Liquidity Auctions, Fixed Rate Tenders & Bailouts in the EURO Zone *

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Abstract

At the end of September 2008, following the bankruptcy of Lehman Brothers, the European Central Bank (ECB) abandoned its usual procedure of allocating short-term funds using an auction and implemented a full-allottment procedure or, equivalently, a fixed price mechanism. We use this switch to show that the data from auctions preceding this change can be used to gain insights about the future recourse to ECB-provided lending by individual banks. Based on an equilibrium model of bidding, we estimate individual banks' willingness-to-pay for loans and we find that banks whose willingness-to-pay for short-term funds kept increasing through the months of 2008 benefited more from the switch: they were allocated relatively more liquidity and at a cheaper rate than before. We also find that banks that seemed in a worse financial state based on the publicly available balance sheet data, are not the ones who rely relatively more on the liquidity provided by the ECB in the fixed rate tenders than in the period before Lehman. Nevertheless, we find that the dynamics of the willingness-to-pay during 2008 are correlated with changes in several balance variables, such as write-offs, in the expected direction.

Using a new data set on government bailouts of individual banks in the EURO zone we find that banks whose willingness-to-pay increased substantially already in 2007 are much more likely to require a bailout than those whose willingness-to-pay did not increase or started increasing later as the situation on the financial markets deteriorated further.

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1 Introduction

The bankruptcy of Lehman Brothers in September 2008 disturbed the already nervous financial markets and led to drops in equity markets and increased uncertainty that had not been experienced in a long time. The reaction of central bankers to the worsening conditions was to inject liquidity into the markets to alleviate the pressure. In the Euro Zone, the European Central Bank (ECB) abandonded its long-lived policy of holding a weekly discriminatory auction, at which banks could bid for liquidity - and instead offered a fixed price. At the posted rate, any bank could obtain a secured loan of its favorite amount. In this paper we examine the behavior exhibited by banks in the period before the Lehman collapse and we show that several regularities of the data coming from after the collapse can be predicted based on the earlier data already. We further collect data on actual bailouts of individual banks to this date and provide evidence that the likelihood of a bailout is correlated with our measures of a bank's desperation for liquidity, which is based on a transformation of bids in the ECB's repo auctions. Since we view these results as establishing the validity of using our measures to address the risk level of individual banks, we use our estimates to futher investigate aggregate risk factors and potential systemic risk.

In our previous work (Cassola, Hortaçsu & Kastl 2011) we looked at the evolution of banks' behavior during the onset of the financial crisis: from January to December 2007. We argued that the bidding data from the main refinancing operations of the ECB may provide a high-frequency source of information about the financial distress of individual banks when this data is interpreted via a model. We documented a substantial increase in the heterogeneity of the cost of funding among banks. We further argued that interpreting the data through a model is important, since changes in the bidding behavior itself involve also strategic adjustment to the changes in other bidders' behavior (strategies), which in case of a financial turmoil may be quite important. In other words, a bank i may be bidding higher not because its underlying willingness-to-pay increased, for example

due to unfavorable development of other banks' perceptions of i's default risk, but because other banks increased their bids and i thus also increased its bid so as to optimally resolve the trade-off between the surplus on the marginal amount of the loan and the probability of winning this marginal amount. We showed that the estimates of the changes in banks' willingness-to-pay coming from the model are consistent with the ex-post observed changes in the usual accounting measures of banks' performance such as cost-to-income ratio or return on equity.

In this paper, we focus on the ECB's change of the liquidity-allocating mechanism. We use this event as an opportunity to test other means of classifying financial health of individual banks, which we view as complementary. In particular, we maintain the intuitive assumption that less financially sound banks have worse position on the interbank market and hence, if they can access funds there at all, they have to pay higher rates. Therefore, other things equal, they would be more likely to ask for larger loans from the central bank relative to their previous demand. We show that classifying bidders based on the differential dynamics of their willingness-to-pay during the months preceding the Lehman collapse does a good job predicting which banks will demand more in fixed rate tenders. More importantly, however, we show that when we look for banks whose reliance on the ECB funding (as measured by the total loans obtained) substantially increased after the switch to the full allotment tenders and whose willingness-to-pay significantly increased during the months preceding the Lehman collapse, we identify a small subset of banks (about a dozen) many of which are currently in severe difficulties, or they previously have been until a merger or a bailout. We also show that the likelihood of needing some kind of government intervention during the early wave of bailouts following the 2007 financial crisis (in late 2007 and before September 2008) is correlated with the dynamics in the willingness-to-pay for liquidity in the primary market during 2007. We therefore believe that our results provide further support for central banks to use the high-frequency data from liquidity auctions together with economic models of bidding to aid the policy-makers make informed decisions about monetary policy, bailouts or bank regulation.

The remainder of the paper proceeds as follows. In section 2 we provide details on the several data sets that we merge together. We continue in section 3 with the description of the model used to link the bids to the willingness-to-pay. In section 4 we discuss the results of our analysis and we

conclude in section 5.

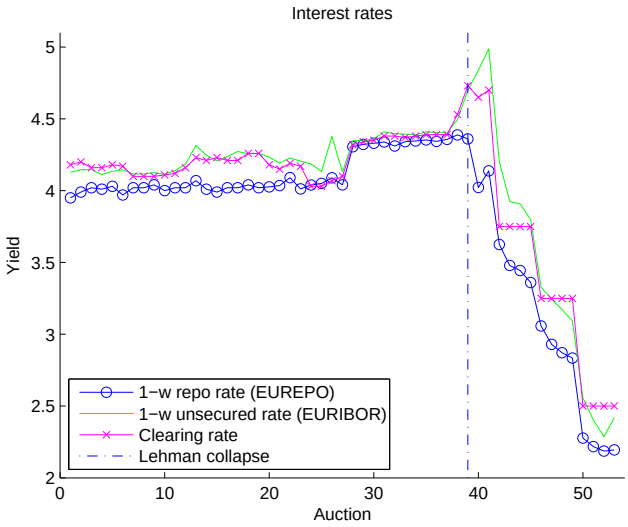


Figure 1: Interest Rates during 2008

2 Data

Figure 1 depicts the evolution of the secured and unsecured interest rates during the period of our study. It shows that the financial markets were experiencing fairly quiet times during 2008 until mid September, when Lehman Brothers declared bankruptcy. Subsequently, central banks reacted by lowering the key interest rates and substantially adjusting the monetary policy. In case of the ECB, the main refinancing operations were conducted as discriminatory auctions until early October 2008 and as full allottment (or a fixed price mechanism) thereafter. Our main data set consists of all bids in the main refinancing operations and long term refinancing operations of the ECB during 2008. In total there were 41 auctions in the MROs and 19 auctions in the LTROs before the switch to the full allottment took place in mid-October. This switch was a direct consequence of the turmoil in the financial markets that culminated in the collapse of Lehman Brothers. The last standard discriminatory auction took place in the MROs on 10/7/2008, and on 10/8/2008 in the LTROs. The data from the MRO auctions is summarized in Table 1. There are several evident trends. In the period post May 2008, there were many more participants in the MRO auctions

than before (414 verus 284), which may be suggestive of banks experienceing increasing difficulties in securing funding in the secondary market. The larger average number of steps may suggest that the uncertainty about where the auction would clear increased. The bids, however, changed on average rather little – the mean spread over the reference interest rate, EONIA, stayed around 15 basis points. We also obtained data on banks' demands (and allocations) in 12 fixed rate tenders that were offered by the ECB following the collapse of Lehman Borthers. Initially, the offered rate was set at 3.75, and further reduced to 3.25 and finally in late 2008 to 2.5. Notice that the total amount loaned in the fixed rate tenders was about 50% larger as that offered in the auctions before Lehman collapse (291 billion versus 174 billion).

Apart from observing the bidding behavior and quantity demanded at fixed rate tenders, we also obtained data on banks' usage of the standing facilities of the ECB during 2008. The first is the marginal lending facility, at which a bank can obtain a loan against collateral at a fixed rate. This rate was set at 100 basis points above the policy rate (the minimum bid rate set in the auctions). The counterpart of the marginal lending facility is the deposit facility, at which any bank can deposit its extra cash at a fixed rate, which is 100 basis points below the policy rate. After the collapse of Lehman Brothers, these premia were reduced to 50 basis points. This data is summarized in figure 3. Before the switch to fixed rate tenders, banks used the marginal lending facility 136 times with an average loan (conditional on taking a loan) of $1,328$ million euros. After the switch, banks turned to the facility 295 times asking for an average loan of $1,249$ million euros. Before the switch there were 418 deposits, with the mean deposit of $1,285$ million euros. After the switch, there were $5,194$ deposits, with the mean being $2,207$ million - almost double of the earlier average amount! During the three weeks following the collapse of Lehman Brothers, but before the switch to the fixed rate tenders, there were 69 loans from the marginal lending facility, with an average amount of $2,195$ million euro - over 5 times the average amount before that (435 million). Similarly, an average deposit (conditional on depositing a positive amount) before Lehman collapse amounted to 706 million, while it doubled during the two weeks following the Lehman collapse to 1458 million, and increased even more after the switch to the full allotment to $2,208$ million as mentioned above.

Table 1: Data Summary: Before and After May 2008

Summary Statistics				
	Mean		Std Dev	
	Before	After	Before	After
Bidders	284.2	414	28.92	58.46
Submitted steps	2.10	2.66	1.44	1.98
Price bid	4.18	4.37	0.07	0.21
Price bid spread[a]	0.17	0.15	0.07	0.22
Quantity bid[b]	0.005	0.003	0.01	0.01
Issued Amount (billion €)	173.94	147.48	2.49	2.60

[a] Spread against EONIA rate.
[b] Bid expressed as a fraction of the issued amount.

Table 2: Data Summary: Fixed Rate Tenders

Summary Statistics of Fixed Rate Tenders			
	Mean	Median	Std Dev
Allocated amount per bank	391.5	398.6	68.95
Allocated amount per bank (fraction of total amount)	0.001	0.001	0.0002
SD of allocated amount (within auction)	1,337.5	1,452.4	275.3
Rate	3.17	3.25	0.54
Participants	747.1	769.5	86.24
Issued Amount (billion €)	290.8	311.2	52.0

To obtain information on balance sheets of individual banks we also linked our data with Bankscope. We successfully linked the data for 390 European banks. We used these data to obtain information on 40 balance sheet variables, which we list in the appendix. We use data from 2005-2010. We believe that the variables we selected should be representative of the balance sheets of the individual banks.

We also use reports of European Commission on government interventions in individual banks (EC 2011). For 629 banks that appear in our data from liquidity auctions from 2007 and 2008, we identified 20 banks that received targeted government support at least once. Table 3 shows that 50% of these banks in fact received help in multiple rounds. The most notorious recepients of government funds were the Anglo Irish Bank Corporation, which was eventually nationalized, and the IKB Deutsche Industriebank, which after a generous government injection was almost fully privatized in August 2008. From the other 19 banks, 1 more is from Ireland, 8 are German, 2 are

Table 3: Data Summary: Bailouts

Summary Statistics of Bailouts		
# of Bailouts	# of Banks	Average Size (in mil €)
0	609	
1	10	3,327
2	7	18,397
3	1	4,425
4	1	5,825
5	0	
6	1	7,359

from Austria, Belgium and Netherlands, and 1 bank comes from France, Greece and Slovenia. The bailouts can be categorized into several waves. The first wave, which included 5 bailouts, occured before the collapse of Lehman Brothers between February 2008 and September 2008. After the subsequent change of the ECB's liquidity providing mechanism from auctions to fixed rate tenders the second wave followed with 14 bailouts before May 2009. Later, there were additional 17 bailouts before July 2011.

We now move on to discuss the model we use to interpret these data.

3 Model

Our modeling will focus on two aspects. First, we use an equilibrium model of bidding in a discriminatory auction to link the bids in the liquidity auctions to the implied willingness-to-pay for repo loans. As we described in Cassola et al. (2011) this measure provides us with information on prices (interest rates) that a given bank would have to pay to secure liquidity from other sources on the interbank market. Since there likely are various important factors, which affect the evolution of banks' willingness-to-pay for liquidity from week to week and which are unobserved to the econometrician, we will use an estimation method, which uses data only from one auction at a time.

Since we are also interested in providing predictions on the behavior and state of financial sector as a whole, we will also use a model to address the issue of the systemic and aggregate risk. In particular, using the estimated willingness-to-pay from the first part, our goal is to recover

the unobserved aggregate risk factors. Our data allows us to idetify these by making use of the correlation patterns across banks. Finally, we attempt to link these factors to common ownership across banks, geographical location and common evolution on balance sheets.

3.1 Willingness to pay for liquidity

To recover the willingness-to-pay from the bids submitted in the discriminatory auctions we assume that banks play a Bayesian Nash Equilibrium. As in our previous work, we assume conditionally independent private values. This means that conditional on all public information available before a given auction, each bank's willingness-to-pay is a function only of its own information and is independent of its rivals' information. While both independence and private values are clearly restrictive assumptions, we showed in our previous work and will further show here that the estimates produced by such model pass several ex-post tests. We therefore view these estimates as a useful source of information about the situation of individual banks during the crisis. As an example of the ex-post tests that we have in mind here, our estimates of the changes in a bank's willingness-to-pay are correlated with changes in several accounting measures of performance between 2006 and 2007, i.e., at the onset of the financial crisis, such as return on equity or cost-to-income ratio. Our goal here is to focus on the time period when the crisis is already under way and use these new estimates to provide predictions about recourse to fixed rate tenders and future need for government intervention.

Our main model of a discriminatory auction is based on the classic Wilson's (1979) paper on share auctions. There is a unit perfectly divisible good to be sold and bidders submit bids for shares of this good. We do not want to view bidders' values as coming from a vacuum, however. As in Cassola et al. (2011) we link the marginal values to the secondary market secured and unsecured interest rates as follows. Suppose bank i has a liquidity need (possibly due to a reserve requirement, to improve its balance sheet, or to close a funding gap) of R_i. This must be fulfilled through three alternative channels: 1) ECB primary auctions, 2) unsecured interbank lending, which is done through over-the-counter deals, or 3) secured interbank lending, which is also done over-the-counter. W assume that these methods are substitutes, but access to them is limited based on collateral

availability. In particular, bank i has L_i units of "liquid", high-quality collateral acceptable by secured interbank lending counterparties at a zero "haircut" rate. The bank also has $K_i - L_i$ units of securities that are acceptable by the ECB and perhaps by other counterparties as collateral, but are subject to haircuts. The haircuts applied to this set of securities effectively increase the interest rate at which the bank can borrow against these securities; these rates are bounded below by the "secured" interbank lending rate, s_i, that the bank faces (which assumes the use of highest quality, i.e. zero haircut collateral), and bounded above by the "unsecured" interbank lending rate, u_i, which requires no collateral. The marginal value for obtaining liquidity in the auctions run by the ECB can therefore be represented as in Figure 2, where we assume the bank's total collateralized borrowing capacity, K_i, to be less than its liquidity need R_i. The bank's willingness-to-pay for the first $R_i - K_i$ euros of funding, thus, is equal to its unsecured funding rate, u_i. Between the $R_i - K_i$ and $R_i - L_i$, the bank faces different haircut rates depending on its portfolio of securities it can post as collateral. The last L_i euros of funding can be obtained from the "secured" interbank market, thus the bank's willingness-to-pay for these units is s_i. Notice that for banks that submit fairly rich bid curves (i.e., with multiple steps), the above reasoning would allow us to obtain a bank-specific unsecured versus secured spread, $u_i - s_i$. Assuming collateral is liquid, this spread should contain the rival bank's perceptions of bank i's default risk.

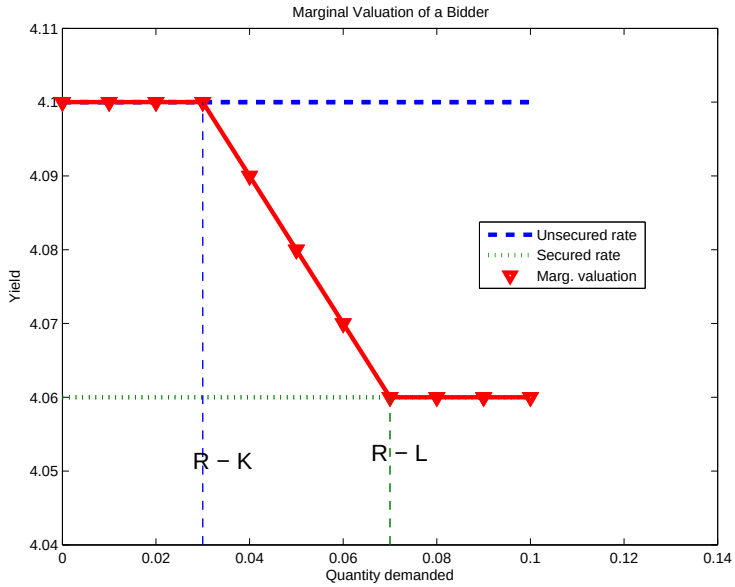
Kastl (2011*b*) analyzes a variant of Wilson's model with bidding in step functions, which is also necessary for our application. He proves that there exists an equilibrium of a discriminatory auction in distributional strategies in this constrained game when signals are not too dependent. The model and its assumptions are formally spelled out in the appendix of Cassola et al. (2011). The necessary conditions for equilibrium bidding by bank with private information θ_i are:

$$v\left(q_k, \theta_i\right) = b_k + \frac{\Pr\left(b_{k+1} \geq P^c\right)}{\Pr\left(b_k > P^c > b_{k+1}\right)}\left(b_k - b_{k+1}\right) \tag{1}$$

where P^c is the market clearing price, which is random from the perspective of each bidder, q_k is the quantity demanded at step k and b_k is the associated bid. Therefore, it is the uncertainty about the market clearing price which creates a wedge between the bid and the willingness-to-pay.

Equation (1) provides us with the link between the observable data (bids) and the variables of

Figure 2: Marginal Value for Liquidity in ECB Auctions



interest: banks' willingness-to-pay. This inversion of bids is a common approach in the empirical auction literature at least since Guerre, Perrigne & Vuong (2000). In order to invert bids using equation (1) we need to estimate the distribution of the market clearing price, P^c, which is bidder-specific, because it depends on the submitted bid.

To do that we employ the resampling method introduced in Hortaçsu & McAdams (2010) and further developed in Kastl (2011*a*) and Hortaçsu & Kastl (2012). In order to perform this step we impose the assumption of (within group) independence and ex-ante (within group) symmetry among banks, where we allow two groups of banks: the ones who our indicators designate as experiencing significant changes in the statistic of interest (such as in the mean willingness-to-pay) and those that do not. One of our goals in this paper is to investigate whether defining the two groups based on different statistic will yield to robust classification. The resampling procedure allows us to simulate the distribution of market clearing price using bids submitted only within one particular auction. By repeatedly drawing with replacement $N-1$ bids from the observed sample, we can simulate a state of the world, a particular realization of the residual supply, which interestected with the submitted bid delivers a particular realization of the market clearing price. Repeating the procedure yields an empirical distribution of the market clearing prices and thus

allows us to evaluate the probabilities in equation (1). In Cassola et al. (2011) we showed that with uncertainty about the available supply our estimator is consistent as the number of bidders within an auction goes to infinity.

We use this method to estimate the willingness-to-pay of each bank that participates in a given auction. Since most banks participate quite frequently (and the major one participate virtually always), we thus obtain a time series of willingness-to-pay for every bank, which rationalizes its bids in the MRO auctions. We project this data onto various sets of covariates related to riskiness of individual banks.

3.2 Aggregate and Systemic Risk

An important question when studying the financial system involves how to quantify the systemic risk, i.e., risk that a failure of a financial institution would translate into difficulties for the whole financial system. Acharya, Pedersen, Philippon & Richardson (2010) provide a simple theoretical framework, in which they propose to measure the systemic risk by an institution's marginal contribution to the shortfall of capital in the financial system that can be expected in a crisis. Their analysis focuses on cross-sectional differences. Brownlees & Engle (2010) instead propose to measure the systemic risk by the expected shortage of capital of an institution given its degree of leverage. Farhi & Tirole (2012) provide a simple model of the financial system, where the correlated liquidity shocks may (optimally) result in systemic bailouts. Due to strategic complementarities all banks prefer to engage in maturity mismatch behavior rather than to be the only one to not play along, which in turn results in government bailout when a crisis arises. Adrian & Brunnermeier (2011) propose a way how to empirically assess the degree of systemic risk associated with a bank, which relies on marginal contribution of each bank to the "value at risk" conditional on that bank being under distress relative to its median state.[1] Here we will propose an alternative approach to quantification of aggregate risk and also a new way how to measure the systemic risk. Our approach is based on the dynamics of the willingness-to-pay. In particular, we are interested in recovering the correlation patterns both within the cross-section and over time. The intuition for our approach is the following: Suppose bank i poses a greater risk for the financial system than

[1] Schwarcz (2011) offers an interesting perspective on systemic risk and its measurement from the point of the law.

bank j, but both are important large banks. Further suppose that bank i suffers an adverse shock to its balance sheet in period t, which translates into higher cost of funding on the interbank market. This in turn implies an increase in the willingness-to-pay for liquidity obtained in the main refinancing operations from the ECB for bank i. Suppose a similar scenario occurs with bank j, but in period t'. Since i's contribution to systemic is higher by assumption, we should expect other banks' willingness-to-pay for liquidity in the MROs to increase shortly after the adverse shock to i's balance sheet. It should increase more than following the shock to j's balance sheet. Obviously, an important caveat is that for banks that have healthy balance sheets and rely mostly on loans secured by high quality collateral, the willingness-to-pay for liquidity does not necessarily have to increase after such shocks. To address this caveat, we make use of the simple model of the composition of the willingness-to-pay as depicted in figure 2. In particular, for banks submitting multiple steps in an auction, which large banks typically do, our method allows us to obtain an estimate of the spread $u_i - s_i$. Our goal is therefore to identify banks whose significant changes in the quantity weighted willingness-to-pay and in the spread $u_i - s_i$ propagate further into the system. In other words, whether such changes are followed by similar changes in the spreads for other banks. Ideally, we would also like to use some information on exposure of individual banks to risk associated with bank i. Unfortunately, such data is currently not available to us.

4 Results

4.1 Switch to Fixed Rate Tenders

Before the switch to fixed rate tenders in October 2008, banks had two possibilities to obtain liquidity from the ECB. Either use the marginal lending facility and pay a 100 basis points premium over the policy rate to obtain loan of any size (subject to having suitable collateral available) or participate in the discriminatory auction and bid weakly above the policy rate and potentially obtain a repo loan at a cheaper rate depending on the bids of its rivals. Figure 3 shows that banks seldomly used either the deposit facility or the marginal lending facility before the collapse of Lehman Brothers. Even during the late 2007, well into the crisis, the amount borrowed rarely exceeded 5 billion Euros and the amount deposited hovered around few billions. This picture

changed dramatically, however, after the switch to full allotment: the amounts parked at the deposit facility fluctuated week-to-week peaking at over 300 billion Euros after Lehman's collapse and in the summers of 2009, 2010 and 2011. Why did the ECB switch to the full allotment mechanism and why has the ECB not returned to the discriminatory auctions since then?

Figure 9 depicts the aggregate bids in the auctions under the main refinancing operations that were held in 2008 prior to the switch to the full allotment mechanism. Each solid (blue) curve corresponds to one auction of 1-week repo loans prior to September 15th, 2008 - when Lehman filed for bankruptcy protection. The lowest line-dotted (red) curve corresponds to the aggregate bid on 9/23/2008 and it clearly shows that the market has become quite nervous, since the bids expressed as spreads over the overnight rate increased by about 10-20 basis points. The two highest curves correspond to the last two discriminatory auctions held on 9/30/2008 and 10/7/2008. The amount of funds auctioned on those dates substantially exceeded the amount that the ECB determined was necessary for every bank to be able to satisfy its reserve requirement, i.e., the benchmark amount that the ECB announces on the day of the auction and that, in the usual times, constitutes a very good proxy of the actual supply. In fact, on 9/30/2008, there was more liquidity on the market than needed even before the auction itself by about 40 billion Euro! Nevertheless, additional 190 billion Euro were allocated in the auction. Similarly, on 10/7 only about 40 billion Euro were needed in the market and yet 250 billion were auctioned. These amounts clearly signaled that banks were exceedingly nervous about being able to access sufficient liquidity. Moreover, the marginal rate (the market clearing price) in these auctions exceeded EONIA by close to 100 basis points! Since ECB's policy is to steer this overnight rate, these two auctions suggested that during that time period there was very little difference for banks between using the marginal lending facility (i.e., pay a posted price of the policy rate + 100 basis points) and participating in the auctions. It would thus seem that switching to fixed rate tenders might have been a prudent decision at that time. This conclusion may further be supported by it avoiding the so-called "stigma" that is associated with a bank's reliance on the marginal lending facility. The existence of such stigma is directly evidenced by that fact that in two auctions after the Lehman collapse bids were submitted that exceed the policy rate by more than 100 basis points. This is, however, the price at which loans

can be obtained at the marginal lending facility and hence banks valued liquidity obtained from the MRO more than that obtained at the standing facility.

Before we go on to analyze the behavior of banks in the fixed rate tenders, we want to illustrate what was going on with the aggregate willingness-to-pay for liquidity. Figures 4 and 5 depict aggregate bids and values before and after the collapse of Lehman Brothers. As mentioned in the text above, willingness-to-pay for liquidity obtained in the MROs of the ECB increased substantially. In fact, the value for over 50% of the supply exceeded the rate necessary to obtain a loan at the discount window.

Switching to fixed rate tenders had a very different impact on different banks. For example, a bank that had financial difficulties before the switch would have faced higher borrowing rates in the interbank market and thus would have come to the auctions with a higher willingness-to-pay already. This in turn might suggest that such a bank would also bid more aggressively and hence its benefit (relative to some other financially sound institution) from switching to a posted price mechanism where the price is equal to the policy rate would be higher. To verify this assertion, we run two regressions. The dependent variable in the first two regressions is the difference in quantity-weighted average allotment rate in the fixed rate tenders and in the auctions. The regressor is the change in mean (within a bank, across auctions) quantity-weighted willingness-to-pay post- and pre- May[2] and, for the second regression, the change in the corresponding in mean bid. Column (1) and (2) of Table 4 indeed show that this correlation is significant and negative both for differences in marginal values and bids, respectively. Figure 6 shows this graphically. This suggests that banks that were bidding more aggressively (respectively, for which we estimated a higher willingness-to-pay) closer to the end of the sample also benefited the most from the switch: they paid a relatively lower rate than before. If bank i's willingness-to-pay increased by 100 basis points during 2008, i would have saved about 20 basis on its loans after the full allotment relative to its payment in an auction.

The relationship between savings resulting from fixed rate tenders and more aggressive bidding or relatively higher marginal values in the previous auctions is perhaps not surprising. The external validity test of the estimates produced by our model is, however, related to the changes in the

[2]We chose May since it is the middle of our sample.

Table 4: Changes in Willingness-to-Pay, Bids, Rates Paid and Allocations in Auctions and Fixed Rate Tenders

	Avg Rate Paid		Avg Allocated Amount	
	(1)	(2)	(3)	(4)
Willingness-to-Pay	-0.203**		636.2*	
	(0.08)		(332.4)	
Bids		-0.370***		492.7
		(0.09)		(387.8)
R^2	0.014	0.035	0.008	0.004
N	439	439	439	439

[a] Each column corresponds to a separate regression: $Diff\_Y_i = \alpha + \beta * Diff\_X_i + \varepsilon_i$, where both differences are always defined as the difference post-fixed rate mechanism - pre-fixed rate in the relevant variable.
[b] Standard errors in parentheses.
[c] *, ** , *** significant at 10%, 5% and 1%, respectively.

allocated quantity. On average, Figure 7 shows that there is high persistence of reliance on ECB funding. It illustrates that this persistence holds across the board. Even when we condition on a banking group, the size of the loan allocated in the MRO auctions is highly correlated with the loans obtained in the fixed rate tender. There are a few banking groups, however, started obtaining significantly larger loans after the switch to fixed rate tenders than before.

In particular, a bank that is experiencing tighter conditions in the secondary market should also obtain relatively higher amount of loans once the cheap financing at the policy rate becomes available than a bank that has a relatively easier access to funds from other banks. Columns (3) and (4) of Table 4 show that the changes in average loan size between the auctions and fixed rate tenders are significantly correlated with the changes in the estimated willingness-to-pay (Column (3)), but not with the change in the bids (Column (4)).

Figure 8 depicts the average fraction of the supply allocated to a winning bank, where we distinguish banks that exhibit a significant increase in their willingness-to-pay for liquidity. The number of banks in each group is kept constant, and hence the figure shows that the banks whose willingness-to-pay substantially increased during 2008 were also allocated a larger share in the primary market.

4.2 Banks' Balance Sheets and Changes in the Willingness-to-Pay

We were able to match 390 bidders in our auction data set to the Bankscope database, which includes detailed data on banks' balance sheets. We used 30 variables, which we ex-ante deemed likely to be correlated with banks' willingness-to-pay.

Of the 30 balance sheet variables from Bankscope, 8 indeed exhibit a significant (at 10% level) correlation with our estimates of willingness-to-pay and also with bids.[3]

Table 5: Regressions of Differences in Balance Sheet Variables on Differences in Marginal Values

$Diff\_X_i$	β	S.E.	R^2	N
Deposits & Short Term Funding	-13,731.8	7,370.4*	0.01	363
Total Customer Deposits	-10,338.5	4,768.8**	0.01	362
Equity	-1,738.4	737.6**	0.02	363
Loan Loss Provisions	-289.3	148.4*	0.01	357
Due from Central Banks	-1,620.5	738.8**	0.02	316
Interest Income	-1,233.4	670.8*	0.01	363
Net Interest Margin	-0.42	0.17**	0.02	363
Write-Offs	13.12	7.01*	0.02	170

[a] Each line corresponds to a separate regression: $Diff\_X_i = \alpha + \beta * Diff\_MV_i + \varepsilon_i$, where $Diff\_X_i$ is always defined as the difference post-2007 - pre-2007 in the relevant variable

[b] *, ** significant at 10% and 5%, respectively

The significant correlates are: Deposits & Short Term Funding, Total Customer Deposits, Equity, Loan Loss Provisions, Due from Central Banks, Interest Income, Net Interest Margin, and Write Offs. All these variables, except for write offs, are also significantly correlated with the changes in bids. In addition, Issued Loans and Demand Deposits are also significantly correlated with changes in bids, but not with the changes in marginal values. Table 5 summarizes least square regressions for those variables that are significantly correlated with the changes in marginal values. All coefficients have the expected signs: banks that experience the highest increase in the willingness-to-pay during 2008 at the same time experience the highest decrease in deposits, equity, reserves with central banks, interest income and highest increase in write-offs. Their net interest margin also decreases the most, suggesting that their funding costs likely increased the most.

[3]Note that therefore over 25% of the variables end up being significant. This makes it highly unlikely that this would occur due to chance, unless there is a high degree of colinearity among the chosen variables.

Now we will examine the relative changes in banks' various balance sheet measures for two groups of banks. We classify banks by our preferred measure: the changes in the estimated willingness-to-pay.For each bank, we first compute the quantity-weighted willingness-to-pay in a given auction. This is necessary since banks may submit multiple steps in their bids and thus their estimated willingness-to-pay is a function of the size of the loan requested. For each bank, we then look whether the mean of its willingness-to-pay was increasing during 2008. We implement this procedure by regressing the time series of our estimates of a bank's willigness-to-pay on a dummy indicating the latter half of the sample. We flag those banks, for whom the difference in means is significant on 5% level. This procedure results in 82 out of the total of 588 banks that we observe bidding both in the first and in the second half of the sample (i.e., before and after May 2008) being flagged. For each bank in our sample we also construct the change in various balance sheet measures between 2009 and 2007. Finally, we run a t-test to compare means of these changes across the two groups of banks: the ones that were flagged by our procedure and the other ones that were not. It is reassuring that for those variables, for which there is a significant difference between the means across the two groups, this difference is of the expected sign.

First, let us consider the Tier 1 ratio, which is a ratio of a bank's equity capital to its total risk-weighted assets (i.e., the higher this ratio the more financially sound a bank should be). While the Tier 1 ratio improves virtually for all banks in our sample (the mean Tier 1 in 2007 is 8.84 and in 2009 it is 10.52), it improves significantly less on average for the flagged banks (1.11 versus 1.78). The same story holds for Total Capital Ratio (1.09 versus 1.64). Similarly, while the Cost-to-Income ratio improves slightly on average between 2007 and 2009 (from 57.09 to 56.84), it actually worsens for the flagged banks (increases by 3.90 while the banks that are not flagged improve by -3.03). Among other variables that exhibit significant differences across the two groups are Long-Term Funding (deteriorates much more for the flagged group between 2007 and 2009), Loan-Loss-Reserves, which worsen for the flagged group, but improve for the others, Off-Balance-Sheet Items, which increase by $1,793$ million for the flagged group while they decrease by 2213 for the others, Net Gains on Trading and Derivatives decline for everybody, but much more so for the flagged group (-123 versus -8 million). The flagged banks also decreased their issuance of mortgages (-785)

while the other group increased the mortgage loans by 1370 on average. The amount due from central banks (i.e., the reserves and deposits parked with the central banks) increased substantially for the flagged banks (by 276.8) compared to the decrease among the other banks of -24 on average. On a more comforting note, the flagged banks increased their positions in government securities significantly more than the other banks (1635 versus 417). Net Interest Margin worsened for the flagged banks (-0.006) while it improved for the others (0.13). The difference in the change in Profit-Before-Tax is significant only at 12% level, but the difference amounts to 100% (-443 versus -212). Overall, out of the 30 variables considered, there is a significant difference in 8 of those across the two groups and the sign of this difference is as expected.

4.3 Predicting Bailouts

To provide additional evidence on informational content of our estimates of willingness-to-pay for liquidity we estimated a logit model of probability of a bank receiving bailout in various waves as a function of the changes in the willingness-to-pay. Figure 11 depicts the locations of banks that were bailed out between late 2007 and 2011. These bailouts can be split roughly into three waves. The first wave includes 6 bailouts that occured before Lehman Brothers declared bankruptcy. Therefore, we would expect that these banks suffered an adverse shock earlier than 2008 already. We use the estimates of willingness-to-pay from 2007 from Cassola et al. (2011) to try to capture this. The second wave includes bailouts that occured before May of 2009, i.e., through the trough of the equity markets in March 2009. And the third wave includes the bailouts until the end of 2011.

Table 6 reports the results of logit regressions for the first wave of bailouts. The results clearly show that the dynamics of willingness-to-pay for liquidity during 2007 captured by the difference in the mean WTP before and after August 2007 is significantly correlated with the likelihood of a bank needing a bail out, but the straightforwardly obtained dynamics of the bids is not. Perhaps more importantly, bailouts that came later, i.e., in the second half of 2008 or later, are no longer significantly related to the changes in the willingness-to-pay during 2007. Unfortunately, we did not obtain a similar significant relationship between changes in the willingness-to-pay for liquidity during 2008 and later bailouts. This could potentially be simply due to the data from 2008 not

Table 6: Bailout Logit Regression (1^{st} Wave)

	Bailout Aug 07-Sep 08		
Δ Willingness-to-Pay post-pre Aug 2007	6.72**		7.37*
	(3.33)		(3.92)
Δ Bids post-pre Aug 2007	-19.39		-26.43
	(14.96)		(16.74)
Δ Willingness-to-Pay post-pre May 2008		-3.24	-4.41
		(4.85)	(5.85)
Δ Bids post-pre May 2008		2.33	2.53
		(8.70)	(9.99)
Constant	-4.00***	-4.44***	-3.12**
	(1.16)	(0.54)	(1.22)
Mean of Dependent variable	0.01	0.01	0.01
pseudo-R^2	0.08	0.01	0.10
N	384	369	297

[a] Standard errors in parentheses.
[b] *, ** , *** significant at 10%, 5% and 1%, respectively.

including any such clear break as the outbreak of the subprime market crisis in August 2007 and therefore the difference in mean willingness-to-pay or bids has to be constructed more or less arbitrarily.[4] Changes in bids in the first and second half of 2008 are significantly correlated with the likelihood of a bank being bailed out in the second wave, but when we also include the dynamics of the willingness-to-pay during 2008, the relationship becomes insignificant.

4.4 Aggregate and Systemic Risk

If a bank's willingness-to-pay (or even the bid) exceeds EURIBOR, it means that that bank did not believe it could get an unsecured loan at that rate during that week. We can therefore use our estimates of willingness-to-pay to find a share of banks that are likely unable to obtain an unsecured loan at EURIBOR. Figure 12 plots this share (with the y-axis on the left) and also the unsecured rate (y-axis on the right). It clearly shows that there are fairly big movements in this share, which suggests presence of systemic risk factors: not surprisingly, banks' financial situation tends to be correlated. In future work, we will use our data to investigate this systemic risk and its distribution across countries and/or banking groups in more detail.

[4]This could also be interpreted as a significant course of a measurement error in the explanatory variable.

[TO BE COMPLETED]

5 Conclusion

This paper provides a detailed analysis of the bidding behavior of banks in the Euro area during the heart of the recent financial crisis: from the beginning of 2008, through the fall of Lehman Brothers, all the way to the initial fixed rate tenders offered during the last three months of 2008. We demonstrate that the bidding data submitted with weekly frequency could be potentially informative about the financial state of individual banks. We show that the changes in the marginal willingness-to-pay are significantly correlated (in the expected direction) with several performance measures based on balance sheet data, which, however, are available only ex-post or very infrequently. In future work, we will use this data to investigate the systemic risk and the possibility of predicting the necessity of government interventions. We also will try to address the problem of what would happen if the ECB were to switch back to awarding liquidity in weekly discriminatory auctions rather than through fixed rate tenders.

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6 Appendix

Table 7 summarizes all 30 balance sheet-based variables that we downloaded from Bankscope database.

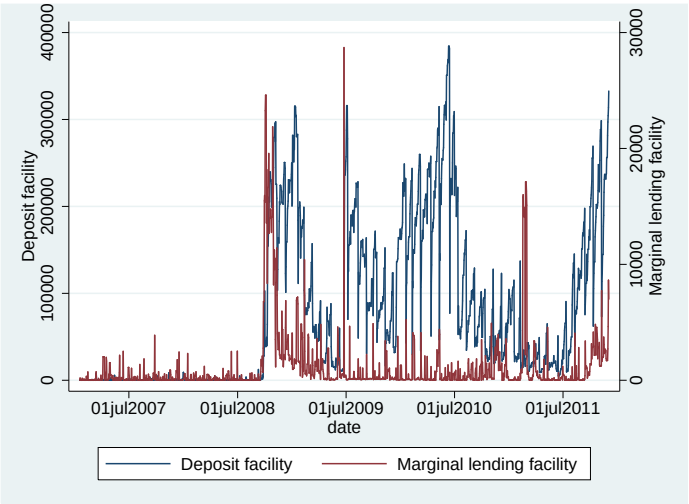

Figure 3: Usage of Deposit and Lending Facilities

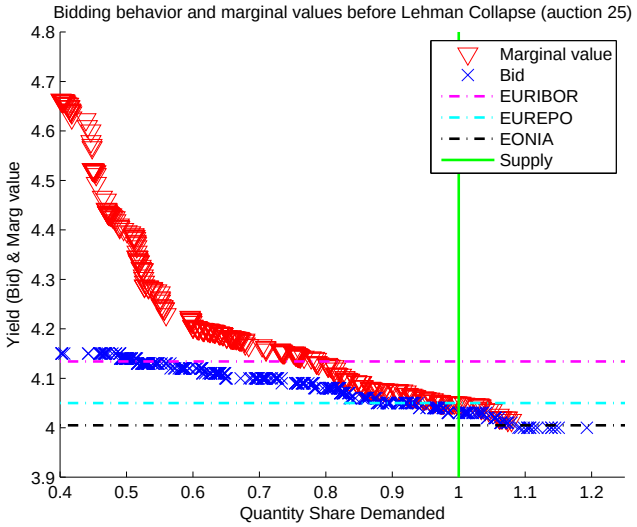

Figure 4: Aggregate Bid and Marginal Values Before Lehman Collapse

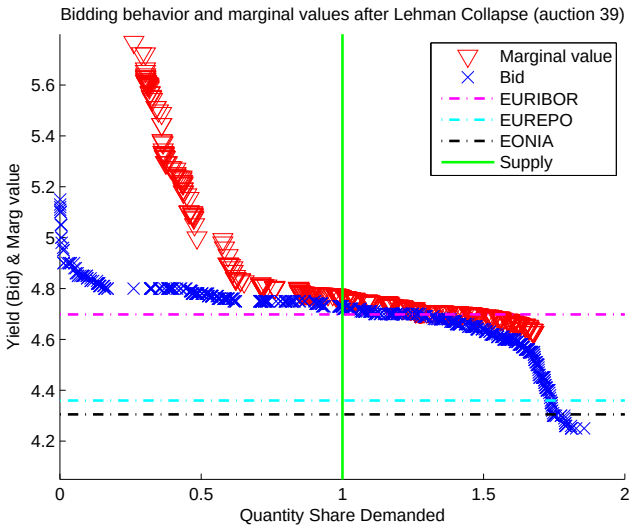

Figure 5: Aggregate Bid and Marginal Values After Lehman Collapse

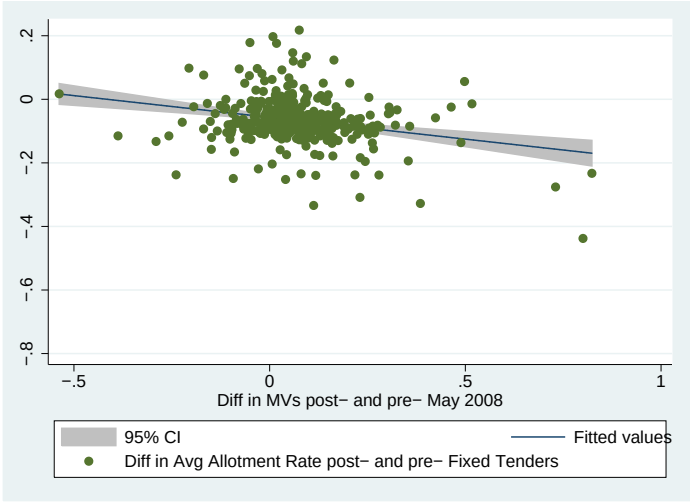

Figure 6: Regression of Δ Avg Rate Paid for a Repo Loan on Δ Marginal Values

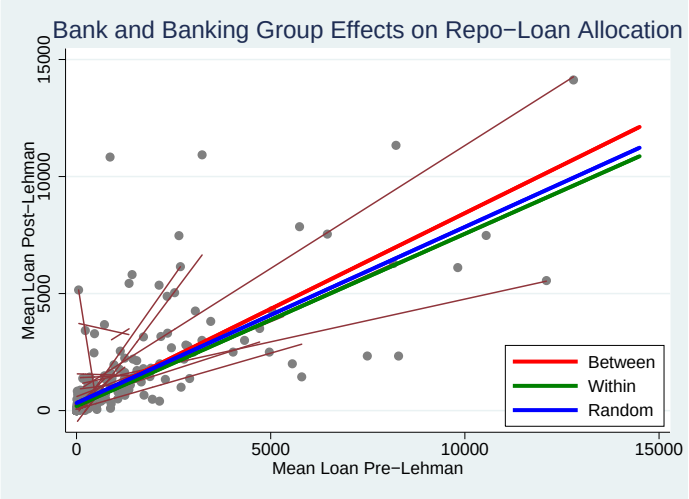

Figure 7: Size of repo loans from the ECB (in million €)

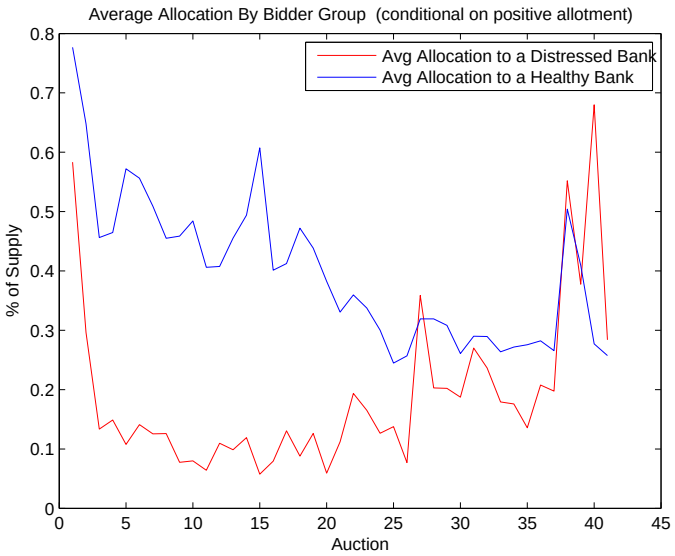

Figure 8: Average allocation

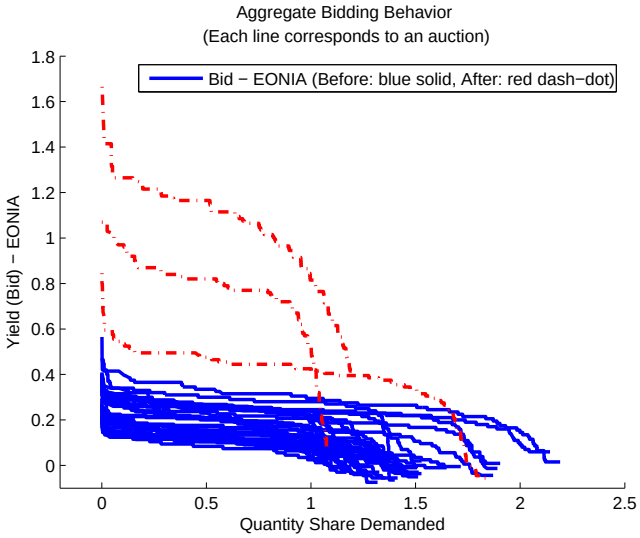

Figure 9: Aggregate Bids in 2008

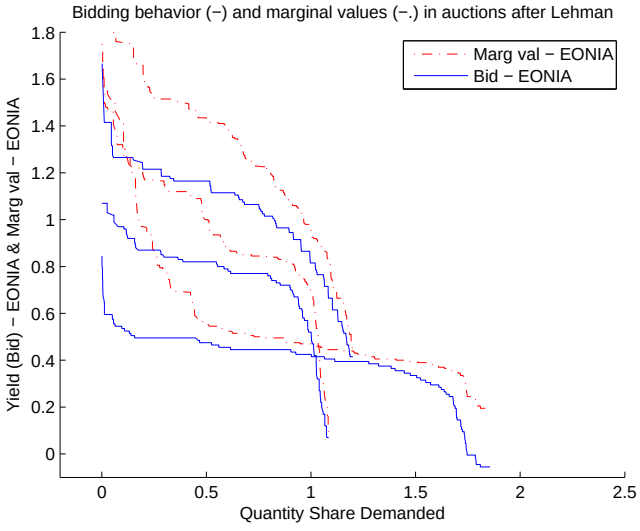

Figure 10: Aggregate Bids and Values Around Lehman Collapse

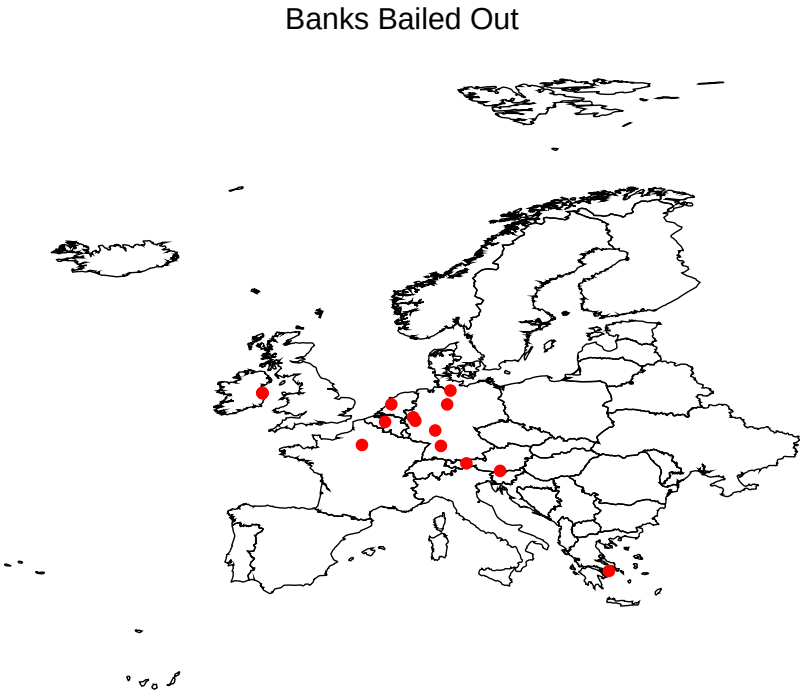

Figure 11: Locations of Bailed-Out Banks

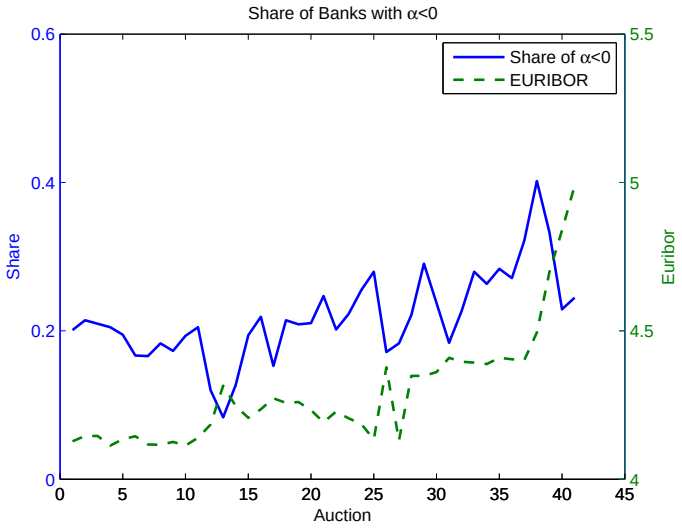

Figure 12: Share of Banks unable to borrow at EURIBOR

Table 7: Variables from Bankscope Database (2008)

	N	Mean	Std Dev
Loans	542	11,642.1	32,909.2
Deposits and Short Term Funding	542	15,031.35	44,263.1
Total Customer Deposits	540	8,383.5	25,480.3
Derivatives	143	10,261.5	40,131.2
Long Term Funding	532	5,966.3	24,309.4
Equity	542	1,008.0	3,720.2
Off Balance Sheet Items	521	3,915.0	16,705.8
Reserve for Impaired Loans/NPLs	154	778.1	1,510.3
Liquid Assets	542	6,933.3	35,572.7
Net Gains on Trading and Derivatives	484	-14.9	220.0
Net Gains on Assets at FV	102	-170.2	895.8
Loan Loss Provisions	535	84.8	286.4
Profit before Tax	542	20.1	578.3
Net Income	542	15.2	529.6
Total Capital Ratio	357	13.6	4.6
Tier 1 Ratio	189	9.5	3.7
Mortgages	383	2,930.3	9,102.9
Total Problem Loans	130	1,290.3	2,230.3
Due from Central Banks	454	389.4	3,153.5
Govt Securities	458	1,451.1	5,540.2
Total Assets	542	25,645.2	85,647.2
Deposits - Demand	529	3,768.3	12,047.9
Interest Income	541	1,274.5	3,927.9
Loan Loss Res / Gross Loans	154	2.54	4.94
Net Interest Margin	530	1.96	0.81
ROAA	542	0.46	2.30
ROAE	542	4.45	19.23
Cost to Income Ratio	535	62.8	29.8
Liquid Assets/ (Dep & ST Funding)	492	34.5	186.0
Write Offs	97	2.24	10.85