtained by summing the daily average amounts traded by banks in our sample within each RMP. Looking at each market's aggregate activity, we observe that borrowing and lending amounts of the banks in our sample are very similar, with aggregate lending being slightly lower than aggregate borrowing in each market. Second, looking at the two markets evolution, we observe opposite trends in the markets relative share. Whereas the unsecured market is significantly larger in 2008, the secured market surpasses the unsecured market in terms of size in the second half of 2011.

It is evident from Figure 1 that the reliance on unsecured borrowing has decreased dramatically overall since 2008. Looking more closely at the unsecured market, we note several trends: i) a sudden decrease in the second half of 2008, following the collapse of Lehman Brothers and the subsequent collapse of the market for commercial papers in the United States; ii) a partial recovery that started in the first quarter of 2009 and lasted until the second quarter of 2011; iii) a further decrease in activity which reached its lowest point in March 2013, surrounding the breakout of the European sovereign debt crisis; and iv) a tepid increase in activity in the second quarter of 2013. Unlike the unsecured segment, activity in the repo market appears to be characterized by constant growth, which halted temporarily in the second half of 2012 and resumed in the first half of 2013.

Figure 2 shows the volume-weighted average rates in the unsecured and secured markets. Interestingly, we observe that in 55 out of 80 RMPs, the average market rate in the secured market is higher than the average market rate in the unsecured market. This suggests that banks that were able to borrow in the unsecured market could do so at low rates. The average unsecured rate is significantly higher than the secured rate in the second half of 2012, when secured rates decreased with the ECB deposit rate, whereas unsecured rates remained more positive.

Figure 3 presents the average number of daily transactions in the two markets, confirming the decrease of activity in the unsecured market shown in Figure 1. The number of daily transactions in the unsecured market decreases from an initial 500–600 at the beginning of our sample to reach a minimum of about 100 daily transactions in the second quarter of 2012. The number of transaction in the secured market was low in the beginning of the sample, but reached 150 in 2014.

Finally, Figure 4 displays the daily average unsecured market shares for both lending and borrowing activity, obtained by first computing, for each bank, the ratio of unsecured borrowing (lending) over total borrowing (lending) during a given RMP, and then by averaging this measure across the 79 banks in the sample. In line with the aggregate volume figures, both lending and

borrowing shift over time to the secured segment.

Having established the aggregate developments in our sample, the next section presents bank-specific data and investigates developments in both markets using regression analyses.

[Figures 1 to 4 about here]

2. Joint analysis of unsecured and secured borrowing and lending

In this section, we perform a number of regression analyses to understand the drivers of individual banks' borrowing and lending and the choice of secured or unsecured money market. This allows us to test the different hypothesis from money market theory.

The liquidity hoarding theory (e.g., Caballero and Krishnamurthy, 2008; Allen, Carletti, and Gale, 2009; Acharya and Skeie, 2011; Acharya, Gromb, and Yorulmazer, 2012) predicts that banks reduce the supply of liquidity in both the unsecured and secured market. The motivation to hoard liquidity for precautionary reasons is larger for weaker lenders, i.e., lenders which have higher credit risk. Counterparty risk may lead to lower money market volumes and/or higher interest rates either due to asymmetric information about borrowers' credit risk (e.g., Stiglitz and Weiss, 1981; Heider, Hoerova, and Holthausen, 2015) or because lenders monitor borrowers' credit risk (Calomiris and Kahn, 1991; Rochet and Tirole, 1996). We expect the theories with counterparty risk to mainly impact the unsecured market. Given that trading in the secured market is anonymous and the lender is not exposed to the counterparty directly (see Mancini, Ranaldo, and Wrampelmeyer, 2016), counterparty risk is likely to have only a small effect on secured borrowing, if any.

Theories based on asymmetric information have different implications than theories based on monitoring of credit quality. According to adverse-selection theories, uncertainty about credit risk would indiscriminately increase interest rates in the unsecured market, penalizing low-risk borrowers, who would then have an incentive to replace unsecured with secured borrowing. According to theories in which lenders monitor borrowers' credit quality, borrowers with high credit risk face more difficult and costly funding conditions in the unsecured money market, prompting a substitution from unsecured to secured borrowing as long as borrowers have sufficient collateral. Thus, two opposite patterns emerge: banks with lower (higher) credit risk substitute unsecured with secured borrowing according to the asymmetric information (monitoring) hypothesis. In the following subsections, we augment our data set with the necessary bank-specific variables and then

run regression analysis to test which theory best describes reality in funding markets.

2.1. Definition of bank-specific variables

For our regression analysis, we rely on RMP-average, bank-specific traded amounts, number of trades, and unsecured borrowing and lending shares, as illustrated in the previous section. Moreover, we define the average rates weighted by trade size for each bank, for each trading day, for borrowing and lending, and for both money markets. We then subtract from these rates the market rate, computed as the volume-weighted average rate for the entire market. Finally, for each bank we compute the average rate across all days included in a given RMP, to obtain RMP-average bank-specific interest rate spreads. Summary statistics for all measures of money market activity are shown in Table I.

[Table I about here]

To be able to test the liquidity hoarding and credit risk hypotheses, we augment the money market data with credit rating time-series for each participant by combining information from Bloomberg and Bankscope. We also collect yearly information on bank characteristics, such as total assets, total equity and total funding. In addition, we add information from the ECB statistical warehouse databases on the Eurosystem's level of excess reserves.

For each bank, we compute the following variables in addition to the measures of money market activity:

i. To measure credit risk for each bank, we translate the ratings of the rating agencies Standard & Poor's, Fitch, and Moody's into a numeric scale ranging from 1 (best) to 25 (worst). We then choose the worst among these three ratings and compute the RMP average, to obtain one single bank-specific credit rating for each RMP. We adopt a similar procedure to compute a measure of each bank's country rating.

ii. We compute a bank's roll-over risk by dividing its unsecured borrowing by its total funding, where the numerator corresponds to the one-lagged RMP unsecured borrowing and the denominator corresponds to the year-end value of the year preceding a given RMP.

iii. For each bank, we compute funding risk, defined as the standard deviation of its daily unsecured borrowing during the previous RMP.

iv. We compute a bank's leverage by dividing its total equity by its total assets. Both values correspond to the year-end values of the year preceding a given RMP.

Summary statistics for the unsecured and secured market variables are presented in Tables II, and III, while Figure 5 shows average bank-specific and country ratings.

[Table II and III and Figure 5 about here]

Givent that some theories state that the credit risk stems from aggregate market risk (e.g., Allen, Carletti, and Gale, 2009) or general adverse selection issues (e.g., Heider, Hoerova, and Holthausen, 2015) rather than the credit risk specific to a given borrower, we include the composite indicator of systemic stress (CISS) of Hollo, Kremer, and Lo Duca (2012) as a general measure of risk in the European financial system.

Lastly, as in Mancini, Ranaldo, and Wrampelmeyer (2016), we control for the liquidity in the financial system by computing excess reserves defined as Eurosystem's deposits at the ECB deposit facility net of the recourse to the marginal lending facility, plus current account holdings in excess of those contributing to the minimum reserve requirements.

2.2. Regression analysis

In the following, we investigate trading volume and interest rates in both markets. Moreover, we analyze the relative reliance of banks on unsecured and secured borrowing and lending by investigating the share of total money market funding. We perform dynamic panel regressions to account for persistence in the dependent variables. We include time fixed- as well as bank fixed-effects to control for market-wide developments, such as new regulation, and bank heterogeneity that are not captured by the dependent variables.

Table IV shows the regression results for money market volumes. In line with the hypothesis that lenders monitor borrowers' credit quality, banks with a worse credit rating tend to borrow less in the unsecured market. At the same time, their usage of the secured market increases by a similar amount, suggesting that banks were able to replace their loss in unsecured borrowing in the secured market. On the lending side, the reduction in unsecured lending by banks bearing more credit risk is not statistically significant and seems to be more than offset by an increase in secured lending. This result suggests that liquidity hoarding is not prevalent in the European money market. Funding risk is negatively related to borrowing volume, implying that borrowers

with more volatile funding needs tend to have more limited access to unsecured funding. Central bank liquidity negatively affects borrowing and lending volume in both markets. Thus, when banks can obtain liquidity cheaply and easily from the central bank as in the ECB's full allotment regime, banks rely less on interbank funding.

Columns 4 and 7 of Table IV show the results for the share of the unsecured borrowing and lending. Consistent with the quantity results, banks with higher credit risk borrow and lend less in the unsecured market. Funding risk does not have a significant effect on bank's funding choice. In line with the theoretical model of (Ranaldo, Rupprecht, and Wrampelmeyer, 2016), the share of unsecured borrowing is negatively related to central bank liquidity and positively associated with risk.

[Table IV about here]

Table V shows the regression results for interest rate spreads. Overall, the effect of bank ratings on spreads are smaller than the ones for quantities, suggesting that credit risk in the euro money market mainly affects quantities. Unsecured spreads of banks that still have access to unsecured borrowing increase with credit risk, but not in a dramatic fashion. Moreover, interacting credit risk with excess reserves shows that the effects of credit risk on spreads are even weaker when central bank liquidity is high. The spreads for secured borrowing do not increase. Interest rates for all forms of lending tend to increase with higher credit rating, but the magnitude is relatively small.

The regression estimates in Tables IV and V are also significant in economic terms. On average over our sample period, a bank rated as non-investment grade speculative (i.e., a S&P and Fitch's BB, or a Moody's Ba2) would approximately access EUR 154 millions less of unsecured funding on a daily basis compared with a top-rated bank (AAA). In contrast, the lower rated bank would be able to raise a similar amount of secured funding. In terms of interest rates, the lower rated bank would pay 4.6 basis points more for unsecured funding.

To summarize, our results show that credit risk negatively affects the unsecured money market. In line with theories of credit quality monitoring, banks with worse credit ratings borrow less and have to pay higher rates. However, these banks are able to replace their unsecured funding in the secured money market, highlighting the importance of the market for financial stability.

[Table V about here]

3. Vulnerable banks

Which banks are able to substitute a loss in unsecured funding by more secured funding? The last step of our analysis is the identification of the characteristics that make banks most vulnerable to money market strains prior to a financial crisis. To do this, we analyze their ex-ante profile before the outbreak of the Lehman collapse, i.e., in June 2008. As shown in Table VI, we find that the initial leverage and reliance to short-term funding play an important role. We sort banks from lowest to highest leverage (Panel A) and the ratio between unsecured funding to total asset (Panel B) at the beginning of the sample period. Then, we form quartiles and compute the percentage changes in unsecured and secured borrowing and lending, and in shares of unsecured borrowing and lending.

Three main results arise: First, higher initial leverage and dependence on short-term funding are associated with larger decrease of unsecured borrowing, consistent with the credit monitoring theory. Second, it is more difficult to substitute unsecured borrowing with secured loans for banks with higher leverage and short-term funding needs. This pattern is discernible in terms of changes of unsecured and secured borrowing, and share of unsecured borrowing that decreases less for high-leverage banks. This finding is in line with the theory of (Ranaldo, Rupprecht, and Wrampelmeyer, 2016), who show that banks' initial leverage prior to a shock is a key driver for money market fragility. If initial leverage is high, banks are more likely to become funding constrained in both money markets at the same time. The theoretical underpinning is that the shadow costs of capital in the secured market represent the marginal funding costs in the unsecured market for bank facing binding capital constraint. Therefore, the higher is a borrower's leverage at the time of a shock, such as the European sovereign debt crisis, the more difficult it is to substitute a shortage of unsecured funding with secured loans. Third, the higher is the bank's leverage and reliance on short-term funding, the more banks reduce unsecured money market lending. Banks (partially) offset the reduction of unsecured lending with an increase of secured lending. The increase in secured lending is strongest for low leverage banks and smallest for high leverage banks.

The previous analysis indicates that banks struggling for funding in the money market reduce lending to other banks thus intensifying funding problems within the interbank system. An important question is whether this transmission mechanism goes beyond the interbank system and also has a negative impact on the real economy. To address this question, we analyze whether

banks enduring money market problems subsequently reduce lending to non-financial customers. More precisely, we regress the changes of banks' loans to non-financial customers during the European sovereign debt crisis from 2010 to 2013 on four dummy variables that capture the increase or decrease of unsecured and secured money market funding prior to the European crisis, i.e., from October 2008 to June 2010. As shown in Table VII, banks that experience a joint reduction of unsecured and secured borrowing subsequently cut back loans to non-financials stronger than banks that were able to raise secured funding. This result holds true whether those banks reduce unsecured funding (but increase secured funding), and controlling for the initial leverage, total asset size, and return on asset prior to the Lehman failure. This finding suggests that the roots of the vulnerability of a bank also lie in its money market fragility. If a bank is more exposed to reductions of money market funding and it is unable to substitute unsecured with secured funding, then it contributes more to a credit crunch inside and outside the financial system.

[Tables VI and VII about here]

4. Conclusion

This paper provides the first joint analysis of the secured and unsecured money markets of the euro area using bank-level data. Our analysis uncovers two important substitution mechanisms. On the borrowing side, banks bearing higher credit risk suffer more severe funding strains in terms of lower borrowing volume and higher funding costs in the unsecured market. However, these banks are able to replace unsecured funding with secured borrowing. On the lending side, riskier banks reduce their uncollateralized lending, but this reduction is counterbalanced by more collateralized lending. These findings support theories in which lenders react to changes in credit quality, which they learn through monitoring (Calomiris and Kahn, 1991; Rochet and Tirole, 1996).

Then, we analyze why banks are more exposed to money market strains. Our findings suggest that banks with high leverage and reliance to short-term funding prior to the Lehman bankruptcy are most vulnerable. For them, the decrease of interbank borrowing and lending is most severe, and the ability to substitute unsecured with secured funding and lending is reduced. Moreover, banks enduring money market strains curtail lending to non-financial customers contributing to the credit crunch.

Our study delivers two key insights for academics, market participants, and policy makers.

First, it highlights the importance of a joint analysis of the unsecured and secured components of money markets. A separate inspection would overlook whether secured and unsecured funding complement or substitute each other, how idiosyncratic characteristics such as credit risk affect banks' borrowing and lending, and it can lead to an imprecise test of the counterparty risk and liquidity hoarding hypotheses. Second, our findings suggest that the secured funding market contributes to reduce the fragility of the whole euro money market. The secured segment facilitates the substitution of unsecured funding with secured liquidity, especially for banks bearing higher credit risk. However, banks with high leverage and short-term funding needs appear more vulnerable to money market strains and more likely to contribute to the credit crunch. Thus, the ongoing regulatory initiatives that bolster collateralized lending (Financial Stability Board, 2012, 2013) and institutional designs that facilitate the substitutability between unsecured and secured money markets such as the European repo market should contribute to financial stability mitigating systemic risk due to short-term funding strains and contagion effects.

References

Acharya, V., Skeie, D. R., 2011. A Model of Liquidity Hoarding and Term Premia in Inter-bank Markets. Journal of Monetary Economics 58, 436–447.

Acharya, V. V., Gale, D., Yorulmazer, T., 2011. Rollover risk and market freezes. Journal of Finance 66, 1177–1209.

Acharya, V. V., Gromb, D., Yorulmazer, T., 2012. Imperfect competition in the interbank market for liquidity as a rationale for central banking. American Economic Journal: Macroeconomics 4, 184–217.

Acharya, V. V., Merrouche, O., 2013. Precautionary hoarding of liquidity and interbank markets: Evidence from the subprime crisis. Review of Finance 17, 107–160.

Afonso, G., Kovner, A., Schoar, A., 2011. Stressed, not frozen: The federal funds market in the financial crisis. Journal of Finance 66, 1109–1139.

Allen, F., Carletti, E., Gale, D., 2009. Interbank Market Liquidity and Central Bank Intervention. Journal of Monetary Economics 56, 639–652.

Angelini, P., Nobili, A., Picillo, C., 2011. The interbank market after august 2007: what has changed, and why? Journal of Money, Credit and Banking 43, 923–958.

Ashcraft, A., McAndrews, J., Skeie, D., 2011. Precautionary reserves and the interbank market. Journal of Money, Credit and Banking 43, 311–348.

Ashcraft, A. B., Duffie, D., 2007. Systemic illiquidity in the federal funds market. American Economic Review 97, 221–225.

Boissel, C., Derrien, F., Ors, E., Thesmar, D., 2015. Sovereign Crises and Bank Financing: Evidence from the European Repo Market. Working paper, HEC Paris.

Brunetti, C., di Filippo, M., Harris, J. H., 2011. Effects of Central Bank Intervention on the Interbank Market During the Subprime Crisis. Review of Financial Studies 24, 2053–2083.

Caballero, R. J., Krishnamurthy, A., 2008. Collective Risk Management in a Flight to Quality Episode. Journal of Finance 63, 2195–2230.

Calomiris, C. W., Kahn, C. M., 1991. The role of demandable debt in structuring optimal banking arrangements. The American Economic Review 81, 497–513.

Copeland, A., Martin, A., Walker, M., 2014. Repo runs: Evidence from the tri-party repo market. Journal of Finance 69, 2343–2380.

Dang, T. V., Gorton, G. B., Holmström, B., 2012. Ignorance, Debt, and Financial Crises. Working paper, Yale School of Management.

Diamond, D. W., Rajan, R. G., 2011. Fear of Fire Sales, Illiquidity Seeking, and Credit Freezes. Quarterly Journal of Economics 126, 557–591.

Financial Stability Board, 2012. Securities Lending and Repos: Market Overview and Financial Stability Issues. Interim Report of the FSB Workstream on Securities Lending and Repos, FSB.

Financial Stability Board, 2013. Strengthening Oversight and Regulation of Shadow Banking. Policy Framework for Addressing Shadow Banking Risks in Securities Lending and Repos, FSB.

Freixas, X., Jorge, J., 2008. The role of interbank markets in monetary policy: A model with rationing. Journal of Money, Credit and Banking 40, 1151–1176.

Frutos, J. C., Garcia-de Andoain, C., Heider, F., Papsdorf, P., 2016. Stressed interbank markets: Evidence from the european financial and sovereign debt crisis. ECB Working Paper 1925, European Central Bank.

Furfine, C. H., 2000. Interbank payments and the daily federal funds rate. Journal of Monetary Economics 46, 535–553.

Garcia-de-Andoain, C., Heider, F., Hoerova, M., Manganelli, S., 2016. Lending-of-last-resort is as lending-of-last-resort does: Central bank liquidity provision and interbank market functioning in the euro area. Journal of Financial Intermediation forthcoming.

Garcia-de-Andoain, C., Hoffmann, P., Manganelli, S., 2014. Fragmentation in the euro overnight unsecured money market. Economics Letters 125, 298–302.

Gorton, G., Ordoñez, G., 2014. Collateral Crises. American Economic Review 104, 343–78.

Gorton, G. B., Metrick, A., 2012. Securitized Banking and the Run on Repo. Journal of Financial Economics 104, 425–451.

Heider, F., Hoerova, M., Holthausen, C., 2015. Liquidity hoarding and interbank market spreads: the role of counterparty risk. Journal of Financial Economics 118, 336–354.

Hollo, D., Kremer, M., Lo Duca, M., 2012. CISS – A Composite Indicator of Systemic Stress in the Financial System. Working paper, European Central Bank and National Bank of Hungary.

Krishnamurthy, A., Nagel, S., Orlov, D., 2014. Sizing up repo. Journal of Finance 69, 2381–2417.

Mancini, L., Ranaldo, A., Wrampelmeyer, J., 2016. The euro repo interbank market. The Review of Financial Studies 29, 1747–1779.

Martin, A., Skeie, D. R., von Thadden, E.-L., 2014a. Repo Runs. Review of Financial Studies 27, 957–989.

Martin, A., Skeie, D. R., von Thadden, E.-L., 2014b. The Fragility of Short-Term Secured Funding Markets. Journal of Economic Theory 149, 15–42.

Ranaldo, A., Rupprecht, M., Wrampelmeyer, J., 2016. Fragility of money markets. School of Finance Working Paper 2016/01, University of St. Gallen.

Rochet, J.-C., Tirole, J., 1996. Interbank lending and systemic risk. Journal of Money, Credit, and Banking 28, 733–762.

Stiglitz, J. E., Weiss, A., 1981. Credit rationing in markets with imperfect information. American Economic Review 71, 393–410.

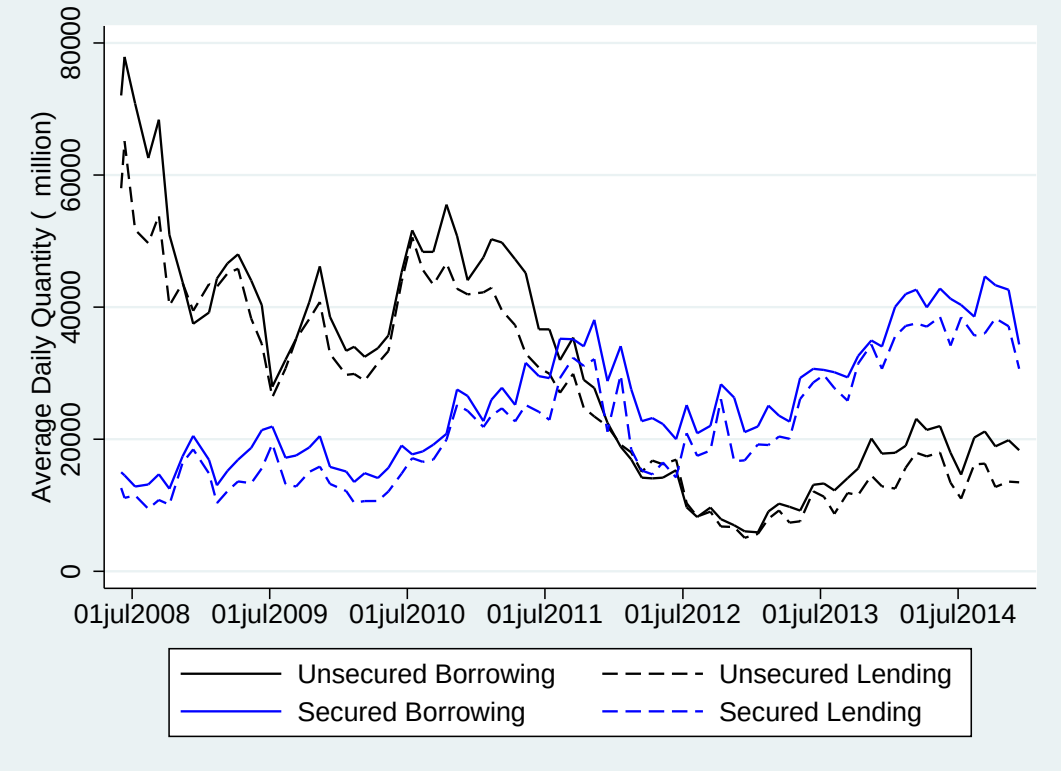

Figure 1. Average daily volume of money market transactions. The figure shows the daily averages within each reserve maintenance period from June 2008 to December 2014 of aggregate trading in the unsecured and secured markets (in millions of Euros). The black (blue) lines refer to the unsecured (secured) market and continuous (dashed) lines refer to borrowing (lending), respectively.

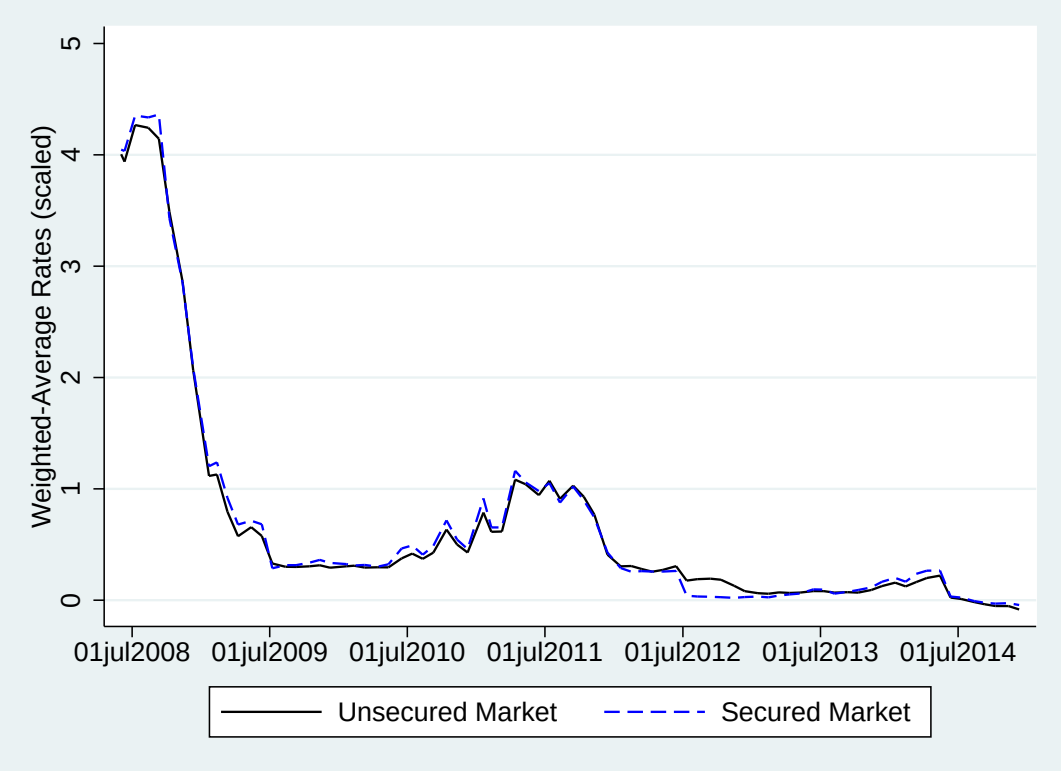

Figure 2. Money market interest rates. The continuous and dashed lines show the volume weighted average rates for each reserve maintenance period from June 2008 to December 2014 in the unsecured and secured money markets.

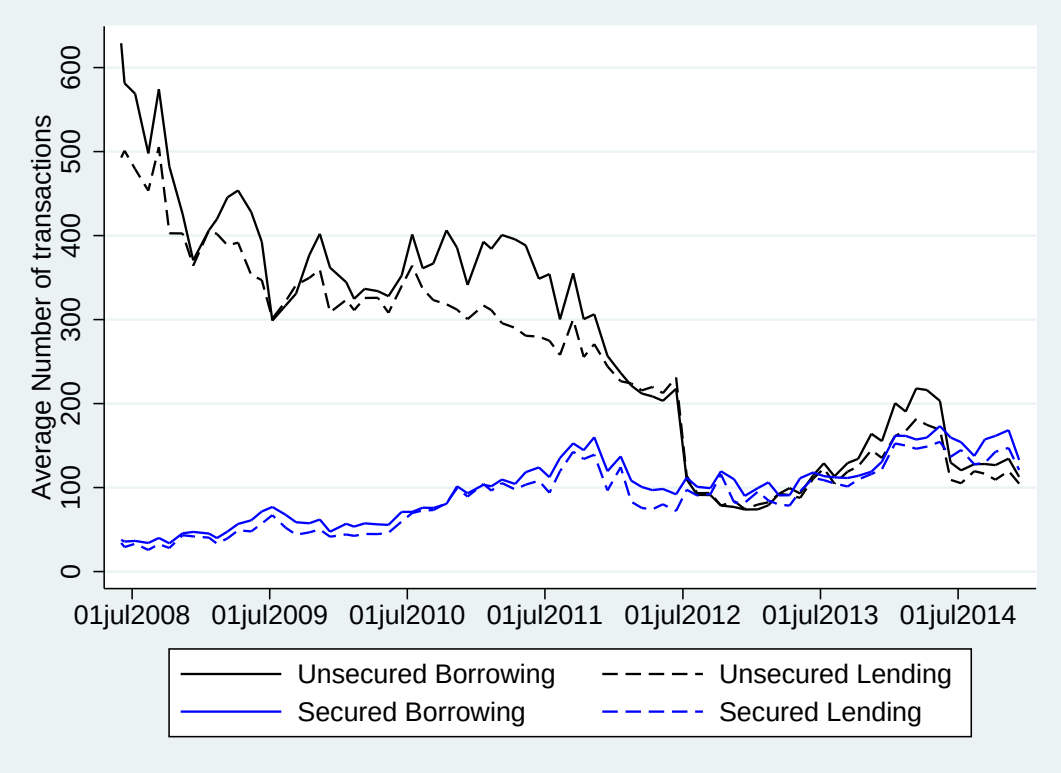

Figure 3. Number of money market transactions. The figure shows the daily averages within each reserve maintenance period from June 2008 to December 2014 of the number of transactions. The black (blue) lines refer to the unsecured (secured) market and continuous (dashed) lines refer to borrowing (lending), respectively.

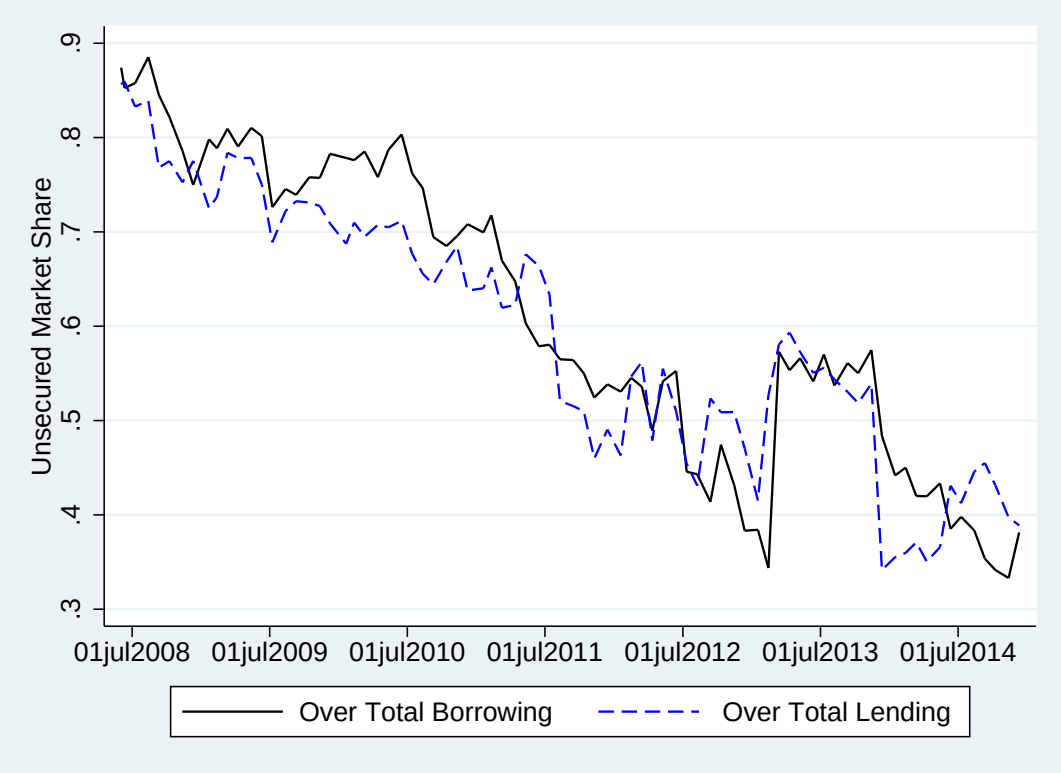

Figure 4. Money market interest rates. Unsecured Market Share. The continuous and dashed lines show the unsecured borrowing share over total borrowing and the unsecured lending share over total lending, respectively. Shares are computed as daily averages within each reserve maintenance period from June 2008 to December 2014.

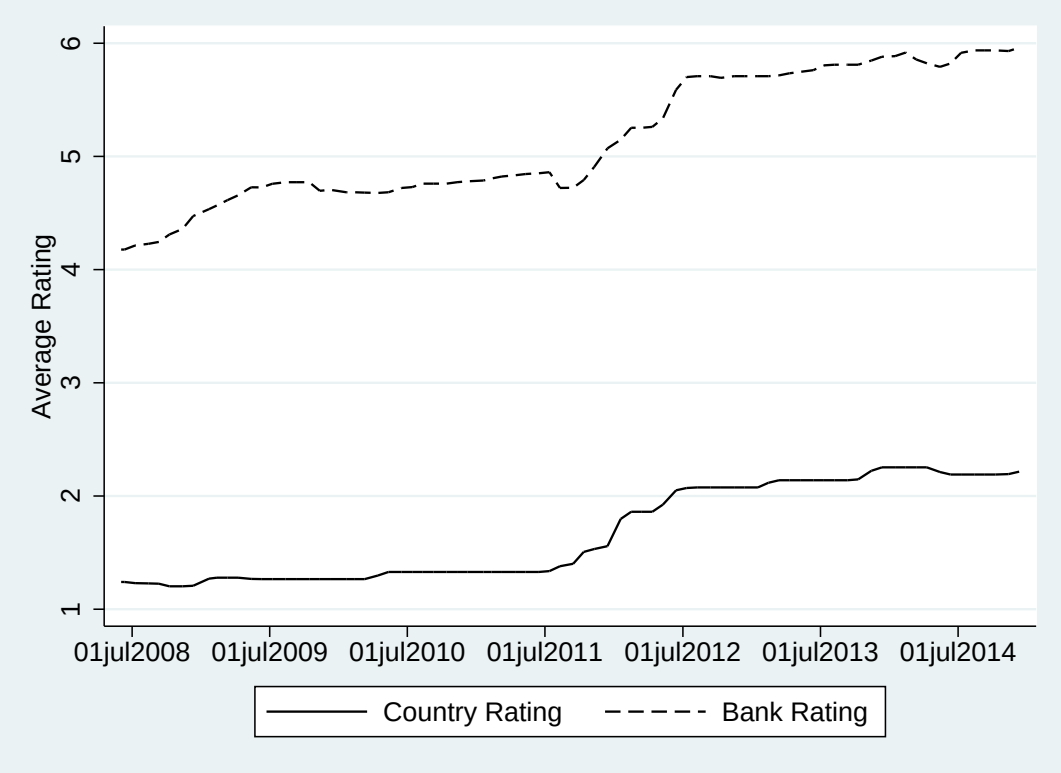

Figure 5. Average Ratings. The figure shows the average country and bank-specific ratings across reserve maintenance periods (RMPs) from June 2008 to December 2014. The rating is based on a homogenized scale ranging from 1 (best, or AAA/Aaa) to 25 (worst) across Standard & Poor's, Fitch, and Moody's.

Table I
Descriptive statistics for money market activity

This table shows descriptive statistics of money market variables in terms of number of observations (obs), median, mean, standard deviation (std. dev.), 25% and 75% percentiles (25% and 75%). Interest rates are computed relative to the market rate and as daily volume-weighted average rates. Quantities refer to daily amount of transactions in EUR millions. Trades refer to the number of transactions. Unsecured and secured borrowing (lending) are labeled "Unsec. Borrow" and "Sec. Borrow" ("Unsec. Lend" and "Sec. Lend"). The sample consists of 6,320 observations, including 79 banks during 80 reserve maintenance periods (RMPs) from June 2008 to December 2014. The variables include one observation per bank per RMP.

Variables	Obs.	25%	Median	Mean	75%	Std. Dev.
Interest rates						
Unsec. Borrow	3'953	−0.06	−0.02	−0.02	0.01	0.11
Unsec. Lend	4'214	−0.04	−0.01	0.00	0.03	0.12
Sec. Borrow	3'023	−0.02	0.00	0.00	0.01	0.05
Sec. Lend	2'963	−0.02	0.00	0.01	0.02	0.11
Volume						
Unsec. Borrow	3'953	38	247	624	823	979
Unsec. Lend	4'214	12	83	511	388	1'408
Sec. Borrow	3'023	40	202	679	829	1'116
Sec. Lend	2'963	33	150	589	534	1'655
Trades						
Unsec. Borrow	3'953	0.7	2.8	5.7	7.3	7.5
Unsec. Lend	4'214	0.3	1.2	4.7	4.3	11.2
Sec. Borrow	3'023	0.3	1.2	2.6	3.4	3.6
Sec. Lend	2'963	0.3	0.9	2.3	2.7	4.4

Table II
Balance Sheet Information of Market Participants

The table shows balance sheet information in terms of leverage ratio, total equity, assets and funding. Leverage ratio is expressed in % and remaining variables in billions of Euros. The descriptive statistics are the number of observations (obs), median, mean, standard deviation (std. dev.), 25% and 75% percentiles (25% and 75%). The total number of observations is of 553 observations, including 79 banks, and the sample period spans from June 2007 to December 2013 including 80 reserve maintenance periods (RMPs). The variables include one observation per bank per year. The last row shows the excess reserves (EUR billions) as Eurosystem's deposits at the ECB deposit facility net of the recourse to the marginal lending facility, plus current account holdings in excess of those contributing to the minimum reserve requirements.

Balance sheet variables	Obs.	25%	Median	Mean	75%	Std. Dev.
Borrower Characteristics						
Leverage Ratio	538	3.11	4.22	5.27	5.91	5.03
Total Equity	542	1	7	20	31	27
Total Assets	539	13	150	440	670	580
Total Funding	539	13	140	380	590	500
Excess reserves	80	76	160	229	263	226

Table III
Unsecured/Secured Euro Interbank Market Summary Statistics

For each bank and period, this table shows money market statistics in terms of total money market borrowing (total borrowing) composed of unsecured and secured borrowing. The ratio between unsecured borrowing (lending) over total borrowing (lending) is called Share Unsec. Borrow (Share Unsec. Lend). Roll-over funds is the average bank's unsecured borrowing of the last reserve maintenance period (RMP) over total funding as the last balance sheet. Unsecured funding risk (Funding Risk) is the standard deviation of the daily bank's unsecured borrowing during the previous RMP. Credit risk is measured as the worst bank's rating of a homogenized scale ranging from 1 (best) to 25 (worst) across Standard & Poor's, Fitch, and Moody's. The descriptive statistics are the number of observations (obs), median, mean, standard deviation (std. dev.), 25% and 75% percentiles (25% and 75%). The total number of observations is 553, including 79 banks, and the sample period spans from June 2007 to December 2013 including 80 RMPs. The variables include one observation per bank per year.

Variables	Obs.	25%	Median	Mean	75%	Std. Dev.
Total Borrowing	6'241	0	97	719	867	1'338
Roll-over Risk	6'093	0.000	0.079	0.526	0.353	1.951
Credit Risk	6'320	4	6	5	7	2.6
Share Unsec. Borrow	4'584	16	77	61	100	41
Funding Risk	6'241	0	29	226	309	387
Share Unsec. Lend	4'878	6	84	60	100	43

Table IV
Borrowing and Lending Volume

This table shows the panel regression results for money market volumes. The depended variables are the average daily bank's volume of unsecured and secured borrowing (Columns 2 and 3) and lending (Columns 5 and 6) as well the share of unsecured borrowing and lending (Columns 4 and 7) across the reserve maintenance periods (RMPs). The dependent variable is regressed on its lagged value (Lagged Dep. Variable), a measure of bank's credit risk based on agencies' ratings (Credit Risk), unsecured funding risk of the previous RMP (Funding Risk), Eurosystem's excess reserves, the CISS risk variable (Risk), and a constant. The bottom of the table shows the number of observations and banks, and the regression R-squares. Standard errors are reported in parenthesis. Significance at 1%, 5%, and 10% is denoted by $***$, $**$, and $*$, respectively.

	Borrowing			Lending		
	Unsecured	Secured	Share Unsec.	Unsecured	Secured	Share Unsec.
Lagged Dep. Variable	0.844***	0.734***	0.783***	0.864***	0.882***	0.761***
	(0.0114)	(0.00874)	(0.00988)	(0.00601)	(0.00609)	(0.00971)
Credit Risk	−12.80***	13.95***	−0.00490**	−4.586	12.14***	−0.0122***
	(3.481)	(3.914)	(0.00203)	(3.512)	(4.617)	(0.00238)
Funding Risk	−0.140***	−0.0513***	5.58e−06	0.0589***	0.00928	1.88e−06
	(0.0276)	(0.0194)	(9.54e−06)	(0.0174)	(0.0226)	(1.01e−05)
Excess Reserves	−0.146***	−0.0627***	−4.91e−05***	−0.0499**	−0.0329	−2.60e−05*
	(0.0195)	(0.0218)	(1.26e−05)	(0.0196)	(0.0253)	(1.35e−05)
Risk	0.0561	−0.710	0.0785***	0.223	−14.08	0.0642***
	(0.446)	(0.499)	(0.0144)	(0.448)	(27.63)	(0.0148)
Constant	182.8***	64.11**	0.140***	55.48**	−17.19	0.187***
	(24.87)	(27.87)	(0.0148)	(25.17)	(28.89)	(0.0166)
Observations	6,241	6,241	4,313	6,241	6,241	4,602
Number of banks	79	79	78	79	79	78
R-squared	0.700	0.545	0.668	0.784	0.777	0.630

Table V
Interest Rate Spreads

This table shows the panel regression results for money market rates. The depended variables are volume-weighted rates for unsecured and secured borrowing (Columns 2–3 and 4–5) and lending (Columns 6–7 and 8–9) across the reserve maintenance periods (RMPs). The dependent variable is regressed on its lagged value (Lagged Dep. Variable), a measure of bank's credit risk based on agencies' ratings (Credit Risk), the interaction term between credit risk and Eurosystem's excess reserves (Credit*Reserves), unsecured funding risk (Funding Risk), the interaction term between funding risk and Eurosystem's excess reserves (Funding*Reserves), and a constant. The bottom of the table shows the number of observations and banks, and the regression R-squares. Standard errors are reported in parenthesis. Significance at 1%, 5%, and 10% is denoted by $***$, $**$, and $*$, respectively.

	Borrowing				Lending			
	Unsecured		Secured		Unsecured		Secured	
Lagged Dep. Variable	0.418***	0.407***	0.276***	0.275***	0.512***	0.505***	0.294***	0.293***
	(0.0147)	(0.0147)	(0.0179)	(0.0179)	(0.0160)	(0.0161)	(0.0181)	(0.0182)
Credit Risk	0.00383***	0.00649***	−0.00168***	−0.00159**	0.00373***	0.00555***	0.00203*	0.00139
	(0.00104)	(0.00119)	(0.000628)	(0.000665)	(0.00123)	(0.00139)	(0.00117)	(0.00123)
Credit*Reserves		−0.00245**		−0.000644		−0.00215		0.00247**
		(0.00123)		(0.000654)		(0.00136)		(0.000986)
Funding Risk		0.0203***		−0.00279		0.00908		0.00465
		(0.00490)		(0.00302)		(0.00554)		(0.00471)
Funding*Reserves		−0.0131		0.00622		−0.0164		−0.0371*
		(0.0216)		(0.0117)		(0.0240)		(0.0190)
Constant	−0.0332***	−0.0515***	0.00561	0.00652*	−0.0184***	−0.0277***	−0.00749	−0.00685
	(0.00584)	(0.00673)	(0.00362)	(0.00396)	(0.00682)	(0.00775)	(0.00647)	(0.00697)
Observations	3,670	3,670	2,649	2,649	3,850	3,850	2,602	2,602
Number of banks	69	69	74	74	74	74	72	72
R-squared	0.191	0.198	0.090	0.090	0.220	0.222	0.096	0.098

Table VI
Ex ante analysis

We form four quartiles sorting banks from lowest to highest leverage (Panel A) and unsecured funding to total asset called funding share (Panel B) at the beginning of the sample period, i.e., July 2008. A higher quartile means higher leverage or a higher reliance on unsecured funding. Then, we compute averages of percentage changes over the entire sample period that ends in December 2014 of the following quantities: unsecured borrowing (Unsec. Borrow), secured borrowing (Sec. Borrow), unsecured lending (Unsec. Lend), secured lending (Sec. Lend), share of unsecured borrowing to total borrowing (Share Unsec. Borrow), and share of unsecured lending to total lending (Share Unsec. Lend). $*$, $**$, and $***$ refer to the F-ratio statistic of inequality in means at the 10%, 5%, and 1% significance level, respectively.

Panel A: Leverage (End of Sample - Beginning of Sample)						
Quartile	Unsec. Borrow***	Sec. Borrow	Unsec. Lend***	Sec. Lend	Share Unsec. Borrow.	Share Unsec. Lend
1	16.7%	196.4%	−83.5%	155.6%	−42.82%	−26.54%
2	−117.4%	189.4%	−225.7%	155.6%	−53.84%	−68.85%
3	−156.4%	350.9%	−216.7%	138.7%	−52.53%	−33.72%
4	−212.9%	114.2%	−368.4%	51.0%	−19.32%	−52.77%
Panel B: Short-term unsecured funding to Assets ratio						
Quartile	Unsec. Borrow***	Sec. Borrow	Unsec. Lend***	Sec. Lend	Share Unsec. Borrow.	Share Unsec. Lend
1	51.7%	170.9%	−122.6%	125.1%	na	−39.38%
2	−73.8%	129.2%	−310.2%	87.2%	−36.84%	−46.79%
3	−249.3%	263.0%	−284.7%	95.4%	−47.04%	−37.93%
4	−213.8%	249.0%	−250.2%	198.5%	−35.77%	−47.98%

Table VII
Ex post analysis

This table shows the results of the regression analysis in which the changes of bank's loans to non-financial customers during the European sovereign debt crisis (2010 – 2013) are regressed on four dummy variables that are one if during the previous period (October 2008 to June 2010) the bank reduced both unsecured and secured borrowing (Unsec. Down / Sec. Down), increased both (Unsec. Up / Sec. Up), reduced unsecured borrowing but increased secured one (Unsec. Down / Sec. Up), and the opposite (Unsec. Up / Sec. Down) while controlling for the initial leverage (Leverage), total asset size (Size), and return on asset (ROA). Standard errors are reported in parenthesis. The bottom of the table shows the number of banks and R^2s. Significance at 1%, 5%, and 10% is denoted by $***$, $**$, and $*$, respectively.

	dLoans in%	dLoans in%	dLoans in%
C	−0.225	−1.254	−0.648
	(0.149)	(0.998)	(0.871)
Unsec. Down / Sec. Down			−0.442**
			(0.179)
Unsec. Down / Sec. Up	0.414**	0.444**	
	(0.168)	(0.184)	
Unsec. Up / Sec. Up	0.417*	0.527*	
	(0.228)	(0.277)	
Unsec. Up / Sec. Down	0.413	0.319	
	(0.333)	(0.364)	
Size		0.041	0.033
		(0.0515)	(0.0478)
Leverage		0.002	0.003
		(0.00618)	(0.00597)
ROA		0.201	0.194
		(0.285)	(0.264)
R^2	0.144	0.207	0.189
N	46	45	45