Strains on money market makers and money market tensions

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Abstract

We analyze the trading book of a key market maker in the European unsecured money market and study the extent to which liquidity risks accumulated by this market maker affect his pricing of liquidity and the bid-ask-spread he quotes on unsecured borrowing and lending. We find that the larger the funding liquidity risk assumed by the market maker the higher the market price for liquidity and the higher his term premium. Furthermore, his bid-ask-spread and the sensitivity of his bid-ask-spread to the maturity of transactions increases as his assumed liquidity risk rises. This suggests that also in the unsecured money market funding constraints and funding risks of the market maker affect market liquidity in line with Gromp and Vayanos (2004) and Brunnermeier and Pedersen (2009).

Keywords: Funding liquidity risk and money market liquidity, Liquidity constraints, Money market makers, Liquidity spirals

JEL Classification: G01, G10, G21

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1 Introduction

The ongoing financial crisis has highlighted the neuralgic role of the interbank market for the functioning of the financial system. The subprime crisis in the U.S. only turned into a global financial crisis because of the resulting dry-up of money markets. The evolving sovereign debt crisis in the Euro area in 2011/2012 was severely aggravated by tensions in interbank markets in particular by the national segmentation of those markets in the European Monetary Union.

Several reasons for this money market dry-up have been put forward and empirically assessed in the academic literature: Afonso et al. (2011) show that a jump in counterparty credit risks, as suggested by Flannery (1996), has played an important role for tensions in the U.S. federal funds market. Elevated informational asymmetries about conterparties' credit risk, proposed by Freixas and Jorge (2009), are shown to be a key driver for the money market dry-up after the onset of the financial crisis in 2007 by Abbassi et al (2014). On the other hand, precautionary liquidity hoarding, as modelled by Allen, Carletti, and Gale (2009), was pointed out as another potential cause for the market turmoil. Indeed, Acharya and Merrouche (2013) show for the U.K. that liquidity hoarding was a key reason for tensions in the interbank market. However, none of those approaches explicitly accounts for the micro structure of money markets despite the fact that several theoretical contributions highlighted that in search driven markets middlemen play an important role in facilitating transactions (see Rubinstein and Wolinsky (1987), Biglaiser (1993), Li (1998), Afonso and Lagos (2014)). Clearly, the over-the-counter nature of unsecured interbank trading qualifies this market as a search driven one. Indeed, there is strong evidence of a tiering structure in the interbank market, suggesting that some banks serve as money market makers (see Craig and von Peter, 2014). Therefore, given that market makers play an important role in money markets, it seems reasonable to expect that the ability of market makers to take positions and facilitate trades is also an important determinant for the functioning of this market. For instance, feedback effects from increased funding constraints and elevated funding risks of market makers as modeled by Gromb and Varyano (2004) and Brunnermeier and Pedersen (2009) might be present in the money market as well and might have contributed substantially to the tensions in this market during the recent financial crisis.

In this paper, we use a unique data set that comprises the order book of the unsecured money market trading of one of the largest market makers in the Euro area. We study the extent to which funding constraints and particularly funding liquidity risks accumulated by this market maker affect his pricing of liquidity and the realized bid-ask-spread he quotes. We measure the assumed funding liquidity risks by the deviation of the maturity mismatch of outstanding interbank loans and deposits from its long-term average, assuming that this average captures the 'target' maturity mismatch. We then regress the rate the market maker charged for his interbank loans and deposits as well as his realized bid-ask-spread against his assumed funding liquidity risk. Using time fixed effects and allowing for varying sensitivities to the funding liquidity risk in different time periods accounts for changes in the targeted mismatch. Furthermore, for each transaction, we control for the counterparty's characteristics using an official credit rating, counterparty fixed- and relationship effects. Moreover, we include the market-wide credit risk premium and changes in the net money market funding demanded by the market maker.

Our results provide four key insights: First, the larger the funding liquidity risk assumed by the market maker, the higher the market price for liquidity (the price the market maker pays for deposits and the rate he charges for loans). Thus, the market maker seems to hoard liquidity in response to a higher liquidity risk exposure. Second, with a higher accumulated funding liquidity risk, the marker maker has a higher term premium (longer term loan *and* deposit contracts require a higher interest rate when compared with respective shorter contracts). As a consequence it becomes pricier for other market participants to hedge their liquidity risk through transactions with the market maker. Third, the market liquidity – measured by the realized bid-ask-spread quoted by the market maker – deceases significantly as the retained funding liquidity risk of the market maker increases. Thus, transaction costs for participants in the unsecured money market increase and the efficiency of the liquidity reallocation within the banking system is impaired. Forth, the realized bid-ask-spread rises substantially for longer term loans and deposits if the market maker's liquidity risk increases, while such an increase has much less of an effect on short-term contracts. This suggest that particularly in the term segment of the money market, market liquidity and transaction costs depend on the market maker's funding risks. As a further interesting result, we find some evidence that a deterioration in the market maker's own perceived credit quality (measured by his credit default swap rate) for the crisis period not only required him to pay a higher risk premium on deposits received from the interbank market, but that he also charged a higher mark-up on loans granted. Apparently the market maker rolled over his own elevated funding costs to his borrowers. In sum, we find along various dimensions a detrimental effect of the market maker's assumed funding risks and funding costs on the price for liquidity on the one hand and the market liquidity in the unsecured money market on the other hand. An increasing price of liquidity, a deteriorating money market liquidity, and higher costs of hedging maturity mismatches is likely to increase banks' sensitivity to liquidity risk exposures. Therefore, these documented effects have the potential to give rise to adverse liquidity spirals as suggested in Brunnermeier and Pedersen (2009).

These results have important policy implications. On the one hand, they might suggest that apart from higher capital requirements, money center banks – as systemically important financial institutions – should also be required to hold larger liquidity buffers, in particular to maintain a higher liquidity coverage ratio. On the other hand, our results also show that the ECB was well advised to not only provide additional liquidity to the banking system, but to provide it at longer-term maturities through LTROs since these mitigated the accumulated liquidity risks of money market makers, thereby lowering the spread between the unsecured and secured interbank rates and fostering the liquidity in the unsecured money market.

2 Related Literature

Our paper is related to several strands of the literature. It builds on the discussion about key frictions in money markets and the extent to which frictions contributed to the tensions prevailing in this market after the failure of Lehman Brothers and the sovereign debt crisis in the Euro area. Previous work stresses informational asymmetries in the money markets as a main driver for the turmoil: Freixas and Jorge (2009) argue that uncertainty about counterparties' credit worthiness generates a lemons problem in interbank market. Acharya and Skeie (2011) and Heider, Hoerova and Holthausen (2009) show that banks hoard liquidity and reduce term lending in anticipation of being rationed in the interbank market (or unable to roll-over short-term debt) which leads to a shortfall of liquidity supply. Allen, Carletti and Gale (2009) argue that market incompleteness (due to informational asymmetries about liquidity needs) also generate inefficient liquidity hoarding in the presence of aggregate uncertainty. Those models all assume a centralized interbank market. But in practice, money markets have an over-the-counter (OTC) structure and hence, this assumption seems not necessarily appropriate for this market. Thus several recent contributions such as Afonso and Lagos (2013) model the unsecured money market as a decentralized market with search frictions.

However, a large strand of the theoretical literature emphasizes that in search driven OTC markets, the microstructure and in particular middlemen serving as market makers, play an important role. Rubinstein and Wolinsky (1987) show that middlemen enhance efficiency in an OTC market, given that they facilitate search. Biglaiser (1993) finds that in an OTC market with a lemons problem, the middlemen with a better screening technology improve efficiency. Li (1998) shows that middlemen emerge endogenously in an OTC market with lemons problems and a screening technology. However, none of those models takes into account that the ability of market makers to assume positions, to facilitate trade, and to provide market liquidity might be restrained. Lagos, Rocheteau, and Weill (2011) show that even middlemen without financial constraints provide only limited liquidity as their own liquidity risk grows. While Gromb and Vayanos (2004) and Brunnermeier and Pedersen (2009) neglect the OTC market structure with search frictions in their models, they show that funding restraints and funding risks of market makers are important determinants for asset market liquidity. They also show that deteriorating market liquidity aggravates market makers' funding constraints, impairing market liquidity further. Using the trading book of a key market maker in the unsecured European money market, we are able to empirically assess whether changes in the funding constraints and funding risks of the market maker indeed affect his liquidity provision to the money market.

Knowing the exact source of frictions that prevail in the interbank markets and contributed to the financial crisis is of upmost importance for monetary policy makers since the effectiveness of the policy measures depend on the particular source of the friction(s): If indeed liquidity hoarding was the key driver, then additional liquidity supply would be appropriate and sufficient to mitigate tensions in the interbank market. If counterparty credit risk or elevated uncertainty about it lead to the dry-up, then measures to recapitalize banks and to foster trust in their solvency are key. If search frictions and market makers are important and their funding restraints matter for pricing and the liquidity of funds in the money market, the measures that primarily aim at mitigating those constrains are particularly effective. Thus, several papers empirically assess the the role of different frictions. Acharya and Merrouche (2013) and Ashcraft et al. (2011) find evidence for liquidity hoarding in the U.K. and U.S. money market, respectively. Similarly, Angelini, Nobili, and Picillo (2011) report that risk aversion led to a dry-up of liquidity supply in the Italian interbank market. Afonso et al. (2011) report evidence for the federal fund market that the stress in the market was solely due to an elevated credit risk. Braeuning and Fecht (2012) and also Abbassi, Brauning, Fecht and Peydro (2014) find that informational asymmetries about counterparty credit risks was a crucial driver of the dry-up in the Lehman crisis as well as in the sovereign debt crisis in the Euro area. But to the best of our knowledge no study has addressed up to now the question to what extent the microstructure and in particular strains on market makers severely amplify tensions in the money market and thus contributed to its dry-up. This is surprising given that Ashcraft and Duffie (2007) and Afonso, Kovner, and Schoar (2013) find evidence for the importance of search frictions in the federal funds market and that Craig and von Peter (2014) at the same time also show that money center banks play an important role as market makers in this market. Based on the trading book data of a single market maker in the unsecured money market we try to fill this gap. Obviously such an analysis would also be feasible using the bilateral interbank transactions extracted from payments data (as used for instance in Afonso et al (2011) Braeuning and Fecht (2012) and Abbassi, Brauning, Fecht and Peydro (2014)). While this data would also permit to analyze the behavior of different intermediaries and their interactions, this data does not comprise transactions with fairly small banks that have no access to the payment system, in particular small foreign banks or non-Euro zone banks. For those banks, however, it is likely that search costs are particularly high and hence, a market maker therefore particularly important for their market access. Thus, while using our data for this analysis has a drawback since we are missing a cross-section of market makers, our data has the advantage of providing for a single market maker his entire trading activity in the unsecured market, also with all small and foreign banks.

While to the best of our knowledge there is no paper studying the empirical relevance of funding risks and funding constraints of market makers in the unsecured money market, there are a number of papers assessing these effects empirically in other financial markets. Most prominently, Comerton-Forde et al (2010) show that the larger the positions market makers hold in the New York Stock Exchange and the larger capital losses they incur are, the higher the bid-ask-spreads the respective market maker quotes and the higher the spread prevailing in the stock market in which the market maker is active. Thus, their results are very much in line with our findings for a very different market though. Further papers - which however also focus on stock markets - are Anand, Irvine, Puckett, and Venkataraman (2013) and Hameed, Kang, and Viswanathan (2010).

3 Data and variable construction

3.1 Data set

Our analysis is based on data comprising the trading book in the unsecured money market of one of the major German private banks which is also a key player and market maker in the Euro zone money market. All trades were arranged from the global headquarter of the bank in Germany. The data set initially comprises 20,670 trades for the time period 02. January 2007 to 31. December 2008. It includes the capture date and a time stamp (Central European Time, CET) for each trade, the contractual agreed interest rate in basis points, the trade amount in Euro, the value and maturity date and time, the type of transaction (interbank deposit or loan), name of the counterparty and type of the counterparty (whether it is a central bank or a private bank). The data set also allows us to match the name of the trader to each transaction.

For some trades, the value date and capture date didn't match, meaning that the trade was not recorded at the correct date and time. We decided to drop those observations. Furthermore, some trades were transactions with central banks. While we include these trades when deriving the accumulated liquidity risk and the net funding received in the money market (and as a robustness check, we exclude all transactions with central banks in those calculations), we do not consider those transactions when estimating the pricing of money market transactions. Thus, our final sample consists of 17,712 trade observations. Since we analyze the evolving positions of the bank, we need a unique time ID for each trade. The data set has 1,365 duplicate time IDs since the time stamp on the capture date only records minutes but not seconds. If a duplicate time ID occurred, the order of transactions is maintained as in the original data set but each duplicate is ordered one second after the trade with the first duplicate occurrence. The popposite ordering would not alter our empirical results.

3.2 Variable construction

To set up our pricing model, we first construct a risk-free benchmark interest rate: in order to capture general changes in the money market rates - for instance due to monetary policy interventions - we decided to use the *Eurepo* as the risk-free benchmark rate. The Eurepo rates are obtained from a panel survey of banks, where banks can submit a rate by 11.00 a.m. CET to Brussels. The key difference between the Eurepo and the Euribor is that the Eurepo covers rates for collateralized interbank lending while the Euribor rate comprises unsecured interbank loans. Thus, while the Eurepo measures only the price for liquidity for different maturities, the Euribor also captures the general credit risks as perceived by market participants. The bank from which we obtained the order book is part of the Eurepo and the Euribor panel. We prefer the Eurepo as the benchmark rate since this allows us to analyze the market wide credit risk separately. Additionally, we lag the Eurepo rate by one day. We match the appropriate maturity of the Eurepo benchmark rate to each transaction in the data set and use the following maturity brackets: for overnight loans and deposits, we use the Eurepo overnight (TN) rate.

The 1, 2, 3 week and the 1, 2, 3, 6, 9, 12 months Eurepo rates are used for the term lending transactions. We do not interpolate between these rates and use the next lower maturity bucket for matching.

From the order book, we construct the variable *Maturity* as the length between the time on the capture date C when the transaction was initiated and the close of the transaction at 7:20 p.m. CET on the maturity date *M.* Secondly, *Amount* enters the regression directly from the order book (in Euros). Thirdly, to account for possible relationship influences between the bank and its counterparties, we define a dummy variable, *Relationship banking dummy*, which is equal to 1 if the bank was involved in a trade with the same counterparty and transaction type over the previous 350 transactions which equals around two weeks. To control for the specificity of transactions with a central bank in our robustness checks, we create a dummy variable *Central bank dummy* which is equal to 1 if the counterparty is a central bank (373 transactions were conducted with central banks). In the more sophisticated panel regression approach, bank fixed effects will pick up any of those influences.

We matched the order book data at the transaction level with external data sources: First, we merged each counterparties' credit rating to the respective transaction by creating a categorial variable *Counterparty credit rating* with the following aggregated categories: AAA, AA, A, BBB, BB, B, CCC, and Not Available (N/A). The ratings were obtained from Fitch, Standard & Poor's and Moody's. If more than one rating agency provided a rating, we gave preference to Fitch, then to Standard & Poor's and then to Moody's. Our results do not change if we were to change this ranking order. Next, we include - as an approximation of the credit risk of our market-making bank - the daily first-order difference of the bank's credit default swap rate with a five year maturity (*Five year CDS*). Thirdly, as a measure for the aggregate counterparty credit risk (CCR), we include the variable *3 months Euribor - Eurepo* rate, lagged by one day, in our regressions.

Our key variable of interest is the unsecured funding liquidity risk indicator LIQ. It captures after each trade the deviation of the current maturity mismatch of outstanding interbank loans and deposits from the long-run mean maturity mismatch the bank runs on its interbank trading book. It is calculated as

$$LIQ_{t+i} = \sum_{C=0}^{t+i} (m_C^l - \bar{m}) V_C^l - \sum_{C=0}^{t+i} (m_C^d - \bar{m}) V_C^d, \tag{1}$$

whereby m_C^l and m_C^d is the remaining maturity in days (excluding weekends) at $t + i$ of all outstanding loans and deposits, respectively.[1] These are loans and deposits with a capture date C before the current point in time $t+i$. The respective remaining maturities are normalize with the volume weighted average maturity $\bar{m}$ across all deposits and loans granted during the full

[1]This implies that we assume that all trades are settled at 7:20 p.m. on the maturity date. Specifying an earlier maturity time would not change our results.

sample.[2] This way, only loans with a maturity larger than the average maturity and deposits with a maturity below the average maturity add to our funding liquidity risk measure. Note that this implies that the bank 'targets' a certain liquidity risks assumed in the money market. It is reasonable to assume that the risk tolerance changed over time in particular in response to the crisis. Since this would imply a level shift in our LIQ_{t+i}, we partially control for this in our analysis by including time fixed effects. Our measure also implies that a loan can migrate from liquidity risk contributing to liquidity risk mitigating when its maturity falls below $\bar{m}$ (and vice versa for deposits).[3] LIQ_{t+i} is re-calculated after each new loan or deposit and is used as an explanatory variable for the pricing of subsequent loan or deposit trades. This however not only assumes that the liquidity risk is managed continuously on an aggregate level but also implies that the assumed liquidity risk is instantaneously known to each trader after each trade. To relax this assumption, we also calculate the liquidity risk on a daily basis: LIQ_{daily} is equal to the funding liquidity risk at the close of business on the previous trading day. By using this specification as an explanatory variable for the pricing of subsequent loan and deposit trades, we assume that the funding liquidity risk level is communicated to all traders either at the beginning of the next trading day or at the end of the current day. The LIQ_{daily} specification will be used as a robustness check. For further robustness checks, we re-calculate LIQ by (i) excluding all transactions with central banks which are officially designated so in the bank's order book and by (ii) excluding only these central bank transactions which were conducted with the European Central Bank or the Deutsche Bundesbank. Note that the respective transactions with central banks will also be excluded in the empirical regressions.

Finally, one might have the notion that the amount of funding received and needed from the unsecured money market is what actually drives the pricing of the loans and deposits and that our funding liquidity risk indicator actually only picks up this effect. In order to control for this, we construct an indicator for the net unsecured money market funding, *NMMF*, which is the difference between the currently outstanding deposits and the outstanding loans:

$$NMMF_{t+i} = \sum_{C \leq t+i}^{M} V_C^d - \sum_{C \leq t+i}^{M} V_C^l. \tag{2}$$

whereby C (M) is the capture (maturity) date of the respective contract and V_C^l (V_C^d) is the respective volume of the outstanding loans (deposits).

Thus, while the liquidity risk indicator provides a forward looking perspective, the *net money market funding* indicator draws a contemporary picture of the gap between total deposits and total loans outstanding at $t + i$.[4]

[2] We tried various other sensible specifications for $\bar{m}$ and our results stay broadly robust.

[3] Note that our approach follows the maturity-related measure for liquidity risk proposed by Berger and Bowman (2009). However, our approach is obviously much more granular, as it is based on the *remaining* maturity.

[4] Our constructed funding liquidity risk (LIQ) and the net money market funding (NMMF) indicators follow closely to what has been implemented in the treasury departments of major German banks. The following

4 Descriptive statistics

Tables 1, 2 and 3 outline some key descriptive statistics for our main variables, including central bank transactions. Table 2 shows the structural differences between loan issuance and deposit intakes over time. We split our sample for the descriptive analysis in three distinct time periods: i) the tranquil (normal) phase, ii) the first crisis phase starting on 9th August 2007, when BNP Paribas was forced to freeze three of its funds[5], and iii) the second crisis period after the collapse of Lehman Brothers on 15th September 2008 which pushed the Euribor-Eurepo spread to new all-time highs.

From these descriptive statistics it is interesting to note that only around 17% of all transactions were interbank loans, where the bank extended credit to another financial institution. Moreover, the difference between the price of loans to deposits was on average always positive and around 70% of all transactions were overnight. Deposits had on average a longer maturity than loans. Interestingly, the average maturity on interbank loans has risen after the collapse of Lehman Brothers. Overall the average amount is significantly higher for loans. Thus, the bank engages in its money market trades in lot size transformation and pooled deposits to issue loans and thereby profited from the average interest rate spread which was always positive across the different time regimes. This also indicates that the bank was indeed a market maker in the money market, making a profit though its trading activities rather than funding the liquidity needs of other business units. Looking at the rating distributions, one can clearly see that loans were on average granted to counterparties rated two notches higher than for counterparties that deposited funds with the bank. Moreover, the mean rating for loans increased over time from A at the beginning of the sample, to AAA after the collapse of Lehman Brothers. This may indicate that the bank increased its lending standards with the onset of the crisis due to worries about counterparty credit risks. In fact, the bank stopped lending to counterparties with a rating below A completely. The issued average amount of loans, however, remained unaffected. During the two sample years, a total of 33 traders conducted money market transactions for the bank. Of the 33 traders however, only 14 were trading over all sub-sample periods. Each trader made on average 550 trades. We will control for trader-specific effects in the panel regression

paragraph provides a short summary of what Deutsche Bank and Commerzbank (No. 1 and No. 2 in Germany in terms of balance sheet size) have implemented with respect to their liquidity risk management: (Net) liquidity and funding risks are steered by the treasury department, taking into account the liquidity risk structure for a one-year time horizon. Reporting systems are run on a daily basis, providing liquidity and funding risk information to the bank's branches and the headquarter. There is an operational liquidity risk management in place which is based on an intraday setting. Funding limits apply to (i) the cumulated global cash flows from the money market and to (ii) the total volume of unsecured funding from this market. See also: Annual Report 2013 of Deutsche Bank AG (pp. 184-191; March 2014): `https://www.db.com/ir/en/download/Deutsche_Bank_Annual_Report_2013_entire.pdfandAnnualReport2013ofCommerzbank` and the Annual Report 2013 of Commerzbank AG (pp. 126-127; March 2014): `https://www.commerzbank.de/media/aktionaere/service/archive/konzern/2014_2/Geschaeftsbericht2013_Konzern_EN.pdf`.

[5]The three months Euribor-Eurepo spread, a measure for the sentiment of trading participants in the money market, shoot up to 100 basis points and remained at an elevated level for the remainder of the sample period.

with trader-fixed effects.

[Table 1 and 2 about here]

Table 3 depicts the total observations and the means of the three order book entries with respect to the rating of the respective counterparty with which the bank traded. Looking at the *Fixed rate*, it is clearly evident that the rates the bank charges for the most creditworthy borrowers (AAA-rated) is the same as the rate it pays when it takes a deposit in. For borrowers with worse ratings the spread between loan and deposit rates is positive but not strictly increasing with deteriorating credit quality. This is likely due to a selection effect in crisis periods. We find a very similar pattern for the mean maturity and the mean amount of the transaction across the rating classes.

[Table 3 about here]

Finally, we depict the evolution of our LIQ measures in Figure 1: In plot (a), we show the LIQ indicator calculated as the end-of-day closing balance. Plot (b) shows the real time version (i.e. calculated trade-by-trade) LIQ indicator which is used as the specification for the main models. The daily LIQ measure displays a much lower variation than the trade-by-trade LIQ measure and also has a lower overall level of funding liquidity risks. This suggests that the bank indeed actively manages its funding liquidity risk and tries to reduce it towards the end of the trading day.

[Figure 1 about here]

5 Methodology

5.1 Econometric strategy

In terms of econometric strategy, we will estimate two different types of econometric specifications for our models. First, we use a standard OLS regression of the form

$$y_i = x_i'\beta + u_i,\ i = 1, ..., N \tag{3}$$

However, our data set also allows us to construct two panel perspectives which we use as robustness checks: First, we are able to identify the exact name of the counterparty which allows us to run a panel regression by tracking the name of the counterparty over time. This specification allows us to account for time-invariant counterparty-specific factors which we couldn't otherwise include in our model. Secondly, we can match the name of each trader to the respective transaction which allows us to split the interbank pricing of the bank itself into its components by accounting for the respective trader who was responsible for the conditions of the trade. This also allows use to capture trader-specific effects like time-invariant personality characteristics, attitudes to risk or time-invariant relationship banking effects. We will estimate a standard panel regression model of the form

$$y_{jt} = \alpha_j + x'_{jt}\beta + u_{jt}, \quad t = 1, ..., T; \;\; j = 1, ..., N \tag{4}$$

where α_j can be specified as the j's bank/trader fixed- or random effects. As we will show, there are no major differences between the fixed- and random effects models and thus, we do not report the Hausmann test.

5.2 Model specifications

For our main specifications, we estimate eight models by OLS. We run separate estimations for (i) deposits and (ii) loans using the logs of the respective rates as our dependent variable. When analyzing how increases in the funding liquidity risks transmit to the bid/ask spread of liquidity, we also run one regression where all deposit and loan trades enter a single regression.

In Model 1, we include the *Eurepo* in logs as the risk-free benchmark rate which serves as the pricing intercept for each transaction as well as the *maturity*, and the *amount* of each trade. We expect that a one percentage change in the Eurepo leads to an approximate one percentage change for the deposit price and a slightly stronger change in the loan price. Model 2 introduces the main explanatory variable, the funding liquidity measure, *LIQ*, lagged by one observation. Additionally, the *inventory* holdings, lagged by one observation, are included. Model 3 introduces an interaction term *LIQ * Maturity*. While model 2 only allows to assess whether the pricing of liquidity obtained and deposited at the bank varies with its assumed liquidity risk, model 3 also tests whether the pricing of further liquidity risks assumed by the bank is determined by the liquidity risk that it accumulated in past trades. Thus, model 3 tests whether the bank actually manages its funding liquidity risks: If the bank is willing to pay a higher price for an interbank deposit when its funding liquidity risk increased with the last trade *and* if it can secure a higher maturity for the deposit with the current trade, then the bank manages its liquidity risks actively.

Model 4 includes the variable *Ratings* to control for counterparties' credit quality. We expect that banks with a worse credit rating have to pay a higher mark-up when borrowing liquidity. From model 4 onwards, we also allow for monthly time fixed effects to account for intertemporal changes in the mark-ups. The base category for our *Ratings* indicator is the *AAA* rating category for both, deposit and loan trades. Model 5 accounts for the one-day lagged changes in the credit risk spread of the bank itself (*Five year CDS*). The more risky the bank is perceived by market participants, the higher the risk premium should be when the bank borrows from interbank market participants. If the bank can (partially) roll over this price increase in its own refinancing costs, we should also find a positive response of the loan rates to increases in the bank's default swap rate. Model 6 includes the one-day lagged *3 months Euribor-Eurepo spread (in logs)* to account for market-wide increases in the counterparty credit risk and elevated systemic risk.

In model 7, we account for *Relationship lending and deposit-taking.* We expect that if the bank conducted more frequent trades with a specific counterparty that it may demand a lower price for its loan transactions. Finally, in model 8 we interact *LIQ*, the *LIQ*Maturity* interaction, the *NMMF*, the *Five year CDS*, and the *Relationship* variables with three time regimes: (i) the tranquil phase until August 2007, (ii) the subprime crisis phases from August 2007 to September 2008, and (iii) the Lehman crisis phase from September 2008 to December 2008. This way, we can assess the relative role of these variables, particularly the liquidity and the credit risks, over the various time regimes.

In addition to these 8 models, we estimate further models to check the robustness of our results. All robustness checks are carried out for model 7 only. For *RC1* and *RC2*, we re-estimate model 8 as (i) a panel regression with counterparty specific effects[6] and (ii) a panel regression with trader specific effects. For *RC3* to *RC5* we calculate the funding liquidity risk measure (i) on a end-of-day basis (RC3) to allow for frictions in the coordination amongst traders during the day, (ii) by excluding all central bank transactions, (iii) by excluding those transactions which were conducted with the European Central Bank or the Deutsche Bundesbank. Note that those transactions are also excluded from the empirical regressions. For *RC6*, the main specification of LIQ is used again, this time excluding all central bank transactions in the empirical regression (but including those in the *LIQ* specification). *RC7* re-runs Model 8 with robust standard errors. Finally, for *RC8* and *RC9*, we re-run model 7 for the tranquil pre-crisis phase until August 2007 and the crisis phase August 2007 to December 2008 only respectively to account for the structural change in the behavior of our key variables (see Figure 1).

6 Empirical Results

Table 4 reports the results for our main models. As regards to the standard pricing factors, we find the risk-free rate, *Eurepo*, to be highly positively significant across all models and of a plausible magnitude: If the one-day lagged Eurepo increases by one percent, the bank pays (charges) around one percent more in terms of the price of a deposit and loan respectively.[7] The *Amount* of the trade has a significantly positive impact for the deposit regressions. The considered bank is willing to pay more if it can secure a deposit intake with a larger Euro amount. As expected, an increase in the *Maturity* has a positive impact on the pricing of deposits. Loan rates are surprisingly not significantly dependent on the size and the maturity of a granted loan across all specifications. This might be due to a selection problem. Note however, that the *Maturity* measure, as used in this paper, has to been seen as an add-on term premium, since we matched an Eurepo rate with a maturity corresponding to the maturity of

[6]We thus control for the rating indirectly by running bank fixed effects regressions.

[7]Note that the regression output gives a coefficient slightly above 1 for both the deposit and loan regressions even after controlling for credit risk and other factors. This is reasonable due to the fact that we do not interpolate between the Eurepo rates and use the next lower maturity for matching.

each transaction.

Turning to the key variable of interest, we find that the assumed liquidity risk faced by the market maker significantly affects the rate he pays for deposit intakes. This holds for all model specifications. Similarly, an increase in the accumulated liquidity risk also leads to a significantly higher price charged for an interbank loan. Thus, liquidity becomes pricier the higher the assumed liquidity risk of the market maker. Moreover, as the results for model 3 onwards show, *LIQ * Maturity* has a highly significant effect across all models: this implies that the bank is willing to pay more for longer-term deposit and charges a higher price for a longer-term loan when it has accumulated an elevated level of liquidity risks. This implies that the market maker indeed actively manages the maturity mismatch in his orderbook. On the other hand, it also implies that it becomes pricier for other market participants to offload liquidity risks with the market maker the higher his assumed liquidity risk already is. Surprisingly the *Net money market funding* has not the expected sign.[8] Looking at the different subperiods separately, though, reveals that this is only due to the crisis period: results reported in Table 5 show that in normal times, the *Net money market funding* indicator has the expected significantly negative effect. The more funding the bank already received from interbank markets, the less it is willing to pay for further deposits. However, for the crisis time, the positive effect dominates both for deposit and loan rates. This might actually reflect a reversed causality: in this period banks hoarded liquidity. Thus in order to increase its net money market funding, the bank increased the mark-up it paid for deposits while at the same time charged also a higher mark-up on unsecured loans. This is in line with the finding of Acharya and Merrouche (2013), who show that large settlement banks in the UK paid a lower price in the interbank market if their liquidity buffers increased in a period of normalcy but find a significant inversed relationship after the onset of the crisis.

As regards to the credit risk measures, we find that for counterparties with a weaker credit rating than the base group (the base group is *AAA*-rated banks) that loans are significantly pricier. However, for weaker credit ratings, we do not find a strictly increasing credit risk premium for deteriorating credit risks. Interestingly, we find significantly negative coefficients for the ratings of counterparties from which the bank obtained liquidity: banks with a poorer credit rating than *AAA* get paid a lower deposit rate by the market maker. This likely indicates that the market maker uses its market power to squeeze a lower rate on the borrowing from lower-rated counterparties, knowing that those banks' outside options are limited (see Ashcraft and Duffie, 2007).

The one-day lagged change in the *five year CDS* of the market maker has – for our full sample estimates – no significant effect on the deposit rate he has to pay, while the rate paid on loans granted by the market maker declines for a increase in his own market-perceived credit risk. This is similar to what we observe for deposit rates paid by the market maker when deposits are received from weaker-rated counterparties. Hence, the market power of the market

[8] This result even holds, when we re-run model 2 without *LIQ* and the *LIQ * Maturity* interaction. Results not reported here for brevity.

maker seems also to be related to his credit standing. Finally, an increase in the *market-wide counterparty credit risk* (3 months Euribor - 3 months Eurepo) leads the bank to increase its price for interbank loans, whereas market wide changes in the credit risk have no influence on the price the bank has to pay for obtaining liquidity in the interbank market. However, the effect on loans is economically rather small: a one percent increase in the market wide credit risk increases the price of loan transaction on average by only 0.13%. Nonetheless, it is interesting to note that in addition to the borrower specific credit risk (measured by the rating) this measure of systemic risk also matters for the pricing of interbank liquidity. We qualify these results further when looking at the time period interactions on the credit risk measure in model 8.

Turning to the *Relationship* variables, we find that the bank pays a higher price for deposits to banks that frequently supplied funds to the market maker in the past. However, for loans granted, the market maker charges a higher rate to borrowers that recently received funds from him. Since we cannot model the factors responsible for the individual credit decision of the market maker, this effect might result from a selection effect: relationship borrowers might still get credit from the market maker but had to pay a markup on the lending rate (see Braeuning and Fecht (2012) for a more detailed analysis of this). But it might also be an indication for a hold-up (see Acharya et al., 2008). As we will show later on, controlling for time invariant counterparty characteristics (counterparty fixed effects) does not affect these results. Furthermore, we find that both effects on deposits as well as loan rates hold particularly during the subprime crisis (see Table 5). However, for the Lehman crisis time, the relationship effect for loans vanishes completely and the effect for deposit intakes becomes significantly negative.

[Table 4 about here]

Model 8 in Table 5 depicts the results for our difference-in-difference analysis, where we interacted the key explanatory variables with time dummies (normal, subprime and Lehman time regimes) to see whether their effect on the pricing of liquidity was significantly different in the different subperiods. Noteworthy is that *LIQ* is significantly negative for the deposit regression and insignificant for the loan regression and that active funding liquidity risk played no role for the pricing of loans in the normal time period. It was not before the onset of the financial crisis in August 2007 that the bank reacted with price increases to an increase in its funding liquidity risk for both, loans and deposits. Moreover, only with the onset of the crisis, the bank started to price the maturity of loans and deposits differently depending on its accumulated liquidity risk in past trades.

As already discussed above, the *Net money market funding* has the expected sign only for the normal time period. With the onset of the crisis, the mark-up increased on both, deposit and loan prices, with an increased net money market funding which might reflect the bank's liquidity hoarding (see Acharya and Merrouche, 2009). Looking at the bank's own credit risk, (*5 year CDS*), we find that an increase in the bank's own credit risk did not play any role for the pricing of its loans, neither did the bank had to pay a mark-up for its deposit intakes in a phase of normalcy. This changed for the first time during the subprime crisis: surprisingly, at the start of the financial crisis, each increase in the bank's credit risk led actually to a lower price for both deposits and loans.

However, after the failure of Lehman Brothers in September 2008, an increase in the bank's perceived credit risk led market participants to not only require a significantly higher risk premium from the market maker for their interbank deposits, but the market maker also significantly increased the rate he charged from borrowers. This suggests that the market maker rolled over the risk premium he had to pay in the interbank market to his borrowers. Thus banks borrowing from the market maker not only paid 'their' credit risk premium, but they also had to pay for the lenders' risk premium. Hence, the credit risk premia actually seem to have accumulated along the 'intermediation chain' in the interbank market which might have contributed to the extreme increase in the spread between secured and unsecured interbank rates observed after the collapse of Lehman Brothers.

[Table 5 about here]

So far, we considered the pricing of loans and deposits in separate regressions. Our results already show that an increase in the funding liquidity risk assumed by the market maker makes trading for liquidity with him pricier, i.e. the rates on loans and deposits increase. In addition, our results indicate that with a higher level of accumulated liquidity risks, the market maker prices further liquidity risks higher, i.e. the mark-up he pays and charges for longer-term deposits and loans, respectively, is higher if he already runs a high maturity mismatch. Thus, very much along the lines of Brunnermeier and Pedersen (2009), we find that a higher funding liquidity risk of the market maker indeed increases the market price of liquidity.

To see whether a higher accumulated funding liquidity risk of the market maker leads to a deterioration of the money market liquidity, we next study the effect of a change in *LIQ* on the realized bid-ask-spread that the market maker quotes. In order to do so, we re-run an adjusted version of model, using a difference-in-difference regression – including simultaneously both loans and deposits – but interacting our key explanatory variables with a dummy variable for the type of contract, i.e. a dummy equalling one if the trade was for loan and zero if it was for a deposit. This permits us to calculate the price difference (price delta) between loans and deposits for varying levels of *LIQ* while controlling for counterparty credit risk effects and influences of aggregate interbank market conditions. Figure 2 represents graphically our key results. As panel (a) of Figure 2 shows, except for extremely negative values for *LIQ* (below c.200,000 millions), the price delta between loans and deposits is statistically significant. More importantly, it also significantly increases in the funding liquidity risk retained by the market maker, leading to a wider bid-ask spread as *LIQ* increases. Hence, we find evidence for a destabilizing reinforcement between funding liquidity risks of a market maker and the realized bid-ask-spread in the interbank market as theoretical models such as Gromb and Vayanos (2002) would suggest. Even more interesting, when considering the implications for the price sensitivity to the maturity of the respective transaction (*LIQ * Maturity*), we find that the market maker gets more averse to further maturity mismatches the larger his current accumulated funding liquidity risk is. Panel (b) of Figure 2 depicts the sensitivity of the price difference between loans and deposits to a change in *LIQ* for a fairly long maturity (100 days) and a fairly short maturity (c.3 days). As it can easily be seen, for larger positive levels of assumed liquidity risks the market maker increases the mark-up on loans relative to deposits significantly more for longer-term than for shorter-term contracts. Hence, the realized bid-ask-spread for longer term transactions is larger and offloading liquidity risk with the market maker involves higher transaction costs the higher the market makers current funding liquidity risk level already is.

[Figure 2 about here]

7 Robustness checks

To check the robustness of our key findings, we run a large battery of further specifications. On the right hand side of Table 5, we ran model 8 with (a) bank-specific fixed- and random effects (*RC1*) and (b) trader-specific fixed- and random effects (*RC2*). The results point towards the same overall direction as our plain OLS regressions and also the coefficients are not very different when compared to the OLS estimates. Hence, controlling for time invariant unobservable counterparty or trader effects leave our results largely intact. *RC3* to *RC5* in Table 6 show the results when we use differently calculated measures for *LIQ*: Most importantly, independent of which specification for *LIQ* is used, the active funding liquidity management remains highly significantly positive across deposit and loan transactions: *RC6* uses *LIQ* as specified in the main models but excludes all transactions with central banks. As it can be seen, our results stay robust. The same holds when we re-run model 7 using robust standard errors (see *RC7*). Finally, one might get the notion that *LIQ* has undergone a regime shift after the onset of the financial/Lehman Brothers crisis when looking at Figure 1. Hence, we split our sample in two distinct subperiods: *RC8* shows our results when only the sample period from January 2007 to before the Lehman collapse is used and *RC9* shows the results when only the crisis time from August 2007 to December 2008 is used. As it can be seen, our results stay broadly robust.

[Table 5 and 6 about here]

8 Conclusions

All in all, our empirical analysis provides four key insights: First, the larger the funding liquidity risk assumed by the market maker, the higher the market price for liquidity (the price the market maker pays for deposits and the rate he charges for loans). The market maker seems to hoard liquidity in response to a higher liquidity risk exposure. Second, a higher accumulated liquidity risk by the marker maker goes along with a higher term premium (longer term loans and deposits pay a higher rate compared with respective shorter contracts). Thus it becomes pricier for other market participants to reduce their liquidity risk by trading with the market maker. Third, the market liquidity – measured by the realized bid-ask-spread charged by the market maker –

rises significantly if the funding liquidity risk retained by the market maker increases. Thus, transaction costs in the unsecured money market increase and the efficiency of the liquidity reallocation within the banking sector deteriorates with the market makers' funding liquidity risks. Forth, market liquidity is more sensitive to the accumulated liquidity risk for longer-term contracts. The realized bid-ask-spread rises substantially for longer term loans and deposits if the market maker's liquidity risk increases, while such an increase has much less of an effect for short term contracts. This suggest that particularly in the term lending segment of the money market, liquidity and transactions costs depend on the market makers' funding liquidity risks. Furthermore, we find, at least in the crisis period, that a deterioration in the market makers own perceived credit quality not only required him to pay a higher risk premium on deposits received, but he also charged a higher mark-up on loans. Hence, he was apparently able to roll over his own elevated funding costs to his borrowers. In sum, we find along various dimensions a detrimental effect of the market makers' assumed funding risks and funding costs on the market conditions in the unsecured money market.

These findings have important policy implications. Obviously, the market maker is a money center bank and a systemically important financial institution for the Euro area. But it is not only systemically important because it imposes a huge credit risk on interbank lenders and thus creates a risk of significant knock-on effects. In fact, our results also show that liquidity becomes pricier and the efficiency of its reallocation in the banking system is impaired by higher retained funding liquidity risks of the market maker (and not only by a failure of this financial institution, which obviously becomes also more likely the higher the accumulated risks are). But if an elevated funding liquidity risk level of money center banks indeed affects money market liquidity, then liquidity risks are likely to feed back into an elevated risk associated with a given maturity mismatch, potentially sparking off a liquidity spiral very much in line with Shleifer and Vishny (1997), Gromb and Vayanos (2002) and Brunnermeier and Pedersen (2009). Thus, our results support the view that systemically important financial institutions should not only be subject to higher minimum capital requirements but that they should also be obliged to maintain a larger liquidity buffer.

As regards to monetary policy implications, our results indicate that funding risks of market makers in the Euro area money markets, in particular their retained liquidity risk, aggravated the increase in unsecured money market rates and contributed to the dry-up of this market. Thus, the European Central Bank was obviously well advised to mitigate these effects not only by allotting further liquidity to the banking system, but also by providing liquidity at longer maturities via LTRO operations. This way, the ECB likely helped to contain an even stronger increase in the spread levels between unsecured and secured interbank lending rates and fostered market liquidity in the unsecured interbank market.

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Table 1: Descriptive statistics of the empirical variables

This table presents some key descriptive statistics for the explanatory variables for the time period January 2007 to December 2008 which are used in the empirical regressions. The **Order book data** was directly supplied by the bank, the **Liquidity measures** are calculated using the order book data and the formulas outlined in the main text, and the **Market data** were obtained from Bloomberg and appropriately matched to each transaction.

	Simple mean	Median (p50)	Minimum	Maximum	Standard Dev.	25th percentile	75 percentile
Order book data							
Fixed rate (in %)	3.65	3.85	1.4	4.89	0.57	3.51	4
Log of fixed rate	1.28	1.35	0.34	1.59	0.19	1.26	1.39
Maturity (in days)	2.90	1.20	1.02	185.19	6.20	1.13	3.13
Amount (in EUR millions)	176	10	0	33,100	1,230	3	47
Liquidity measures							
LIQ (in EUR millions)	78,300	51,800	-306,000	930,000	135,000	-12,200	138,000
LIQ daily (in EUR millions)	55,800	24,900	-245,000	438,000	122,000	-15,500	86,700
LIQ excl. CB (in EUR millions)	73,500	47,900	-302,000	828,000	129,000	-11,300	131,000
LIQ excl. facilities (in EUR millions)	75,400	49,600	-305,000	840,000	131,000	-12,000	134,000
Net money market funding (in EUR millions)	-6,550	-4,100	-62,000	14,300	9,230	-10,200	-92
Market data							
Eurepo (in %)	3.83	4.01	1.87	4.52	0.47	3.63	4.06
Log of Eurepo	1.33	1.39	0.63	1.51	0.14	1.29	1.40
3 months Euribor - Eurepo (in %)	0.65	0.60	0.06	3.17	0.51	0.08	0.80
Log of 3 months Euribor - Eurepo	-0.90	-0.51	-2.90	1.15	1.12	-2.49	-0.22
Abs. change of the bank's CDS (in %)	0.19	0.04	-50.93	35.64	6.65	-1.37	2.00

Table 2: Descriptive statistics over different time regimes

This table presents the descriptive statistics for key order book metrics over (i) the total sample period, (ii) the tranquil phase from Janauary 2007 to August 2007, (iii) the subprime crisis phase from August 2007 to September 2008, and (iv) the post Lehman collapse time period from September 2008 to December 2008. Note that the average amount is shown excluding central bank transactions and the average rating is calculated by excluding non-rated (N/A) banks.

	Total Sample 01/2007 - 12/2008	Tranquil Phase 01/2007-08/2007	Subprime Crisis 08/2007 - 09/2008	Lehman collapse 09/2008 - 12/2008
Average fixed rate (in %)				
Deposits	3.61	3.70	3.93	2.80
Loans	3.90	3.84	4.04	3.06
Average maturity (in days)				
Deposits	2.9	2.8	3.0	2.6
Loans	1.5	1.7	1.4	1.8
Average amount (in EUR millions, w/o CB)				
Deposits	32	39	29	31
Loans	525	551	502	664
Average rating (w/o N/A)				
Deposits	BB	BB	BB	BB-B
Loans	AA	A	AA	AAA
Number of transactions				
Deposits	15485	4218	7732	3535
Loans	2609	646	1723	240
Number of counterparties	450	270	349	243
Number of traders	33	23	29	19
Average trades per day	35	32	33	50
Transactions with central banks				
Deposits	276	166	63	47
Loans	97	0	24	73

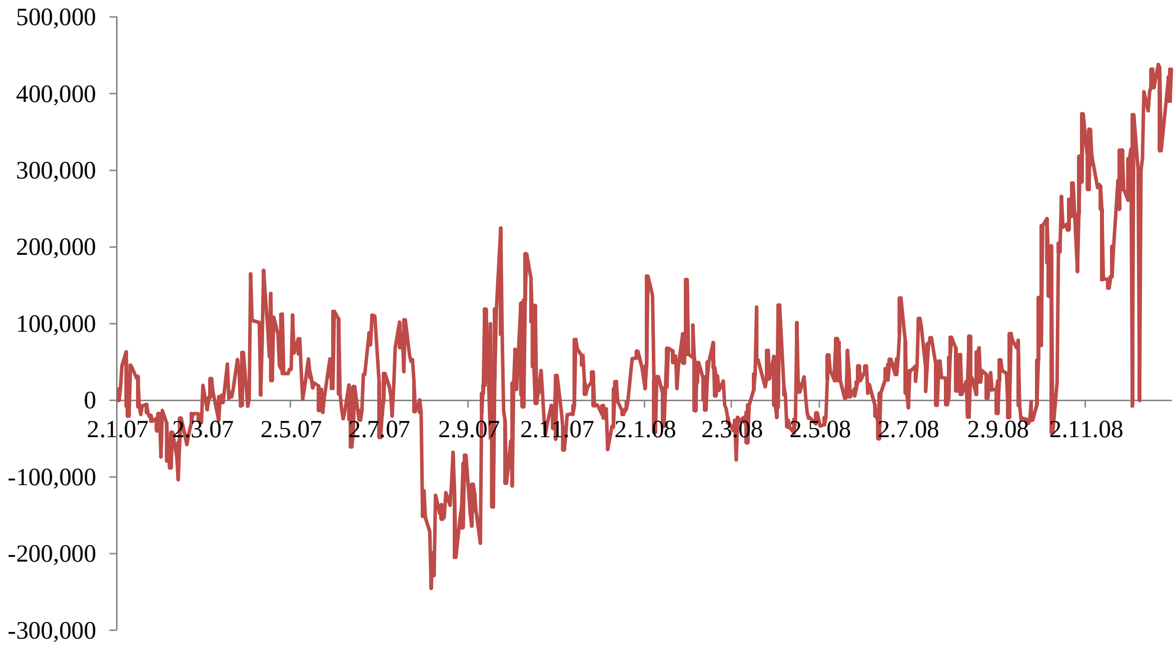
Table 3: Descriptive statistics according to rating and transaction type

This table depicts the total observations and the means of the three order book entries with respect to the rating of the respective counterparty with which the bank traded for the time period January 2007 to December 2008. Note that **N/A** means that no official rating was available. The ratings were obtained from Fitch, Standard & Poor's and Moody's. If more than one rating agency provided a rating, we gave preference to Fitch, then to Standard & Poor's and then to Moody's.

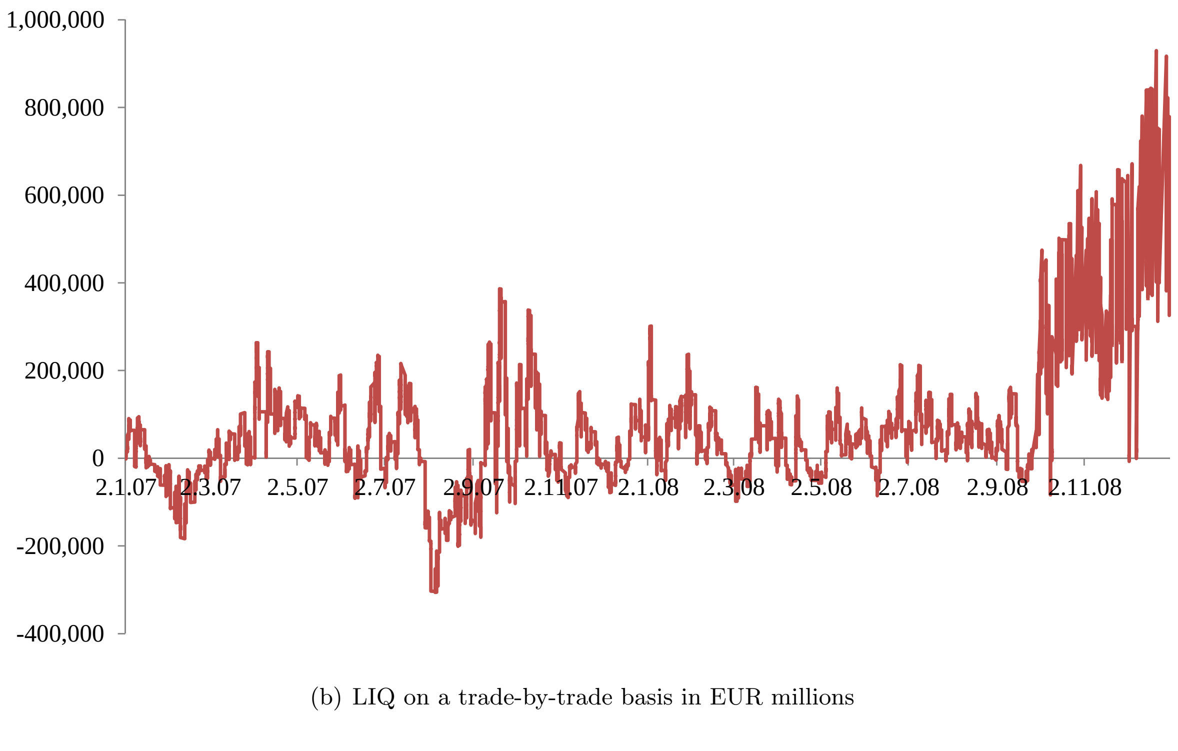
	AAA	**AA**	**A**	**BBB**	**BB**	**B**	**CCC**	**N/A**
Total Observations								
Deposits	1369	1701	254	558	1978	923	6932	1770
Loans	572	1451	315	4		32	82	153
Mean Fixed Rate (in %)								
Deposits	3.72	3.59	3.67	3.66	3.67	3.60	3.65	3.30
Loans	3.72	3.98	3.89	3.97		4.01	3.92	3.49
% gap (loan rate/deposit rate)	*0%*	*11%*	*6%*	*9%*		*11%*	*7%*	*6%*
Mean Maturity (in days)								
Deposits	1.93	2.31	3.03	4.4	2.08	2.84	3.4	3.26
Loans	1.71	1.81	1.86	1.25		2.27	1.9	2.04
% gap (loan MAT/deposit MAT)	*-11%*	*-22%*	*-39%*	*-72%*		*-20%*	*-44%*	*-37%*
Mean Amount (in EUR millions)								
Deposits	226	101	45	28	16	6	26	21
Loans	795	525	462	388	0	70	1,141	8,066
% gap (loan amount/deposit amount)	*251%*	*419%*	*932%*	*1263%*		*1051%*	*4336%*	*38564%*

Figure 1: Evolution of key empirical variables over the sample period

This panel of graphs shows the evolution of the differently calculated liquidity measures for the whole sample period January 2007 to December 2008: In plot (a), the LIQ indicator calculated as the end-of-day closing balance is shown. Plot (b) shows the real time version (calculated trade-by-trade) LIQ indicator which is used as the specification for the main models.



(a) LIQ on a daily basis in EUR millions



(b) LIQ on a trade-by-trade basis in EUR millions

Table 4: Main Models (Models 1 to 7)

This table shows the empirical results for our main model specifications, separated by the transaction type (loan or deposit transaction) for the full set of 17,721 observations (January 2007 to December 2008), excluding transactions with central banks. Each model is estimated by OLS and from model 4 onwards, monthly time fixed effects are included in the estimation process (not shown in the regression output). Note that the dependant variable, **Fixed rate**, is in logs. The regression output is separated by variable group attributes: For the *order book data* group, note that the **Eurepo** is in logs and the maturity of the Eurepo has been matched to the maturity of the respective transaction. This variable is lagged by one day. For the liquidity and net money market funding measures, note that **LIQ** is calculated on a trade-by-trade basis using all 18,094 transactions. Both variables are lagged by one trade observation. For the *ratings and credit risk measures* group, note that the base group for **Ratings** is the *AAA*-group for both, the deposit and loan regressions. Also note here, that the **Five year CDS** is for the bank from which we obtained the data, lagged by one day and in terms of daily first order differences. The **3 months Euribor-Eurepo spread** is in logs and controls for increases in the market wide credit risk in the interbank market. For the group *Relationship dummies*, note that the **Relationship dummy** is equal to one if the bank from which we obtained the data has traded with the same counterparty and in the same transaction type within the last 350 trades (which equals a time horizon of around two weeks). Finally note that the **Constant** changes to the first monthly time fixed effect (**TFE intercept**) when including TFEs in the regressions.

	Orderbook data (M1)		**Liquidity (M2)**		**LIQ * Maturity (M3)**		**Rating (M4)**		**CDS of the bank (M5)**		**Aggregate CCR (M6)**		**Relationships (M7)**	
	Deposits	*Loans*	*Deposits*	*Loans*	*Deposits*	*Loans*	*Deposits*	*Loans*	*Deposits*	*Loans*	*Deposits*	*Loans*	*Deposits*	*Loans*
Order book data														
Eurepo (in logs)	1.23***	0.98***	1.12***	0.96***	1.12***	0.96***	1.04***	1.22***	1.04***	1.22***	1.04***	1.22***	1.04***	1.22***
	(0.0035)	(0.010)	(0.0044)	(0.011)	(0.0044)	(0.011)	(0.010)	(0.036)	(0.010)	(0.036)	(0.010)	(0.036)	(0.010)	(0.036)
Amount (in EUR)	9.5e-12*	-2.6e-12	-4.7e-12	-9.2e-13	-4.0e-12	-9.8e-13	1.5e-11***	-5.5e-13	1.5e-11***	-5.7e-13	1.5e-11***	-6.6e-13	1.6e-11***	-1.2e-12
	(5.5e-12)	(2.1e-12)	(5.2e-12)	(2.1e-12)	(5.2e-12)	(2.1e-12)	(4.5e-12)	(2.1e-12)	(4.5e-12)	(2.1e-12)	(4.5e-12)	(2.1e-12)	(4.5e-12)	(2.1e-12)
Maturity (in days)	0.0019***	0.00042	0.0018***	0.00040	0.0016***	0.00027	0.0015***	0.000053	0.0015***	0.000071	0.0015***	0.000066	0.0016***	0.00010
	(0.000084)	(0.00034)	(0.000079)	(0.00034)	(0.000086)	(0.00034)	(0.000072)	(0.00032)	(0.000072)	(0.00032)	(0.000072)	(0.00032)	(0.000073)	(0.00032)
Liquidity and inventory measures														
Funding liquidity risk (LIQ)			1.9e-13***	6.9e-14**	1.8e-13***	5.3e-14*	3.9e-13***	1.6e-13*	4.0e-13***	1.6e-13*	3.9e-13***	2.1e-13**	3.8e-13***	2.2e-13**
			(1.7e-14)	(2.8e-14)	(1.7e-14)	(2.9e-14)	(3.5e-14)	(8.3e-14)	(3.5e-14)	(8.3e-14)	(3.6e-14)	(8.7e-14)	(3.6e-14)	(8.7e-14)
Net money market funding			5.5e-12***	1.6e-12***	5.5e-12***	1.6e-12***	5.7e-12***	3.0e-12**	5.8e-12***	3.1e-12**	5.6e-12***	3.8e-12***	5.6e-12***	3.9e-12***
			(2.5e-13)	(4.1e-13)	(2.5e-13)	(4.1e-13)	(5.1e-13)	(1.2e-12)	(5.1e-13)	(1.2e-12)	(5.2e-13)	(1.3e-12)	(5.2e-13)	(1.3e-12)
Interaction: LIQ * Maturity					4.8e-15***	9.0e-15***	4.7e-15***	7.9e-15***	4.7e-15***	8.1e-15***	4.7e-15***	7.9e-15***	4.8e-15***	7.5e-15***
					(6.4e-16)	(3.0e-15)	(5.3e-16)	(2.8e-15)	(5.3e-16)	(2.8e-15)	(5.3e-16)	(2.8e-15)	(5.3e-16)	(2.8e-15)
Ratings and credit risk measures														
Rating: AA							-0.073***	0.037***	-0.073***	0.037***	-0.073***	0.037***	-0.073***	0.037***
							(0.0037)	(0.0032)	(0.0037)	(0.0032)	(0.0037)	(0.0032)	(0.0037)	(0.0032)
Rating: A							-0.064***	0.034***	-0.064***	0.034***	-0.064***	0.034***	-0.064***	0.035***
							(0.0038)	(0.0035)	(0.0038)	(0.0035)	(0.0038)	(0.0035)	(0.0038)	(0.0035)
Rating: BBB							-0.061***	0.030***	-0.061***	0.031***	-0.061***	0.031***	-0.061***	0.032***
							(0.0039)	(0.0088)	(0.0039)	(0.0088)	(0.0039)	(0.0088)	(0.0039)	(0.0088)
Rating: BB							-0.053***		-0.053***		-0.052***		-0.053***	
							(0.0037)		(0.0037)		(0.0037)		(0.0037)	
Rating: B							-0.086***	0.045*	-0.086***	0.046*	-0.086***	0.046*	-0.086***	0.051**
							(0.0041)	(0.024)	(0.0041)	(0.024)	(0.0041)	(0.024)	(0.0041)	(0.024)
Rating: CCC							-0.058***	0.038***	-0.058***	0.038***	-0.058***	0.038***	-0.058***	0.038***
							(0.0036)	(0.0063)	(0.0036)	(0.0063)	(0.0036)	(0.0062)	(0.0036)	(0.0062)
Rating: N/A							-0.064***	0.045***	-0.064***	0.045***	-0.064***	0.045***	-0.064***	0.047***
							(0.0038)	(0.0059)	(0.0038)	(0.0059)	(0.0038)	(0.0059)	(0.0038)	(0.0060)
Five year CDS (one-day change)									0.000099	-0.00053**	0.000094	-0.00051**	0.000094	-0.00049**
									(0.000060)	(0.00020)	(0.000060)	(0.00020)	(0.000060)	(0.00020)
3 months Euribor-Eurepo spread (in logs)											-0.0033	0.014**	-0.0034	0.015**
											(0.0022)	(0.0070)	(0.0022)	(0.0069)
Relationship dummies														
Relationship dummy (c.2 weeks; deposits)													0.0045***	
													(0.0014)	
Relationship dummy (c.2 weeks; loans)														0.0068***
														(0.0023)
Constant (or TFE intercept)	-0.37***	0.019	-0.20***	0.052***	-0.20***	0.048***	-0.024*	-0.31***	-0.025*	-0.31***	-0.034**	-0.27***	-0.038**	-0.27***
	(0.0047)	(0.014)	(0.0062)	(0.016)	(0.0061)	(0.016)	(0.014)	(0.046)	(0.014)	(0.046)	(0.015)	(0.050)	(0.015)	(0.049)
Summary statistics														
Observations	15209	2512	15208	2512	15208	2512	15208	2512	15208	2512	15208	2512	15208	2512
Time fixed effects (monthly)	No	No	No	No	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Degrees of freedom	3	3	5	5	6	6	36	35	37	36	38	37	39	38
Log-Likelihood	20154.0	3948.6	20982.1	3963.6	21009.6	3968.2	23965.4	4148.4	23966.7	4151.7	23967.9	4153.8	23973.3	4158.3
AIC	-40302.1	-7891.3	-41958.2	-7921.2	-42013.2	-7930.4	-47864.8	-8232.7	-47865.5	-8237.4	-47865.7	-8239.6	-47874.7	-8246.6
R2 (adjusted)	0.89	0.78	0.90	0.79	0.90	0.79	0.93	0.81	0.93	0.81	0.93	0.81	0.93	0.81

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Table 5: Model 8 and the first robustness checks (Models RC1 and RC2)

This table presents the empirical results for our main Model 8 estimated by OLS and separated by the transaction type (loan or deposit transaction) and the first two robustness checks (RC1 and RC2). The robustness checks essentially are re-runs of Model 8 but RC1 is estimated by running a panel regression model with counterparty fixed/random effects. RC2 is estimated as a panel regression model with trader fixed/random effects. All estimations are carried out for the full set of 18,094 observations (January 2007 to December 2008) and include monthly time fixed effects (not shown in the regression output). Note that the dependant variable, **Fixed rate**, is in logs. The regression output is separated by variable group attributes: For the *order book data* group, note that the **Eurepo** is in logs and the maturity of the Eurepo has been matched to the maturity of the respective transaction. This variable is lagged by one day. For the liquidity and net money market funding measures, note that **LIQ** is calculated on a trade-by-trade basis using all 18,094 transactions. Both variables are lagged by one observation. For the *ratings and credit risk measures* group, note that the base group for **Ratings** is the *AAA*-group for both, the deposit and loan regressions. Also note here, that the **Five year CDS** is for the bank from which we obtained the data, lagged by one day and in terms of daily differences. The **3 months Euribor-Eurepo spread** is in logs and controls for increases in the market wide credit risk in the interbank market. For the group *Relationship dummies*, note that the **Relationship Deposit (D) / Loan (L)** is equal to one if the bank from which we obtained the data has traded with the same counterparty and transaction type within the last 350 transaction. Finally note that the constant changes to the first monthly time fixed effect (**TFE intercept**) when including TFEs in the regressions.

	Plain OLS (M8a)		**Panel regression by Bank ID (RC1)**				**Panel regression by Trader ID (RC2)**			
	Deposits	*Loans*	*Deposits*		*Loans*		*Deposits*		*Loans*	
			FE	RE	FE	RE	FE	RE	FE	RE
Eurepo (in logs)	1.08***	1.21***	1.08***	1.08***	1.17***	1.20***	1.08***	1.08***	1.22***	1.21***
	(0.011)	(0.037)	(0.0099)	(0.0099)	(0.034)	(0.036)	(0.010)	(0.011)	(0.036)	(0.037)
Amount (in EUR)	1.5e-11***	-1.8e-12	-5.9e-13	1.4e-11**	3.3e-12	-2.3e-12	4.6e-11***	1.5e-11***	-2.8e-12	-1.8e-12
	(4.4e-12)	(2.1e-12)	(6.6e-12)	(5.7e-12)	(2.4e-12)	(2.2e-12)	(4.5e-12)	(4.4e-12)	(2.3e-12)	(2.1e-12)
Maturity (in days)	0.0017***	-0.00015	0.0012***	0.0013***	-0.0043***	-0.00017	0.0016***	0.0017***	-0.0019	-0.00015
	(0.000074)	(0.00034)	(0.000089)	(0.000082)	(0.0012)	(0.00034)	(0.000071)	(0.000074)	(0.0012)	(0.00034)
Liquidity & INV measures										
LIQ main effect (0)	-1.7e-13***	-5.3e-14	-1.2e-13**	-1.3e-13***	-5.0e-14	-5.4e-14	-1.9e-13***	-1.7e-13***	-5.4e-14	-5.3e-14
	(5.1e-14)	(1.6e-13)	(4.7e-14)	(4.7e-14)	(1.5e-13)	(1.6e-13)	(4.8e-14)	(5.1e-14)	(1.6e-13)	(1.6e-13)
LIQ main effect (1)	3.8e-13***	2.4e-13**	3.7e-13***	3.7e-13***	1.8e-13*	2.4e-13**	3.7e-13***	3.8e-13***	2.4e-13**	2.4e-13**
	(4.6e-14)	(1.0e-13)	(4.2e-14)	(4.2e-14)	(9.6e-14)	(1.0e-13)	(4.3e-14)	(4.6e-14)	(1.0e-13)	(1.0e-13)
LIQ main effect (2)	1.2e-12***	4.9e-13	1.1e-12***	1.1e-12***	1.1e-13	4.3e-13	1.1e-12***	1.2e-12***	3.6e-13	4.9e-13
	(7.3e-14)	(4.0e-13)	(6.8e-14)	(6.8e-14)	(3.7e-13)	(3.9e-13)	(6.9e-14)	(7.3e-14)	(3.9e-13)	(4.0e-13)
Int.: LIQ * Maturity (0)	5.0e-15***	-8.9e-16	1.2e-15	2.7e-15*	3.5e-14***	-5.7e-16	4.0e-15***	5.0e-15***	2.1e-15	-8.9e-16
	(1.5e-15)	(4.8e-15)	(2.0e-15)	(1.5e-15)	(1.3e-14)	(4.7e-15)	(1.4e-15)	(1.5e-15)	(5.5e-15)	(4.8e-15)
Int.: LIQ * Maturity (1)	1.8e-15*	2.2e-14**	1.8e-15*	1.8e-15*	3.1e-14***	1.9e-14**	1.4e-15	1.8e-15*	3.1e-14***	2.2e-14**
	(1.1e-15)	(9.6e-15)	(1.0e-15)	(1.0e-15)	(1.0e-14)	(9.4e-15)	(1.0e-15)	(1.1e-15)	(1.1e-14)	(9.6e-15)
Int.: LIQ * Maturity (2)	4.5e-15***	1.0e-14**	3.1e-15***	3.6e-15***	9.7e-15*	9.6e-15**	4.1e-15***	4.5e-15***	2.0e-14***	1.0e-14**
	(6.3e-16)	(3.9e-15)	(6.2e-16)	(6.0e-16)	(5.7e-15)	(3.9e-15)	(5.9e-16)	(6.3e-16)	(5.3e-15)	(3.9e-15)
Net money market funding (0)	-2.4e-12***	-5.4e-13	-2.0e-12***	-2.1e-12***	-3.3e-14	-6.1e-13	-2.9e-12***	-2.4e-12***	-5.2e-13	-5.4e-13
	(7.9e-13)	(2.4e-12)	(7.4e-13)	(7.3e-13)	(2.2e-12)	(2.3e-12)	(7.4e-13)	(7.9e-13)	(2.3e-12)	(2.4e-12)
Net money market funding (1)	6.4e-12***	4.6e-12***	6.1e-12***	6.2e-12***	3.7e-12***	4.5e-12***	6.2e-12***	6.4e-12***	4.7e-12***	4.6e-12***
	(6.7e-13)	(1.4e-12)	(6.2e-13)	(6.2e-13)	(1.3e-12)	(1.4e-12)	(6.3e-13)	(6.7e-13)	(1.4e-12)	(1.4e-12)
Net money market funding (2)	1.6e-11***	8.1e-12	1.5e-11***	1.5e-11***	2.2e-12	7.2e-12	1.5e-11***	1.6e-11***	6.4e-12	8.1e-12
	(1.1e-12)	(5.7e-12)	(9.8e-13)	(9.8e-13)	(5.3e-12)	(5.5e-12)	(1.0e-12)	(1.1e-12)	(5.6e-12)	(5.7e-12)
Ratings & CCR measures										
Rating: AA	-0.072***	0.037***		-0.067***		0.033***	-0.019***	-0.072***	0.019***	0.037***
	(0.0036)	(0.0032)		(0.010)		(0.0040)	(0.0041)	(0.0036)	(0.0037)	(0.0032)
Rating: A	-0.063***	0.034***		-0.064***		0.033***	-0.024***	-0.063***	0.019***	0.034***
	(0.0037)	(0.0035)		(0.010)		(0.0043)	(0.0040)	(0.0037)	(0.0039)	(0.0035)
Rating: BBB	-0.059***	0.032***		-0.062***		0.029***	-0.026***	-0.059***	0.018**	0.032***
	(0.0038)	(0.0088)		(0.012)		(0.0096)	(0.0042)	(0.0038)	(0.0088)	(0.0088)
Rating: BB	-0.052***			-0.056***			-0.022***	-0.052***		
	(0.0036)			(0.012)			(0.0041)	(0.0036)		
Rating: B	-0.085***	0.052**		-0.066***		0.049**	-0.038***	-0.085***	0.025	0.052**
	(0.0040)	(0.024)		(0.012)		(0.023)	(0.0044)	(0.0040)	(0.046)	(0.024)
Rating: CCC	-0.057***	0.039***		-0.064***		0.036***	-0.021***	-0.057***	0.023***	0.039***
	(0.0035)	(0.0062)		(0.0097)		(0.0073)	(0.0039)	(0.0035)	(0.0064)	(0.0062)
Rating: N/A	-0.063***	0.045***		-0.065***		0.043***	-0.019***	-0.063***	0.041***	0.045***
	(0.0037)	(0.0061)		(0.0098)		(0.0066)	(0.0041)	(0.0037)	(0.0061)	(0.0061)
5 year CDS (0)	0.00034	0.00016	0.00036	0.00037	-0.00010	0.000073	0.00044	0.00034	-0.00016	0.00016
	(0.00055)	(0.0018)	(0.00051)	(0.00051)	(0.0017)	(0.0018)	(0.00052)	(0.00055)	(0.0018)	(0.0018)
5 year CDS (1)	-0.00026**	-0.0010***	-0.00031***	-0.00030***	-0.00084***	-0.00099***	-0.00027**	-0.00026**	-0.00094***	-0.0010***
	(0.00012)	(0.00025)	(0.00011)	(0.00011)	(0.00023)	(0.00024)	(0.00011)	(0.00012)	(0.00025)	(0.00025)
5 year CDS (2)	0.00044***	0.00081**	0.00048***	0.00048***	0.00034	0.00074**	0.00044***	0.00044***	0.00074*	0.00081**
	(0.000069)	(0.00039)	(0.000064)	(0.000064)	(0.00036)	(0.00038)	(0.000065)	(0.000069)	(0.00038)	(0.00039)
3m Euribor-Eurepo (in logs)	0.014***	0.022**	0.015***	0.015***	0.018**	0.021**	0.014***	0.014***	0.023***	0.022**
	(0.0029)	(0.0088)	(0.0027)	(0.0026)	(0.0080)	(0.0085)	(0.0027)	(0.0029)	(0.0086)	(0.0088)
Relationship dummies										
Relationship D/L (0)	0.0092***	0.0045	0.0086***	0.0079***	0.0054	0.0053	0.0023	0.0092***	0.0055	0.0045
	(0.0024)	(0.0044)	(0.0025)	(0.0024)	(0.0043)	(0.0043)	(0.0023)	(0.0024)	(0.0043)	(0.0044)
Relationship D/L (1)	0.016***	0.0078***	0.012***	0.012***	0.0053*	0.0074***	0.011***	0.016***	0.0078***	0.0078***
	(0.0018)	(0.0028)	(0.0019)	(0.0018)	(0.0027)	(0.0027)	(0.0017)	(0.0018)	(0.0027)	(0.0028)
Relationship D/L (2)	-0.025***	0.0015	-0.030***	-0.029***	-0.0020	-0.00098	-0.030***	-0.025***	-0.0070	0.0015
	(0.0024)	(0.0086)	(0.0025)	(0.0024)	(0.0082)	(0.0084)	(0.0023)	(0.0024)	(0.0085)	(0.0086)
Constant/TFE intercept	-0.044***	-0.23***	-0.092***	-0.032*	-0.16***	-0.23***	-0.076***	-0.044***	-0.24***	-0.23***
	(0.016)	(0.053)	(0.015)	(0.017)	(0.048)	(0.051)	(0.015)	(0.016)	(0.052)	(0.053)
Summary statistics										
Observations	15208	2512	15208	15208	2512	2512	15208	15208	2512	2512
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Degrees of freedom	49	48	443	39	167	38	77	39	69	38
Number of groups			402	402	126	126	29	29	22	22
Group average			37.8	37.8	19.9	19.9	524.4	524.4	114.2	114.2
Log-Likelihood	24301.2	4172.6	25873.5		4512.4		25255.7		4241.4	
R2 (within)			0.93	0.93	0.82	0.81	0.93	0.93	0.82	0.81
R2 (between)			0.93	0.94	0.19	0.62	0.75	0.87	0.64	0.82
R2 (adjusted/overall)	0.94	0.82	0.93	0.94	0.78	0.82	0.93	0.94	0.81	0.82

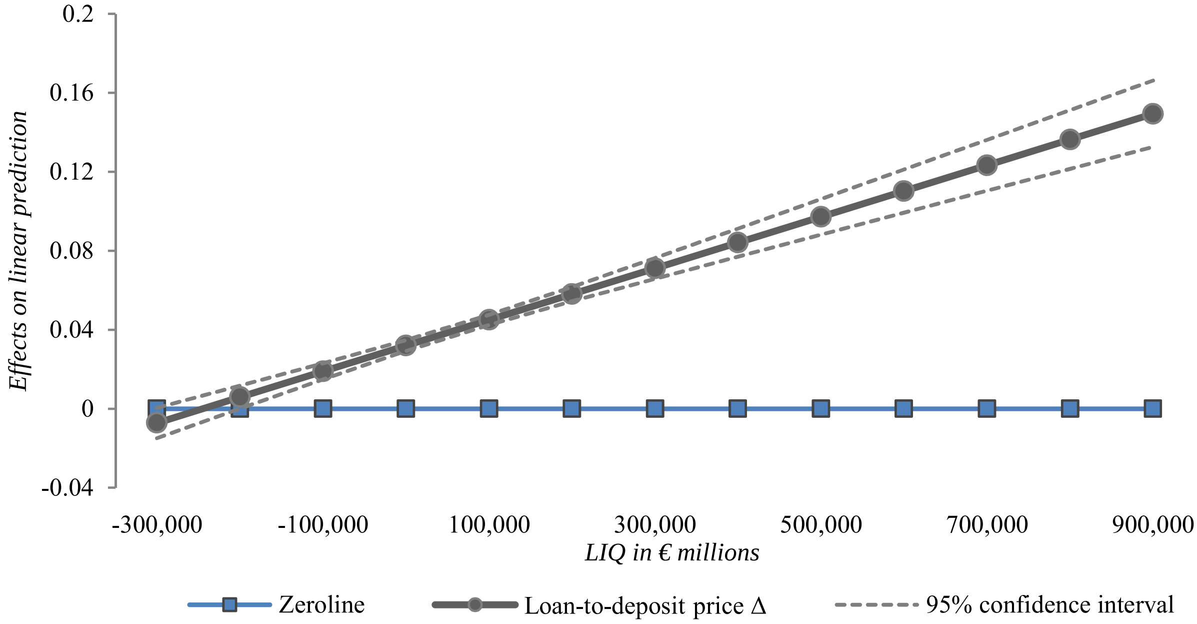
Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01

Figure 2: Illustrating liquidity spirals with the marginal effects of LIQ and maturity

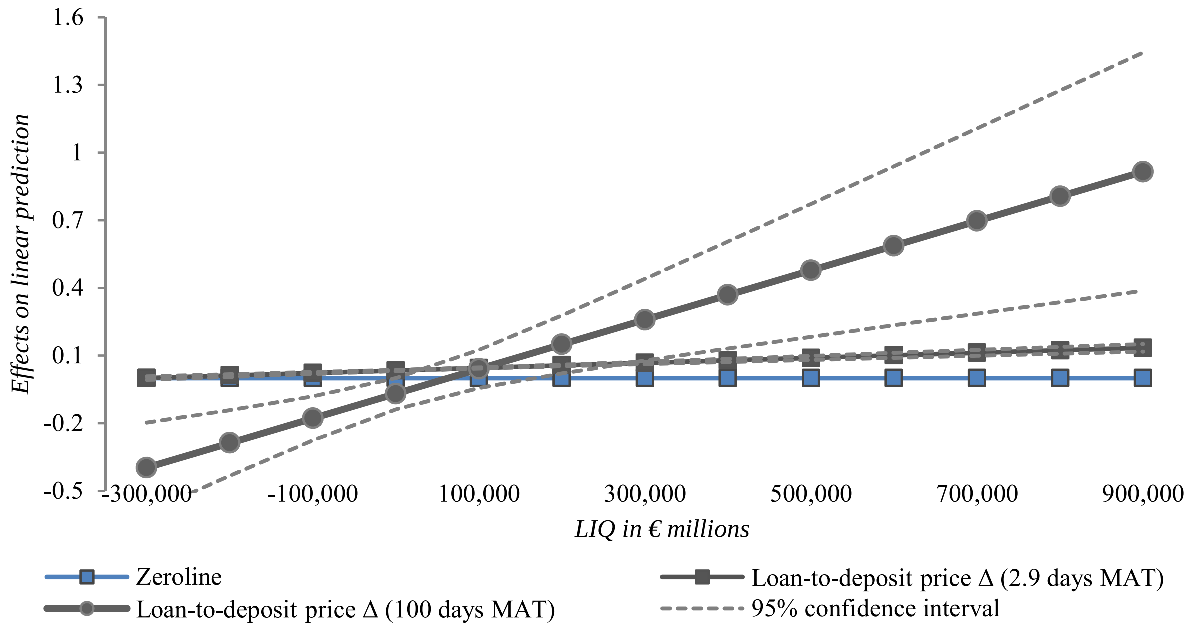
The graphs depicted in this figure are based on a difference-in-difference approach where both deposits and loans enter the regression equation of model 8, excluding the relationship, central bank, and rating dummies. **Type** is equal to 1 if a loan is issued by the bank. The estimation results are as follows (Observations = 18093; Adjusted R^2 = 0.9238; DoF=37; * $p<0.1$, ** $p<0.05$, *** $p<0.01$):

log(Fixed rate) = 1.05*** x log(Eurepo) +1.1e-12*** x Amount +0.047*** x Type(Loan) +0.0015*** x Maturity +0.00000035*** x LIQ +0.000000081*** x Type(Loan)*LIQ −0.0010x Type(Loan)*Maturity +4.7e-09*** x LIQ*Maturity +8.6e-09*** x Type(Loan)*LIQ*Maturity +5.4e-12*** x Net money market funding +0.000098 x CDS +0.00010 x Type(Loan)*CDS −0.0012 x log(CCR) +0.0099*** x Type(Loan)*log(CCR) −0.090*** x Constant

It is already evident, that the regression line for loans slopes higher for every unit increase in **LIQ** than the line for deposits. However, the price difference between loans and deposits may or may not be significant across varying levels of LIQ. The purpose of the two graphs is to analyze this issue: In panel (a) the loan to deposit price difference is drawn for increasing levels of funding liquidity risks. Whenever the confidence interval does not include zero, the difference between the mark-up on a loan transaction compared to the mark-up on the deposit is considered statistically significant. The graph in panel (b) illustrates that as the **Maturity** increases, the price difference widens. Hence, at a very high level of funding liquidity risk, the loan-to-deposit price difference widens more significantly if a loan with a longer-running maturity is issued.



(a) Average Marginal Effects (AMEs) with respect to transaction type for different values for LIQ



(b) AMEs with respect to transaction type for different values for LIQ and maturities

Table 6: Robustness checks continued (RC3 to RC9)

This table shows the empirical results for the remaining robustness checks, separated by the transaction type (loan or deposit transaction) for the time period January 2007 to December 2008. Each model is estimated by OLS and includes monthly time fixed effects in the estimation process (not shown in the regression output). Note that the dependant variable, **Fixed rate**, is in logs. In *RC3*, the funding liquidity risk measure, **LIQ daily**, is calculated on an end-of-day basis and included in the regression as a one day lagged explanatory variable. This specification controls for the possibility that traders don't coordinate on a real-time basis during the trading day but only at the closing or in the morning of the next trading day. The **LIQ daily** measure has a lower variation when compared to all other LIQ measures and is constant across one single trading day. In model *RC4*, LIQ is calculated by excluding all transactions with central banks which are officially designated so in the bank's order book. In *RC5*, all transactions with facilities from the European Central Bank or the Deutsche Bundesbank are excluded from the calculation of the funding liquidity risk indicator and hence from our regressions.In RC6, the main specification for the **LIQ** calculation is used (which means that also all central bank transactions enter the calculation) but all transactions with central banks are excluded in the regression. Finally, *RC7* presents Model 7 in terms of robust standard errors. Finally, *RC8* and *RC9* re-run model 7 for the tranquil pre-crisis phase until August 2007 and the crisis phase August 2007 to December 2008 only respectively to account for the structural change in the behavior of our key variables as outlined in Figure 1. Note that the regression output in this table is separated by variable group attributes: For the *order book data* group, note that the **Eurepo** is in logs and the maturity of the Eurepo has been matched to the maturity of the respective transaction. Note that the inventory measure is calculated on a trade-by-trade basis using all 18,094 observations. For the *ratings and credit risk measures* group, note that the base group for **Ratings** is the *AAA*-group for both, the deposit and loan regressions. Also note here, that the **Five year CDS** is for the bank from which we obtained the data, lagged by one day and in terms of daily differences. The **3 months Euribor-Eurepo spread** is in logs and controls for increases in the market wide credit risk in the interbank market. For the group *central bank and relationship dummies*, note that the **Central bank counterparty dummy** is equal to one if a trade with a central bank is observed (officially recorded in the order book of the bank) and the **Relationship dummy** is equal to one if the bank from which we obtained the data has traded with the same counterparty within the last 350 transaction (which equals around two weeks). Finally note that the constant changes to the first monthly time fixed effect (**TFE intercept**) when including TFEs in the regressions.

	LIQ daily (RC3)		**LIQ excl. CBs (RC4)**		**LIQ excl. facilities (RC5)**		**Excluding CBs (RC6)**		**Robust SEs (RC7)**		**until Sep. 2008 (RC8)**		**Aug07/Dec08 (RC9)**	
	Deposits	*Loans*	*Deposits*	*Loans*	*Deposits*	*Loans*	*Deposits*	*Loans*	*Deposits*	*Loans*	*Deposits*	*Loans*	*Deposits*	*Loans*
Order book data														
Eurepo (in logs)	1.05***	1.18***	1.05***	1.22***	1.05***	1.23***	1.04***	1.22***	1.04***	1.15***	1.28***	1.36***	1.03***	1.15***
	(0.010)	(0.033)	(0.010)	(0.036)	(0.010)	(0.036)	(0.010)	(0.036)	(0.015)	(0.045)	(0.022)	(0.053)	(0.011)	(0.038)
Amount (in EUR)	1.1e-11***	-1.1e-12**	1.9e-11***	-1.4e-12	1.8e-11***	-1.4e-12	1.6e-11***	-1.2e-12	1.2e-11***	-1.0e-12	1.9e-11***	1.1e-12	-7.3e-12	-6.8e-13
	(4.0e-12)	(5.8e-13)	(4.5e-12)	(2.1e-12)	(4.4e-12)	(2.1e-12)	(4.5e-12)	(2.1e-12)	(4.2e-12)	(9.7e-13)	(4.0e-12)	(1.7e-12)	(5.4e-12)	(6.4e-13)
Maturity (in days)	0.0016***	-0.00036	0.0016***	0.000089	0.0016***	0.000087	0.0016***	0.00010	0.0015***	0.00015	0.0013***	0.000020	0.0019***	-0.0015
	(0.000069)	(0.00036)	(0.000072)	(0.00032)	(0.000068)	(0.00032)	(0.000073)	(0.00032)	(0.00014)	(0.00034)	(0.000059)	(0.00033)	(0.000087)	(0.0014)
Liquidity and inventory measures														
LIQ (see column for specification)	6.5e-15	6.3e-14***	1.0e-13***	-3.9e-14	9.6e-14***	-4.2e-14	3.8e-13***	2.2e-13**	3.9e-13***	1.8e-13*	1.6e-13***	1.6e-13*	5.8e-13***	2.0e-13*
	(7.8e-15)	(1.9e-14)	(2.0e-14)	(3.7e-14)	(1.9e-14)	(3.7e-14)	(3.6e-14)	(8.7e-14)	(3.5e-14)	(1.0e-13)	(3.3e-14)	(8.7e-14)	(4.4e-14)	(1.1e-13)
Net money market funding holdings	-9.4e-14	9.0e-13***	1.4e-12***	1.7e-13	1.3e-12***	1.3e-13	5.6e-12***	3.9e-12***	5.6e-12***	3.2e-12**	3.2e-12***	2.9e-12**	8.3e-12***	3.9e-12**
	(8.7e-14)	(1.9e-13)	(2.8e-13)	(5.1e-13)	(2.7e-13)	(5.1e-13)	(5.2e-13)	(1.3e-12)	(5.3e-13)	(1.4e-12)	(4.9e-13)	(1.3e-12)	(6.4e-13)	(1.6e-12)
Interaction: LIQ * Maturity	4.4e-15***	1.7e-14***	4.8e-15***	7.4e-15***	4.9e-15***	7.3e-15***	4.8e-15***	7.5e-15***	4.8e-15***	8.2e-15**	2.7e-15***	4.9e-15	3.7e-15***	1.7e-14***
	(5.6e-16)	(4.2e-15)	(5.4e-16)	(2.8e-15)	(5.1e-16)	(2.8e-15)	(5.3e-16)	(2.8e-15)	(6.3e-16)	(3.4e-15)	(6.8e-16)	(4.1e-15)	(5.9e-16)	(6.2e-15)
Ratings and credit risk measures														
Rating: AA	-0.070***	0.031***	-0.073***	0.037***	-0.073***	0.037***	-0.073***	0.037***	-0.069***	0.031***	-0.048***	0.034***	-0.11***	0.024***
	(0.0035)	(0.0033)	(0.0037)	(0.0032)	(0.0037)	(0.0032)	(0.0037)	(0.0032)	(0.0057)	(0.0043)	(0.0031)	(0.0034)	(0.0049)	(0.0040)
Rating: A	-0.061***	0.029***	-0.064***	0.035***	-0.063***	0.035***	-0.064***	0.035***	-0.060***	0.029***	-0.039***	0.032***	-0.095***	0.024***
	(0.0036)	(0.0036)	(0.0038)	(0.0035)	(0.0037)	(0.0035)	(0.0038)	(0.0035)	(0.0058)	(0.0046)	(0.0031)	(0.0038)	(0.0051)	(0.0043)
Rating: BBB	-0.057***	0.027***	-0.061***	0.033***	-0.060***	0.032***	-0.061***	0.032***	-0.057***	0.027***	-0.035***	0.030***	-0.094***	0.018
	(0.0037)	(0.0092)	(0.0039)	(0.0088)	(0.0039)	(0.0088)	(0.0039)	(0.0088)	(0.0059)	(0.0089)	(0.0033)	(0.0087)	(0.0051)	(0.012)
Rating: BB	-0.049***		-0.052***		-0.052***		-0.053***		-0.049***		-0.028***		-0.085***	
	(0.0035)		(0.0037)		(0.0037)		(0.0037)		(0.0058)		(0.0031)		(0.0050)	
Rating: B	-0.083***	0.041*	-0.086***	0.051**	-0.086***	0.051**	-0.086***	0.051**	-0.082***	0.044***	-0.067***	0.049**	-0.11***	0.044
	(0.0040)	(0.025)	(0.0041)	(0.024)	(0.0041)	(0.024)	(0.0041)	(0.024)	(0.0064)	(0.015)	(0.0035)	(0.023)	(0.0054)	(0.031)
Rating: CCC	-0.055***	0.033***	-0.058***	0.039***	-0.058***	0.039***	-0.058***	0.038***	-0.054***	0.033***	-0.034***	0.034***	-0.089***	0.023*
	(0.0034)	(0.0064)	(0.0036)	(0.0062)	(0.0036)	(0.0062)	(0.0036)	(0.0062)	(0.0057)	(0.0050)	(0.0030)	(0.0062)	(0.0048)	(0.012)
Rating: N/A	-0.060***	0.032***	-0.063***	0.047***	-0.062***	0.047***	-0.064***	0.047***	-0.060***	0.033***	-0.039***	0.025***	-0.095***	0.027***
	(0.0036)	(0.0057)	(0.0038)	(0.0060)	(0.0038)	(0.0060)	(0.0038)	(0.0060)	(0.0060)	(0.0085)	(0.0034)	(0.0066)	(0.0049)	(0.0064)
Five year CDS (one-day change)	0.000058	-0.00046**	0.000074	-0.00050**	0.000079	-0.00050**	0.000094	-0.00049**	0.00010	-0.00040*	-0.00033***	-0.0010***	0.00017***	-0.00036*
	(0.000060)	(0.00020)	(0.000060)	(0.00021)	(0.000060)	(0.00020)	(0.000060)	(0.00020)	(0.000085)	(0.00024)	(0.000096)	(0.00024)	(0.000063)	(0.00022)
3 months Euribor-Eurepo spread (in logs)	-0.0080***	0.010	-0.0071***	0.0089	-0.0070***	0.0088	-0.0034	0.015**	-0.0033	0.013**	-0.0063***	0.0065	0.013***	0.027**
	(0.0022)	(0.0068)	(0.0022)	(0.0067)	(0.0022)	(0.0067)	(0.0022)	(0.0069)	(0.0022)	(0.0066)	(0.0020)	(0.0070)	(0.0032)	(0.011)
Central bank and relationship dummies														
Central bank counterparty dummy	0.0078**	-0.041***			0.010***	0.051***			0.0066***	-0.043**	0.0036	0.012	0.0056	-0.047***
	(0.0033)	(0.0089)			(0.0034)	(0.017)			(0.0023)	(0.020)	(0.0028)	(0.010)	(0.0055)	(0.0099)
Relationship dummy (c.2 weeks; deposits)	0.0041***		0.0047***		0.0042***		0.0045***		0.0041***		0.0045***		0.0043***	
	(0.0014)		(0.0014)		(0.0014)		(0.0014)		(0.0016)		(0.0013)		(0.0017)	
Relationship dummy (c.2 weeks; loans)		0.0043*		0.0066***		0.0065***		0.0068***		0.0052*		0.0070***		0.0057*
		(0.0024)		(0.0023)		(0.0023)		(0.0023)		(0.0027)		(0.0023)		(0.0030)
Constant (or TFE intercept)	-0.061***	-0.23***	-0.054***	-0.30***	-0.053***	-0.30***	-0.038**	-0.27***	-0.042**	-0.19***	-0.37***	-0.47***	0.079***	-0.19***
	(0.015)	(0.045)	(0.015)	(0.049)	(0.015)	(0.049)	(0.015)	(0.049)	(0.021)	(0.065)	(0.028)	(0.068)	(0.018)	(0.057)
Summary statistics														
Observations	15450	2599	15208	2512	15438	2520	15208	2512	15484	2609	11947	2369	11244	1959
Time fixed effects (monthly)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Degrees of freedom	40	39	39	38	40	39	39	38	36	35	37	36	33	32
Log-Likelihood	24344.1	4185.1	23928.7	4154.3	24361.1	4169.5	23973.3	4158.3	24484.9	4190.1	21305.4	3981.4	17331.6	2981.7
R2 (adjusted)	0.93	0.84	0.93	0.81	0.93	0.81	0.93	0.81	0.93	0.84	0.65	0.50	0.94	0.85

Standard errors in parentheses
* p<0.1, ** p<0.05, *** p<0.01