Bidder Behavior in Repo Auctions without Minimum Bid Rate: Evidence from the Bundesbank

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Abstract

A distinguishing feature of the ECB's monetary policy setup is the preannouncement of a minimum bid rate in its weekly repo auctions. However, whenever interest rates are expected to decline, the minimum bid rate is viewed as too high and banks refrain from bidding, severely impeding the ECB's money market management. To shed more light on banks' underbidding, we perform a panel analysis of the bidder behavior in the repo auctions of the Bundesbank where no minimum bid rate was set. Our results indicate that neither bank's participation nor the submitted bid amount is significantly affected by an expected rate cut. This suggests that abandoning the minimum bid rate might increase the efficiency of the ECB's money market management.

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JEL classification: C23, D44, E52

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1 Introduction

Following the monetary policy practice of the Bundesbank, repo auctions are the predominant instrument for the ECB's money market management. A distinguishing feature of the ECB's repo auctions is the announcement of a minimum bid rate which strongly indicates the ECB's policy intentions and typically sets a floor for the short-term interest rates of the euro area. Yet, when banks expect interest rates to decrease, the current minimum bid rate is viewed as too high and banks *underbid*, i.e. they tend to refrain from bidding. On several occasions banks' underbidding severely hampered the ECB's liquidity management, increased interest rate volatility and obscured the monetary policy stance.[1] The ECB recently announced rather involved "measures to improve the efficiency of the operational framework for monetary policy" to keep banks from underbidding, see ECB (2003a). Interestingly, however, the auction format will remain unchanged. In particular, the ECB will still pre-announce a minimum bid rate.

This paper investigates the bidding behavior of banks not constrained by a minimum bid rate. We employ a unique data set of individual bids submitted in the repo auctions of the Bundesbank where no minimum bid rate was set. Apart from the minimum bid rate, however, the repo auctions of the Bundesbank and the ECB share exactly the same rules. Therefore, the Bundesbank auctions provide us with almost a natural experiment to study the role of the minimum bid rate and the ECB's underbidding problem.

In two recent papers, Nyborg, Bindseil and Strebulaev (2002) and Scalia and Ordine (2002) investigated how banks' bidding in the ECB's repo auctions is influenced by factors such as the level of money market rates, interest rate expectations and uncertainty. Nyborg, Bindseil and Strebulaev (2002) use aggregated bidding data to

[1] For example, in the repo auctions on February 13 and April 10 in 2001 and more recently in December 2002 and March 2003, banks' underbidding prevented the ECB from injecting the necessary amount of reserves into the money market. As a result, money market rates increased sharply although anyone expected interest rates to decrease, see ECB (2001).

investigate the winner's curse effect and the relation between the repo rate and the secondary market[2]. Scalia and Ordine (2002) perform a full-blown panel analysis of banks' bidding with the focus on the empirical relevance of country specific effects. Both studies confirm the underbidding problem in the ECB's auctions but remain less explicit on its causes, in particular, the role of the minimum bid rate.

In line with Scalia and Ordine (2002) we will estimate panel regressions for the probability of bidding and a bank's individual bid amount. The latter variable is left-censored since it can only be observed if a bank actually participates in an auction. This property of the data is often neglected in the empirical literature on auctions.[3] This paper accounts for the effect of censored variables using a panel tobit approach.

The remainder of the paper is organized as follows. In Section 2, we introduce the data and variables that are used in the following panel regressions. Section 3 presents the empirical analysis of banks' bidding in the Bundesbank's auctions. First, we estimate a logit model to analyze banks' participation decision. In a second step, we build on the preceding analysis employing a panel tobit model to investigate the determinants of a bank's bid amount. Section 4 gives a summary of the main results and offers some policy conclusions.

2 Data and theoretical predictions

2.1 The bidding data

The following empirical analysis is based on a unique data set of weekly repo auctions performed by the Bundesbank. We collected individual bidding data (which was not available in computer readable form) of 275 banks that had submitted their bids at the Land Central Bank of Hesse. Bidder codes allow us to track each bidder over time. Hesse contains Germany's financial center Frankfurt hosting a major part of

[2] See also Nyborg, Rydqvist and Sundaresan (2002) for a similar study on Swedish treasury auction.
[3] See Scalia and Ordine (2002), but also Bjonnes (2001) who estimates bid functions for the Norwegian Treasury Bill auctions. A notable exception is Ayuso and Repullo (2001) who investigate banks' bidding in the ECB's fixed rate tenders.

German banks including large banks as well as a broad range of small private banks and foreign bank dependencies. Therefore, the results derived from our sample should be fairly representative for the bidding behavior of the German banking sector.

In many respects, banks' bidding behavior in the repo auctions of the Bundesbank and the ECB appear to be very similar.[4] First, large bidders participate more often but their bids are still small relative to the total bid volume, see Table 1. Second, banks usually do not submit more than three bids per auction, see Table 2. In fact, the bid rate dispersion in the Bundesbank's repo auctions is not higher than in the repo auctions of the ECB, although there is no minimum bid rate that constrains banks' bidding. Third, there are many bidders that participate only infrequently, see Table 3. Only 175 out of 275 Hessian banks participated at least once in the auctions covered by our data set. A similar share of active bidders is observed in the repo auctions of the ECB. In contrast to previous empirical work, we do not remove the bidders never participating in an auction to avoid distorting effects on the analysis of banks' participation decision.

Compared with the ECB, which changed the auction format only once in four years, the Bundesbank was far less reluctant to switch between fixed and variable rate tenders.[5] In fact, there is only one longer period, running from April to November 1995, where the Bundesbank did not change the auction format. In this period, the Bundesbank performed its repo auctions exclusively as variable rate tender, which is the auction format used by the ECB since June 2000.[6] We therefore concentrate on this period that provides 33 auctions with the standard maturity of about two weeks. Note that this period was characterized by decreasing interest rates, see Figure 1. In particular, in August 1995 the Bundesbank lowered the rate of its marginal lending facility (the Lombard rate) by 50 basis points. With regard to banks' underbidding

[4] See Nyborg, Bindseil and Strebulaev (2002) and ECB (2001) for descriptive statistics on ECB auctions.

[5] Central banks use fixed rate tenders to provide clear signals about the current interest rate target. The impact of the auction format on interest rate uncertainty is investigated in Nautz (1998) and Manna (2002).

[6] The ECB switched to the variable rate tender format in response to banks' overbidding, i.e. banks increasingly exaggerated their liquidity needs in the bids, see Nautz and Oechssler (2003).

in the repo auctions of the ECB, it will be interesting to see how banks' bidding is affected by the Bundesbank's interest rate cut.

2.2 Variables and theoretical predictions

Following Scalia and Ordine (2002) and Bjonnes (2001), we characterize the bidding behavior of a bank by its participation decision and the log of the individual bid amount which will be explained by various auction as well as bidder-specific factors.

Banks' demand for repos should be affected by the cost of alternative refinancing opportunities. For example, the higher the *spread* defined as the difference between the expected stop out rate and the overnight rate the cheaper is the repo credit.[7] Therefore, a higher *spread* should increase both, the probability of bidding and the bid amount. We estimated the expected stop out rate using the error correction equation implied by the cointegrating relation between the stop out rate and the overnight rate, see Appendix A.

The variable *term spread* is defined as the difference between the one-month rate and the overnight rate where e.g. a negative term spread indicates that interest rates are expected to decline. For the repo auctions of the ECB, expected changes of the ECB's key interest rates have a strong impact on banks' bidding behavior. In particular, when banks expect decreasing interest rates, underbidding hampers the central banks' liquidity management. According to the course of the term spread, banks clearly anticipated the reduction in the rate of the Bundesbank's marginal lending facility in August 1995. To capture possible bidding strike behavior, we introduce a dummy variable *underbidding* which takes the value one in the auction preceding the Bundesbank's rate cut, compare Scalia and Ordine (2002).

The interest rate uncertainty perceived at the auction day is proxied by the variable

[7] Note that it would be more appropriate to define the opportunity cost variable using a money market rate having the same maturity as the repo. Unfortunately, however, a biweekly money market rate, comparable to the newly introduced EONIA swap rate used in Scalia and Ordine (2002), is not available.

volatitity which is estimated using an EGARCH (1,1) model for daily observations of the overnight rate, compare Nyborg, Rydqvist and Sundaresan (2002). Regarding the impact of uncertainty on banks' bidding, the implications of auction theory are ambiguous. On the one hand, there is the well-known 'winner's curse' effect implying that banks bid more cautious when uncertainty increases. On the other hand, according to Scalia and Ordine (2002), if the concern is the risk of losing in an auction, not winning, then higher uncertainty may induce bidders to submit larger bids at higher rates. This behavior would also be in line with the predictions of multi-period reserve management models, where higher interest rate risk increases banks' demand for reserves, see Nautz (1998).

The variable *reserve fulfilment* measures the liquidity need of the banking sector. Since data on the individual reserve holdings are not available it is defined as the ratio of the reserve holdings of all German banks prior to the auction and the aggregate minimum reserve requirement. If reserve holdings are low, banks should have a stronger incentive to participate in the auction. Since the Bundesbank allowed averaging over the maintenance period, this effect might be particularly relevant in the last auction of the maintenance period. We subsequently defined the dummy variable *end of period* taking the value 1 if the auction is the last in the maintenance period.

Finally, we consider two bidder-specific regressors. The variable *maturing allotment* is defined as the log of a bank's repo volume received two weeks before. This variable captures the fact that banks often use the biweekly repo credit on a revolving basis. The dummy variables *large*, *medium*, and *small* characterize a bank's size as it is reflected in the average bid volume, see Table 4. We will interact these dummies with all explanatory variables to investigate how a bank's bidding behavior is influenced by its size.

3 Empirical results

3.1 The participation decision of banks

In a first step, we analyze the participation decision of an individual bank using a panel version of the logit model where the dependent variable y_{it} equals one if bank i participates in auction $t \in \{1, \ldots, N\}$ and is zero otherwise. Using the logistical distribution Λ, the logit model is given by

$$\text{Prob}(y_{it} = 1 | x_{it}) = \Lambda(x'_{it}\beta) = \frac{e^{x'_{it}\beta}}{1 + e^{x'_{it}\beta}} \tag{1}$$

where x_{it} and β denote the vector of explanatory variables and the corresponding coefficients, respectively.

We opted for the random effects logit model since the Hausman-test could not reject the hypothesis that the individual effects are uncorrelated with the other regressors. The random effects model allows for the inclusion of time-invariant bidder-specific regressors like the size dummies introduced above. Our specification is corroborated by the similarity of the parameter estimates from the random and the corresponding conditional fixed effects estimation, see Table 5.

Table 5 presents the estimation results indicating each variable's impact on the participation probability. Yet, as in any nonlinear regression the estimated coefficients do not have the familiar elasticity interpretation. To evaluate the parameter's *economic* significance, we report the appropriate *marginal effects* for the logit case, see column 2. Following Greene (2002), the marginal effect is calculated as

$$\frac{\partial E[y_{it}|x_{it}]}{\partial x_{it}} = \left\{ \Lambda(x'_{it}\beta) \left[1 - \Lambda(x'_{it}\beta) \right] \right\} \beta \tag{2}$$

indicating the percentage point change of the probability upon a one percent increase of the explanatory variables. Since its value varies with x, the marginal effects are evaluated at the sample means of the regressors. In the case of a dummy variable, the derivative with respect to a small change in the variable is not appropriate. Therefore

the marginal effect is given by:

$$\text{Marginal Effect} = \text{Prob}[y_{it} = 1|\bar{x}_{it}, d = 1] - \text{Prob}[y_{it} = 1|\bar{x}_{it}, d = 0]$$

where d represents the dummy variable and $\bar{x}_{it}$ refers to the means of the remaining explanatory variables.

According to Table 5 interest rate expectations have a significant influence on a bank's participation decision. In line with the ECB's experience, the participation probability in the repo auctions of the Bundesbank decreases when a negative *term spread* indicates that interest rates are expected to decrease. However, given the estimated marginal effect (0.879) of the term spread, the economic significance of rate expectations for banks' bidding behavior crucially depends on the existence of a minimum bid rate. To see this, suppose banks anticipate a rate cut by the central bank of 50 basis points. In the ECB's monetary setup, the minimum bid rate prevents the current repo rate and, thus, the overnight rate from falling. As a result, the term spread will decrease to about minus 50 basis points and banks' participation decreases by $50 \times 0.879 = 44\%$. Thus, the introduction of a minimum bid rate would yield a large reduction in the number of bidders comparable to the bidder strikes actually experienced by the ECB. Yet, in the Bundesbank auctions, bids were not constraint by a minimum bid rate such that both, the repo and the overnight rate could fall in anticipation of a Lombard rate cut, see Figure 1. Therefore, the term spread could adjust smoothly and was generally much smaller (e.g. 10 basis points) than the actual rate cut. Accordingly, the impact of rate expectations for the Bundesbank auctions is rather modest ($10 \times 0.879 = 8.8\%$). Finally, the insignificant coefficient of the dummy variable *underbidding* underlines that the expected rate cut of the Bundesbank had no major impact on banks' participation decision.

The variable *spread* measuring the opportunity costs of repos exhibits a significant effect on banks' participation decision and its coefficient is plausibly signed. Particularly, if the expected repo rate of the central bank is high relative to the money market rate fewer banks will decide to participate in the auction. Note that the estimated

coefficients of the spread and the term spread suggest that the overnight rate cancels out. The implied parameter restriction is, however, strongly rejected by the data.

The coefficient of the variable *volatility* is significantly negative. Yet, the marginal effect indicates that volatility's influence on a bank's participation decision is negligible. We are therefore reluctant to interpret the coefficient as evidence in favor of the winner's curse effect. If banks are short in liquidity, i.e. their *reserve fulfilment* is low, they should have a stronger incentive to participate in the auction. As in Scalia and Ordine (2002) this is not substantiated by our data. This plausible effect might be obscured in our estimation because we were left with aggregate data to proxy the liquidity position of an individual bank.

As expected, the variable *maturing allotment* has a positive effect on banks' participation demonstrating that banks use repos on a revolving basis. According to the estimated marginal effect, a 70 percent rise in the volume of the maturing repo raises a bank's participation probability by one percentage point. At a first glance, this effect appears to be small, but banks' individual allotments range between zero and 5 billion DM. Due to that large variation, the maturing allotment is a major determinant of banks' participation probability. For example, the average participation probability of a bank with zero maturing allotment is about 7% while the average probability jumps to 31% if the bank received only one million DM, the minimum allotment set by the Bundesbank.

According to the estimated effect of the *end of period* dummy banks' participation probability rises in the auctions performed in the last week of the maintenance period. Apparently, banks bid more often at the end of the period anticipating the increased probability of being squeezed after the auction, see Nyborg and Strebulaev (2001). The marginal effect indicates that in the last auction of the reserve period the average participation probability of a bank rises by 6 percentage points.

Finally, the coefficients of the size-dummies display the obvious fact that large banks participate more frequently in the auctions than small banks, see also Table 4. Large

banks bid in the auction not only to satisfy their own liquidity needs but also to resale and actively trade reserves in the secondary market.

Size Effects on a Bank's Participation

We now turn to analyzing the role of a bank's size on its participation decision. In order to investigate whether a bank's response to a regressor depends on its size, we interact the size dummies with all other explanatory variables.[8] The results are presented in the first column of Table 6. In the second column we display the p-value of the Wald-statistics testing for the null hypothesis of no size effect.

There are significant size effects with regard to banks' response to interest rate expectations (*term spread*) and to expected opportunity cost (*spread*). For both variables, the medium-sized banks show the weakest response. The coefficients of the size-specific *maturing allotment* variables reflects that the seasonality of participating in an auction is more pronounced for small and medium size banks than for large banks. There is no evidence for a size effect with regard to the remaining explanatory variables. Notably, there were no significant size interactions with the *underbidding* dummy implying that the impact of rate cut expectations on banks' participation is small irrespective of a bank's size.

In the last column of Table 6 we report the p-values of the tests on the overall significance for each group of variables. The results of the extended logit model are very much in line with those obtained for the model without size effects, see Table 5. In particular, the extended logit model confirms the doubts on the significance of volatility for banks' participation decision.

[8] Since large banks participated in almost every auction, the corresponding coefficients can only be estimated imprecisely, see Table 4.

3.2 The bid amount

In this section, we advance on the preceding analysis of bidders' participation decision investigating the determinants of an individual bank's bid amount. Naturally, a bank's bid volume can only be observed if the bank decides to participate in the auction. As a consequence, the variable bid amount is left-censored and ignoring this property might result in biased estimates. Following Ayuso and Repullo (2001), we employ a panel tobit model that accounts for the participation decision of each individual bank.

In the tobit model, the variable bid amount, y_{it}^*, is specified as

$$y_{it}^* = x_{it}\beta + \epsilon_{it} \tag{3}$$

where

$$\epsilon_{it} \sim N(0, \sigma^2)$$

and the *observed* bid amount is

$$y_{it} = \begin{cases} y_{it}^* & \text{if } y_{it}^* > 0 \\ 0 & \text{if } y_{it}^* \leq 0. \end{cases}$$

Notice, that the tobit model uses both, the probability that $y_{it} = 0$ (given x_{it}) and the distribution of y_{it} given that it is positive. This can be illustrated by the log likelihood function

$$\ln \mathrm{L} = \sum_{y_{it}>0} -\frac{1}{2}\left[\ln(2\pi) + \ln\sigma^2 + \frac{(y_{it} - x_{it}'\beta)^2}{\sigma^2}\right] + \sum_{y_{it}=0} \ln\left[1 - \Phi\left(\frac{x_{it}'\beta}{\sigma}\right)\right] \tag{4}$$

where Φ is the standard normal distribution. The first part of the log likelihood function represents the information of the conventional regression on the uncensored observations while the second part corresponds to the probit model describing a bank's participation decision. Obviously, the tobit estimation uses the full set of available information and hence will generally lead to more efficient estimates. Following Greene (2002), the marginal effects for the tobit model are given by

$$\frac{\partial E[y_{it}|x_{it}]}{\partial x_{it}} = \Phi\left(\frac{x_{it}'\beta}{\sigma}\right)\beta \tag{5}$$

Table 7 shows the estimated coefficients and the resulting marginal effects from the tobit model explaining a bank's bid amount. We also display the results of a corresponding naive GLS panel regression which neglects the information contained in the zero bids. With respect to the marginal effects of the tobit model, the results from the GLS regression seem to be broadly in line with the tobit estimates. The general impression is, however, that the GLS model exaggerates the effects of interest rate expectations, opportunity cost and the reserve fulfillment. As expected, the standard deviations of the estimated coefficients are larger in the GLS model. The only exception refers to the variable *reserve fulfillment* whose significant coefficient implies that banks bid larger amounts when their liquidity needs are low. This implausible bidding behavior is not confirmed by the tobit analysis.

Our findings are not in favor of a winner's curse effect, i.e. bidders do not reduce their bids significantly when *volatility* of the market interest rate increases. There is, however, a significant impact of the variable *maturing allotment* and the dummy variable *end of period* indicating that bidders bid more aggressively when their demand for refinancing is high and the danger of becoming squeezed increases.

The estimated coefficients of the *term spread* indicates that a bank's bid amount decreases when a negative term spread reveals that interest rates are expected to decrease. In line with the results obtained from the logit model, the economic significance of the term spread for the bid amount is rather small. Furthermore, the underbidding dummy capturing the Bundesbank's rate cut in August 1995 is far from being significant. This demonstrates that even in the week before an anticipated rate cut, the Bundesbank had no difficulties in supplying the appropriate volume of reserves through its repo auction. Thus, in contrast to the ECB's underbidding experience, interest rate expectations did not impede the Bundesbank's money market management.

Size Effects on the Bid Amount

Table 8 shows the results from the augmented tobit model that incorporates the interactions between the explanatory variables and the size dummies. Size effects are of particular relevance for monetary policy because central banks prefer 'fair' auction formats to avoid any violations of the principle of equal treatment. The tobit model estimates yield strong evidence in favor of a size effect concerning the impact of the term spread on a bank's bid amount in the repo auctions of the Bundesbank. Interestingly, the response of a bank's bid amount to interest rate expectations is most pronounced for small banks. This is in contrast to results obtained for the ECB's auctions where large banks seem to bid more informed than small banks, see e.g. Breitung and Nautz (2001). Note that this conflicting result might originate from neglecting the participation decision (i.e. the left-censoring of the data).

In terms of the other variables, allowing for size effects does not alter the main conclusions. In particular, the insignificant underbidding dummy and the small marginal effects of the term spread on the bid amount found in the augmented tobit model confirm that underbidding was not an issue in the repo auctions of the Bundesbank where no minimum bid rate was set.

4 Conclusions

The crucial difference between the Bundesbank repo auctions and the ECB's current practise is the preannouncement of a minimum bid by the ECB. A major motivation for the current paper was to evaluate the consequences of this bidding constraint for the ECB's underbidding problem. Based on a unique data set of bidders' individual demand schedules, we perform a panel analysis of banks' bidding behavior in repo auctions of the Bundesbank. Specifically, we investigate how e.g. interest rate expectations, opportunity cost, volatility, and bidder size determine banks' participation decision and a bank's bid amount.

Analyzing a bank's bid amount, we explicitly account for the left-censoring of the bidding data by applying a tobit model that uses both, the probability of a bank's participation and the distribution of the bid amount given that it is positive. Using the full set of information, the tobit model delivers more efficient estimates. In the same vein, in our panel logit analysis of banks' participation decision, we did not remove the bidders never participating in an auction to avoid distorting effects on the estimated probabilities.

Our results indicate that interest rate expectations influence both, banks' participation and the submitted bid amount. However, in terms of the economic significance the impact of interest rate expectations is only modest. An important finding in this respect is that banks do not deviate significantly in their behavior prior to an anticipated interest rate cut of the Bundesbank. In the case of the ECB such interest rate expectations have led to underbidding and even bidder strikes. In the Bundesbank's auctions banks did not refrain from bidding but reacted to prevailing rate cut expectations by bidding at lower interest rates. Therefore, banks kept on bidding because the Bundesbank did not constrain bidders by a minimum bid rate. It appears that auctions without a minimum bid rate lead to more favorable outcomes than the current ECB auctions.

This result is of particular interest in the light of recent announcements by the ECB to reorganize its operational framework of monetary policy, see ECB (2003a). All these measures are designed to stop the underbidding problem by mitigating the role of interest rate expectations for banks' bidding. To that aim the maintenance period for required reserves will be determined by the meetings of the Governing councils. Moreover, the ECB emphasized that rate changes will only occur at those meetings. Finally, the maturity of the repos is reduced to one week. As a result there is no more overlapping of a repo in the next maintenance period in which the repo rate could possibly change.

Albeit the predictable success of these measures in fighting the underbidding problem,

there are other problems coming along with the introduction of the new operational framework. The shorter maturity of the repos and the nonoverlapping maturities makes banks' reserve management more difficult. In particular, at the very last auction in the maintenance period, the risk of going out empty handed increases. This may increase bidding rates and banks' refinancing costs, see ECB (2003b). More importantly, however, the commitment of the ECB not to change the interest rates during the maintenance period makes the ECB's interest rate policy less flexible. Note that it was perceived as a major advantage of weekly repo auctions, that the central bank can change interest rates flexibly and even at short notice. For example, situations like September 11 or the war in Iraq may require to react immediately. Therefore, the credibility of the ECB's interest rate commitment could be an issue.

To sum up, we do not doubt that the ECB's measures will serve the purpose to prevent banks from underbidding. Still, in light of the new measures' caveats, our results suggest that abandoning the minimum bid rate would have been another feasible solution. In the ECB's current monetary policy setup, the minimum bid rate is the key interest rate that sets a floor for short-term interest rates and signals the policy intentions. However, neither steering money market rates nor policy signalling requires a minimum bid rate. In particular, recent contributions on monetary policy implementation show that the control over short term interest rates can be achieved by the central bank in various ways, see e.g. Guthrie and Wright (2000). Therefore, the ECB could alternatively introduce a more symmetric interest rate target in the tradition of the US Federal Reserve Bank.

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A The expected stop out rate of the auction

Using weekly observations from April to November 1995, we found that the stop out rate (r) and the interbank overnight rate (i) are cointegrated with a stationary spread, see Nautz (1997). As a consequence, the expected stop out rate is derived from an error correction equation which is estimated as follows:

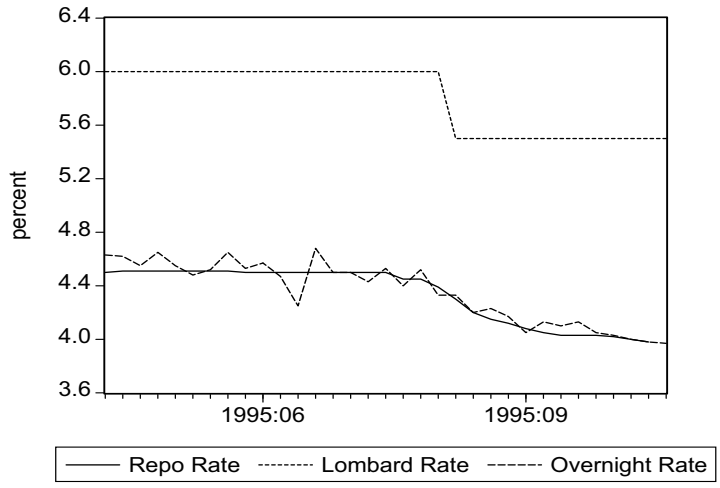
$$\Delta r_t = \underset{(1.92)}{-0.007} - \underset{(3.20)}{0.121}(r-i)_{t-1} + \underset{(5.71)}{0.662}\Delta r_{t-1} + \widehat{\varepsilon}_t$$

$$R^2 = 0.62, \quad Q(4) = 1.26 \quad \text{No. of observ.: } 31$$

Notes: The t-values are reported in parenthesis.

B Figures and Tables

Figure 1: Interest rates in the German money market



Notes: The repo rate corresponds to the stop out rate of the auction. The Lombard rate is the Bundesbank's key interest rate of the marginal lending facility which was lowered in August 1995. The overnight rate refers to the bidding days of the 33 auctions covered by our sample period. Source: Deutsche Bundesbank.

Table 1: Distribution of Average Bid Volume

Bid Volume (in Mio. DM)	**No. of Banks**	**Percent** (Cumulative)
0	100	36.36
1 - 100	132	84.36
101 - 500	29	94.91
501 - 1000	5	96.73
1001 - 3000	4	98.18
≥ 3000	5	100.00
$\sum$	275	

Notes: The data refers to the 33 Bundesbank auctions covered by our sample period (April to November 1995).

Table 2: Distribution of Number of Bids

No. of bids	**No. of bidders**	**Percent** (Cumulative)
0	6248	69.25
1	1315	83.33
2	918	93.35
3	445	98.36
4	105	99.52
5	44	100
$\sum$	9075	

Notes: The data refers to the 33 Bundesbank auctions covered by our sample period (April to November 1995).

Table 3: Participation Frequency

No. of auctions	**No. of banks**	**Percent** (Cumulative)
0	100	36.23
1 - 5	46	52.90
6 - 10	26	62.32
11 - 15	18	68.84
16 - 20	13	73.55
21 - 25	19	80.43
26 - 30	22	88.41
31 - 33	32	100.00
$\sum$	275	

Notes: The data refers to the 33 Bundesbank auctions covered by our sample period (April to November 1995).

Table 4: Bank Types

Bank Type	**Bank Category**	**No. of Banks**	**Average Bid Volume/Bank** (in Mio. DM)	**Average Allotment/Bank** (in Mio. DM)	**Participation Rate**
Large	Big banks Land banks	5	3490	1130	96.36%
Medium	Banks with special functions Regional instit. of credit coop. Regional banks Building associations	87	190	101	49.15%
Small	Credit cooperatives Saving banks Branches of foreign banks	183	23.9	13.1	21.71%

Notes: The data refers to 33 Bundesbank auctions in the period from April to November 1995. Bank categories correspond to the categorization by the Deutsche Bundesbank.

Table 5: The Participation Decision of an Individual Bank: A Panel Logit Analysis

	Random Effects Estimation	**Marginal Effects**	**Conditional Fixed Effects Estimation**
Term spread	8.19	0.879	8.70
	(5.16)		(5.48)
Underbidding dummy	0.36	-	0.30
	(1.20)		(0.97)
Spread	-11.57	-1.242	-12.14
	(-6.82)		(-7.14)
Volatility	-0.19	-0.020	-0.20
	(-2.08)		(-2.18)
Reserve fulfillment	0.68	-	1.11
	(0.55)		(0.90)
Maturing allotment	0.13	0.014	0.11
	(22.24)		(19.15)
End of period dummy	0.74	0.060	0.76
	(6.28)		(6.41)
Size dummies:			
Large	2.51		
	(1.57)		
Medium	-4.58		
	(-3.04)		
Small	-5.82		
	(-3.87)		
Pseudo-R^2	0.1142		0.1048
No. of observations	8525		4495
No. of groups	275		145

Notes: The t-values of the parameter estimates are reported in parenthesis. For the significant parameters we calculated the marginal effects (see Equation 2) that indicate the economic significance of the variables by the usual elasticity interpretation. Note that the Conditional Fixed Effects estimation is restricted to banks which participate at least twice. The Pseudo-R^2 measure is calculated according to Aldrich and Nelson (1984).

Table 6: The Participation Decision of an Individual Bank with Size Specific Regressors

	Coefficient Estimate	H_0**: no size effect** (p-value)	H_0**: zero effect** (p-value)
Term spread/large banks	20.36 (0.98)		
Term spread/medium banks	0.74 (0.31)	0.0002	0.0000
Term spread/small banks	14.02 (6.45)		
Underbidding dummy/large banks	0.19 (0.08)		
Underbidding dummy/medium banks	0.12 (0.26)	0.7285	0.5392
Underbidding dummy/small banks	0.60 (1.45)		
Spread/large banks	-20.71 (-0.92)		
Spread/medium banks	-4.65 (-1.84)	0.0018	0.0000
Spread/small banks	-16.81 (-7.17)		
Volatility/large banks	-1.24 (-1.06)		
Volatility/medium banks	-0.13 (-0.96)	0.5788	0.1260
Volatility/small banks	-0.24 (-1.92)		
Reserve fulfillment/large banks	1.60 (0.12)		
Reserve fulfillment/medium banks	-1.23 (-0.67)	0.3998	0.5626
Reserve fulfillment/small banks	2.17 (1.26)		
Maturing allotment/large banks	0.02 (0.40)		
Maturing allotment/medium banks	0.12 (13.67)	0.0187	0.0000
Maturing allotment/small banks	0.15 (17.27)		
Period end dummy/large banks	1.07 (0.71)		
Period end dummy/medium banks	0.66 (3.59)	0.8521	0.0000
Period end dummy/small banks	0.78 (5.00)		
Size dummies			
Large	-6.23 (-0.40)		
Medium	-1.75 (-0.79)	0.1123	0.0000
Small	-8.12 (-3.89)		
Pseudo-R^2	0.1094		
No. of observations	8525		
No. of groups	275		

Notes: The size specific regressors are obtained from the interaction of the explanatory variables x_{it} with size dummies *large*, *medium*, and *small* (see Table 4). The t-values of the parameter estimates are reported in parenthesis. The second column shows the p-values from a χ^2 distributed Wald-test with the null hypothesis that there are no size effects. The third column reports the p-values from a χ^2 distributed Wald-test with the hypothesis that the interaction terms being jointly equal to zero. The Pseudo-R^2 is calculated according to Aldrich and Nelson (1984).

Table 7: The Determinants of a Bank's Bid Amount: A Panel Analysis

	Tobit Model Coefficient Estimate	**Tobit Model** Marginal Effect	**Random Effects GLS** Coefficient Estimate
Term spread	11.59	1.00	1.43
	(4.23)		(4.27)
Underbidding dummy	0.32	-	0.05
	(0.61)		(1.97)
Spread	-16.55	-1.43	-1.94
	(-7.82)		(-5.40)
Volatility	-0.24	-	0.01
	(-1.50)		(0.38)
Reserve fulfillment	1.32	-	0.67
	(0.61)		(2.39)
Maturing allotment	0.23	0.02	0.01
	(20.41)		(7.39)
End of period dummy	0.93	0.08	-0.08
	(4.61)		(-1.13)
Size dummies			
Large	3.95		-
	(1.50)		
Medium	-8.98		-3.46
	(-3.43)		(-5.10)
Small	-12.70		-4.80
	(-4.82)		(-7.14)
Constant	-		21.01
			(28.61)
Pseudo-R^2	0.161		0.062
No. of observations	8525		2625
No. of groups	275		275

Notes: The t-values of the parameter estimates are reported in parenthesis. For the significant parameters we calculated the marginal effects (see Equation 5) that indicate the economic significance of the variables by the the usual elasticity interpretation. There were 5900 left-cencored observations in our sample. Note that for the linear Random effects GLS estimation all left-censored observations are dropped. The Pseudo-R^2 measure is calculated according to Aldrich and Nelson (1984).

Table 8: The Determinants of a Bank's Bid Amount: Tobit Model Estimation with Bank Size Specific Regressors

	Coefficient Estimate	H_0**: no size effect** (p-value)	H_0**: zero effect** (p-value)
Term spread/large banks	5.19 (0.74)		
Term spread/medium banks	1.82 (0.89)	0.0004	0.0000
Term spread/small banks	12.91 (6.63)		
Underbidding dummy/large banks	-0.70(-0.55)		
Underbidding dummy/medium banks	-0.01(-0.04)	0.5847	0.7014
Underbidding dummy/small banks	0.42 (1.06)		
Spread/large banks	-5.64 (-0.75)		
Spread/medium banks	-6.15 (-2.82)	0.0076	0.0000
Spread/small banks	-15.30 (-7.37)		
Reserve fulfillment/large banks	0.09 (0.02)		
Reserve fulfillment/medium banks	-0.57 (-0.36)	0.5056	0.6187
Reserve fulfillment/small banks	2.02 (1.29)		
Volatility/large banks	-0.23 (-0.57)		
Volatility/medium banks	-0.36 (-0.30)	0.2357	0.0428
Volatility/small banks	-0.31 (-2.78)		
Maturing allotment/large banks	0.03 (1.48)		
Maturing allotment/medium banks	0.13 (17.90)	0.0000	0.0000
Maturing allotment/small banks	0.20 (23.57)		
End of period dummy/large banks	0.09 (0.18)		
End of period dummy/medium banks	0.59 (3.91)	0.5445	0.0000
End of period dummy/small banks	0.67 (4.77)		
Size dummies			
Large	4.78 (0.74)		
Medium	-1.99 (-1.04)	0.0103	0.0001
Small	-8.34 (-4.40)		
Pseudo-R^2	0.228		
No. of observations	8525		
No. of groups	275		

Notes: The size specific regressors are obtained from the interaction of the explanatory variables x_{it} with size dummies *large*, *medium*, and *small* (see Table 4). The t-values of the parameter estimates are reported in parenthesis. Note that there were 5900 left-cencored observations in our sample. For further information see Table 6.