



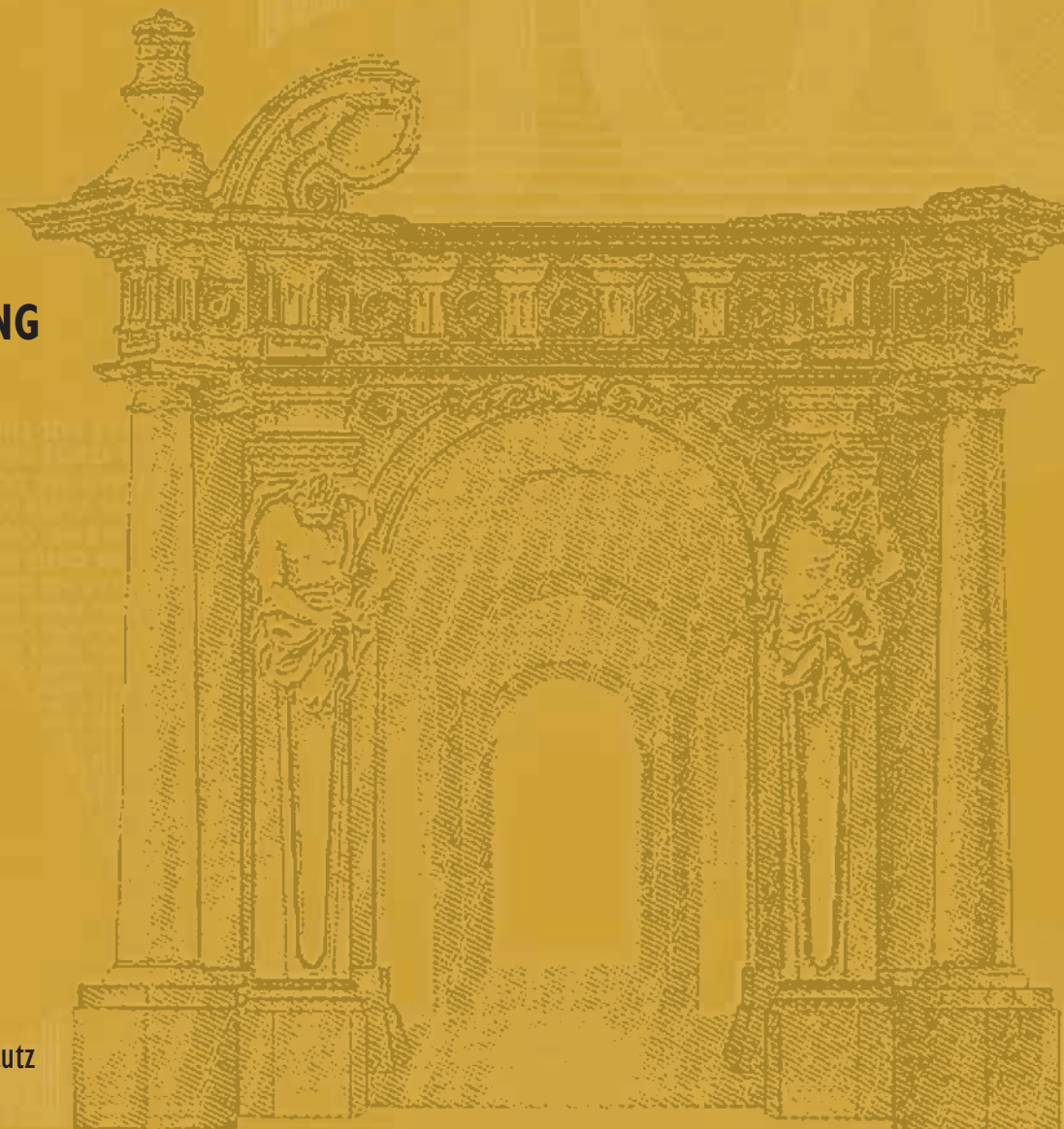
EUROPEAN CENTRAL BANK

**WORKING PAPER SERIES**

**NO. 359 / MAY 2004**

**THE LONGER  
TERM REFINANCING  
OPERATIONS OF  
THE ECB**

by Tobias Linzert, Dieter Nautz  
and Ulrich Bindseil





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by Tobias Linzert <sup>2</sup>, Dieter Nautz <sup>3</sup>  
and Ulrich Bindseil <sup>4</sup>



In 2004 all publications will carry a motif taken from the €100 banknote.

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## Abstract

This paper employs individual bidding data to analyze the empirical performance of the longer term refinancing operations (LTROs) of the European Central Bank (ECB). We investigate how banks' bidding behavior is related to a series of exogenous variables such as collateral costs, interest rate expectations, market volatility and to individual bank characteristics like country of origin, size, and experience. Panel regressions reveal that a bank's bidding depends on bank characteristics. Yet, different bidding behavior generally does not translate into differences concerning bidder success. In contrast to the ECB's main refinancing operations, we find evidence for the winner's curse effect in LTROs. Our results indicate that LTROs do neither lead to market distortions nor to unfair auction outcomes.

**Keywords:** Monetary Policy Instruments of the ECB, Auctions, Winner's Curse, Panel Analysis of Bidding Behavior

**JEL classification:** E52, D44

## Non-technical summary

Repo auctions are the predominant instrument for the implementation of monetary policy of the European Central Bank (ECB). Repo rates govern short-term interest rates and the availability of repo credit determines the liquidity of the European banking sector. The ECB conducts repo auctions as weekly main refinancing operations (MRO) with a (bi)weekly maturity and as monthly longer term refinancing operations (LTRO) maturing after three months. Although MROs are the ECB's primary policy instrument, LTROs are far from negligible. In 2003, refinancing via LTROs amounts to 45 bln Euro which is about 20% of overall liquidity provided by the ECB. This paper analyzes banks' bidding behavior in LTROs to shed more light on the determinants of banks' reserve management and the role of LTROs within the monetary policy framework of the ECB.

The analysis of banks' bidding behavior provided strong evidence for the winner's curse effect in LTROs. In line with theoretical predictions, banks reduce their participation, bid at lower interest rates, and reduce their bid volume as interest rate uncertainty increases. Interestingly, large banks react stronger to rate uncertainty than small banks. This indicates that large banks are particularly interested in the common value component of the longer term refinancing since they have on average a more active interbank money market desk. The finding of a winner's curse effect in LTROs is in marked contrast to the evidence from the ECB's main refinancing operations. This suggests that the private value component of repos is more pronounced in MROs than in LTROs where common money market conditions seem to be more important for banks' bidding behavior.

One of the original intentions of the ECB when establishing LTROs was to give smaller banks with only limited access to the interbank market a comfortable source of longer term refinancing. In terms of their total share in refinancing, LTROs are more important for smaller and medium size banks than for large banks. However, our results do not substantiate the notion that LTROs are especially designed for and used by smaller banks.

An important requirement for its refinancing operations is that the auction procedure does not violate the principle of equal treatment. In particular, certain types of banks should not bid *a priori* more successfully in LTROs than others. Although we find significant differences in the bidding behavior across banks of different size and from different countries, the resulting differences in terms of bidding success were

astonishingly small. The analysis of banks' cover to bid ratio and their refinancing cost showed that different bidding strategies in most cases do not imply an obvious ranking of banks in terms of bidding success. For example, small banks realize higher cover to bid ratios in LTROs than medium and large banks but also tend to have higher refinancing cost.

While the preannounced minimum bid rate is an important feature of the ECB's MROs, LTROs are conducted as pure variable rate tenders. One might expect that without the guidance of a minimum bid rate, bidding in LTRO auctions would be particularly difficult. In fact, in contrast to MROs where most banks place their whole bid volume at a single interest rate, banks typically submit several bids in LTROs. Yet, the weighted standard deviation of bid rates in LTROs is only one basis point which is very close to the bid rate dispersion observed in MROs. Moreover, there is no indication that a pure variable rate tender induces banks to bid on a large scale deliberately below the market consensus. We also found that experienced bidders are not significantly more successful in LTROs than less experienced ones.

Overall, this study demonstrated that the longer term repo auctions of the European Central Bank do neither lead to market distortions nor to unfair auction outcomes.

# 1 Introduction

Repo auctions are the predominant instrument for the implementation of monetary policy of the European Central Bank (ECB). Repo rates govern short-term interest rates and the availability of repo credit determines the liquidity of the European banking sector. The ECB conducts repo auctions as weekly main refinancing operations (MRO) with a biweekly maturity and as monthly longer term refinancing operations (LTRO) maturing after three months. Although MROs are the ECB's primary policy instrument, LTROs are far from negligible. In 2003, refinancing via LTROs amounts to 45 bln Euro which is about 20% of overall liquidity provided by the ECB. Using individual bidding data, this paper studies the role of LTROs in banks' reserve management to shed more light on the relevance of LTROs within the monetary policy framework of the ECB.

Longer term refinancing should be particularly attractive to banks with a less active reserve management. In fact, one motivation of the ECB to establish LTROs was to give "a good opportunity for smaller banks which have limited or no access to the interbank market to receive liquidity for a longer period", see ECB (2002b). In order to investigate whether LTROs are indeed a more important refinancing tool for small banks, we explore how a bank's bidding behavior depends on its size. In particular, we examine how a bidder's size affects the response to changing money market conditions.

The principle of equal treatment is an important criteria of assessing the empirical performance of LTROs. Specifically, a bank's size or its country of origin should not have a severe impact on bidding success. Therefore, we investigate how bidder behavior depends on various bidder characteristics. Advancing on previous studies on Treasury bill and central bank auctions (e.g. Nyborg, Rydqvist and Sundaresan, 2002, Nyborg, Bindseil and Strebulaev, 2002 and Linzert, Nautz and Breitung, 2003), we not only infer on the basis of actual bidding behavior but also look at individual cover to bid ratios as well as relative refinancing cost as complementary measures of bidding success.

In the course of evaluating its operational framework via a public consultation of banks in Fall 2002, the ECB proposed to suspend LTROs "for the sake of a lean implemen-



tation of monetary policy”, see ECB (2002b). However, banks were overwhelmingly in favor of LTROs to be able to diversify the maturity of their liabilities and ”to obtain liquidity during times of general market tensions or when faced with individual liquidity problems”, see ECB (2003b). In order to explore the role of LTROs in banks’ reserve management, we investigate the relation between bidder behavior in LTROs and MROs. In particular, we analyze whether the auction outcome of an MRO affects bidding in LTROs, and whether frequent bidders in MROs tend to be also active in LTROs.

Similar to e.g. Treasury bill auctions but in contrast to the ECB’s main refinancing operations, LTROs are conducted in a pure variable rate tender format, i.e. without minimum bid rate. One concern about auctions without minimum bid rate is that there is no guidance for less informed and less sophisticated bidders. The LTRO auction format should be simple enough so that LTROs are equally accessible to all banks. Therefore, we will also look at the performance of experienced relative to less experienced bidders.

In common value auctions bidders are exposed to winner’s curse implying that they should bid more cautious when interest rate uncertainty rises. In fact, this effect is well documented for Treasury bill auctions, see e.g. Nyborg, Rydqvist and Sundaresan (2002) and Bjonnes (2001). Yet, Nyborg, Bindseil and Strebulaev (2002) found only mixed evidence in favor of the winner’s curse effect in the ECB’s MROs. In the Eurosystem, the demand for reserves in MROs might be more closely related to the banks’ private liquidity needs than in LTROs and could thus be less dependent to common market conditions. In this case, the winner’s curse effect should be particularly relevant for bidders in LTROs.

Our analysis is based on a data set of 50 LTRO auctions conducted between March 1999 and May 2003. Unique bidder codes allow to follow bidding behavior of individual banks over time and to apply panel econometric techniques. A panel probit model will provide insights into a bank’s participation decision. Moreover, banks’ bidding behavior is analyzed in more detail by studying the individual bid amount, the weighted average bid rate and the bid rate dispersion. In particular, we will investigate how collateral costs, interest rate expectations, and interest rate uncertainty affects bidding in LTROs. Bidding variables, like the bid amount, can only be observed if a bank

actually participates in a LTRO. Following e.g. Jofre-Bonet and Pesendorfer (2003) we explicitly account for the censoring problem of the bidding behavior variables.

Our main results can be summarized as follows. First, we find that bidder behavior is influenced by a bank's size and its country of origin. However, differences in bidders' response to various exogenous variables do not necessarily imply that banks bid with different success. In particular, banks with lower refinancing cost must realize lower cover to bid ratios and vice versa. Thus, different bidding strategies in LTROs seem to reflect different attitudes towards the risk of going out empty handed. Second, banks' bidding in MROs and LTROs must not be seen as independent. For example, there are significant spill over effects from MROs to LTROs, i.e. banks use LTROs to adjust the liquidity position from MROs. Third, we found that in LTROs bidder experience is not an important issue with respect to a bank's success. Fourth, there is no evidence that the pure variable rate tender applied in LTROs induces banks to bid at unrealistically low interest rates. In particular, the bid rate dispersion in LTROs is almost the same as in MROs. Fifth, in contrast to the findings from MROs, there is clear evidence for the winner's curse effect in LTROs. In line with auction theory, banks' participation, the bid volume and the bid rate decrease when interest rate uncertainty rises.

The rest of the paper will proceed as follows. The next section describes the role of LTROs in the operational framework of the ECB and the institutional background. Some descriptive statistics on bidder behavior and performance are given in Section 3. Section 4 introduces the variables that enter our panel regressions and discusses how those might affect bidding behavior. The empirical results on banks' participation decision and their bidding behavior in terms of bid volume, bid rate and bid rate dispersion are given in Section 5. In particular, we estimate how a bank's reaction towards changes in collateral costs, interest rate expectations and uncertainty depends on its size and country of origin. That section also presents our results concerning banks' bidding success. Section 6 summarizes the main results and offers some policy conclusions.

## 2 The Role of LTROs within the Operational Framework of the ECB

The role of MROs and LTROs in the ECB's operational framework for monetary policy differs in two main respects. First, due to their higher frequency and their shorter maturity, MROs are designed to actively steer the liquidity of the banking sector. In particular, the repo volume allotted via MROs is not predetermined by the ECB but responds to liquidity shocks and possibly to the bids of the banks. By contrast, the allotment volumes of LTROs are changed only infrequently and are always fixed at the auction's outset. Therefore, LTROs are not used to steer money market conditions but provide banks with "additional longer-term refinancing", i.e. a basis stock of reserves that is unrelated to any short-term liquidity fluctuations, see ECB (2000).

The second crucial difference between MROs and LTROs concerns the influence of the ECB on the interest rate. MROs play the dominant role in steering short term interest rates. The MRO rate serves as the ECB's key interest rate which is either explicitly set by the ECB (if it is conducted as fixed rate tender) or (in case of a variable rate tender) at least restricted by a pre-announced minimum bid rate. By contrast, LTROs are always conducted as pure variable rate tenders, i.e. without a minimum bid rate. The ECB simply accepts the allotment rates resulting from its pre-announced supply of liquidity and the demand for LTROs submitted by the banks. Acting as a price-taker, the ECB cannot use LTROs for signaling intended interest rate levels.<sup>1</sup>

Apart from the omitted minimum bid rate and the pre-announced allotment volume, the rules of LTROs and MROs are identical. Each bank can submit bids at up to ten different bid rates at the precision of one basis point (0.01%). Furthermore, both auctions are price-discriminating, i.e. every successful bidder has to pay its bid. In both auctions, banks need to deposit eligible collateral with the Eurosystem to cover the amounts allotted.

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<sup>1</sup> In fact, banks realized that LTROs convey no relevant information about the future stance of monetary policy. Regressing the change of the three-month Euribor on the aggregate auction data published by the ECB (i.e. on the bid to cover ratio, the marginal rate, the bid rate dispersion etc.) one can show that results of LTROs do not affect interest rates of the interbank money market. These results are not reported in this paper but can be obtained from the authors on request.

What is the 'optimal' share of LTROs in the total liquidity provision of the ECB? On the one hand, the share of LTROs must not be too large in order to leave enough room for manoeuvre in steering the liquidity supply through MROs. In practice, the ECB therefore provides the major part of reserves through MROs but LTROs are still important. Since June 2000 the share of LTROs in the total liquidity provision is between 20% and 25%. Yet one may even argue that LTROs are superfluous for an efficient liquidity management and should be abandoned in order to increase the transparency and simplicity of the ECB's operational framework, see e.g. ECB (2002b). On the other hand, if LTROs allow the banks to improve the efficiency of their liquidity management without introducing market distortions, then the importance of LTROs might even increase, not decrease.

### **3 Descriptive Statistics on LTRO Bidding Data**

#### **3.1 A First Look at the Data**

##### **The Sample**

Our data set consists of individual bidding data of all regular refinancing operations (MROs and LTROs) conducted by the ECB from March 1999 to May 2003.<sup>2</sup> The focus of our analysis is on the performance of the 50 LTROs executed in this period. 6776 credit institutions in the euro area fulfilled the general conditions to participate in the ECB's regular refinancing operations but a lot of banks refrained from bidding irrespectively of the prevailing situation in the money market. We therefore restrict our attention to those 1809 banks that participated at least once in either a MRO or a LTRO.

##### **Number of Bidders**

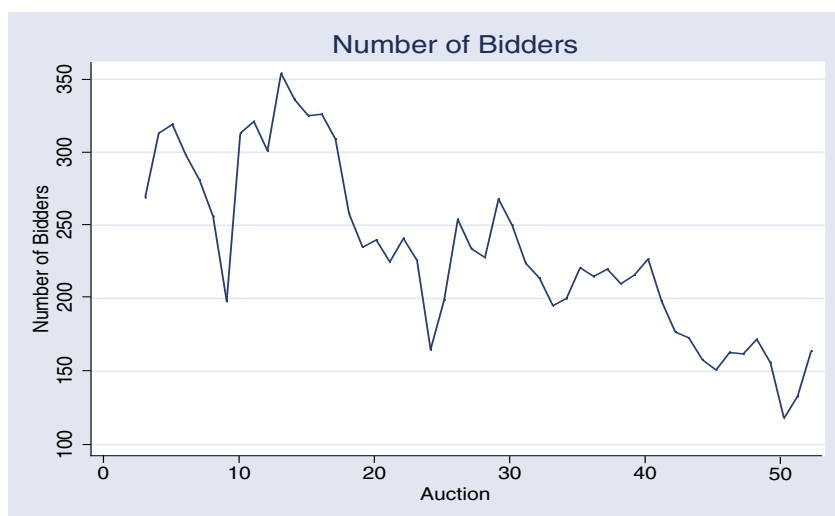
From March 1999 to May 2003, the average number of bidders in LTROs has been 232. However, similar to the trend observed in the MROs the number of bidders in

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<sup>2</sup> In January and February 1999 LTROs were performed as Dutch auctions in which every successful bidder pays the marginal rate.



Figure 1: The Number of Bidders in LTROs



*Notes:* The number of bidders shown in the Figure refers to LTROs conducted from March 1999 until May 2003.

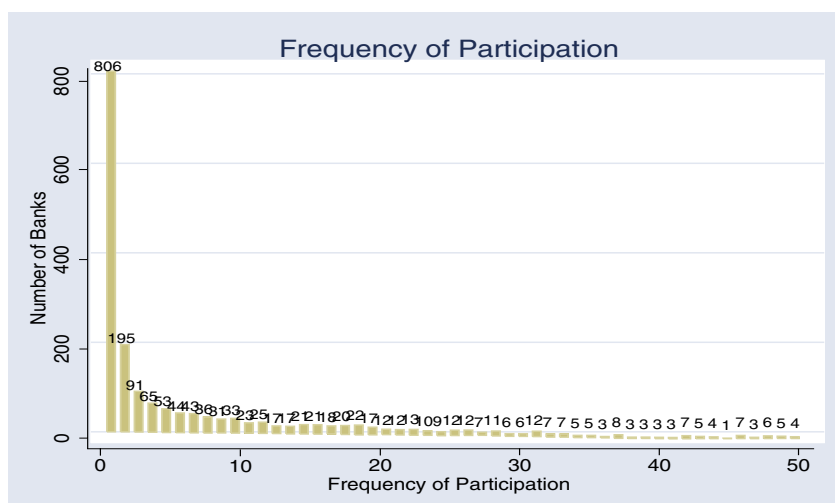
LTROs declines over time, see Figure 1 and Nyborg, Bindseil and Strebulaev (2002).<sup>3</sup> In both types of refinancing operations, the number of bidders dropped to almost 50% of the initial number in 1999. Therefore, the driving factors of the decreasing number of bidders are not LTRO specific. Possible explanations for the declining trend in both open market operations are the ongoing process of concentration and rationalization in the banking sector and the higher efficiency of the interbank market. In particular, the centralization of open market operations in the headquarters of a particular bank makes bidding by the individual branches obsolete.

### **Banks' Participation**

Figure 2 shows the frequency of participation in LTROs, i.e. in how many auctions a bank participated over the sample period. From the 1809 banks under consideration, 1003 banks bid in at least one LTRO but many banks participated on a very infrequent basis. For example, 195 banks placed bids only once while only four banks bid in all 50 LTROs.

<sup>3</sup> Note that this downward trend is not size-specific. According to Figure 12 in Appendix, the number of bidders drops for small, medium and as well as for large bidders.

Figure 2: The Frequency of Auction Participation by Banks in LTROs



*Notes:* The Figure displays the number of banks that participated in a particular number of auctions over the course of all 50 auctions under consideration from March 1999 to May 2003. For example, 806 banks participated in none of the 50 auctions from March 1999 to May 2003.

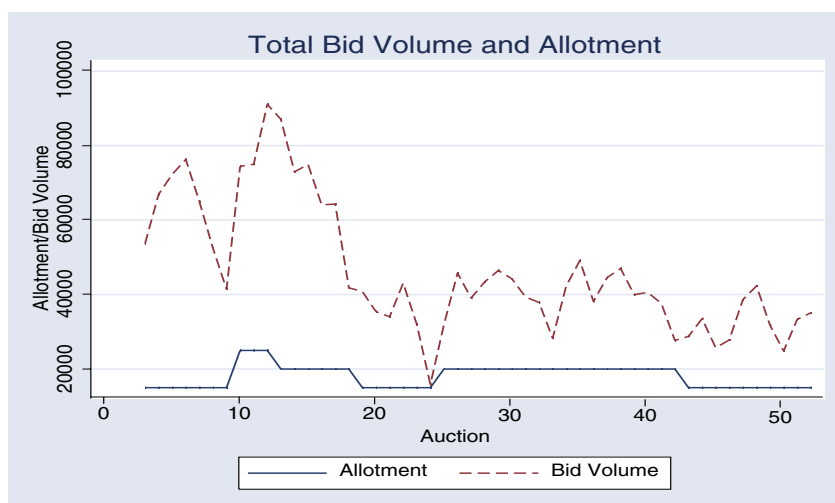
### Total Bids and Allotments

Figure 3 depicts the total bid volume submitted in the LTROs and the total allotment amount. According to the role of LTROs in the ECB’s operational framework, the allotment volume changed only a few times and was always either 15, 20 or 25 bln Euro. The total bid volume is on average around 46 bln Euro. In line with the decreasing number of bidders, the total bid volume is higher in the first part of the sample but the declining trend gets less pronounced since June 2000. There is one occasion where total bids drop almost to the level of the preannounced allotment volume.

### Number of Bids

Figure 4 displays the distribution of the number of bids by bank. In contrast to MROs, where many banks place their whole bid volume at a single interest rate, banks typically submit several bids in LTROs. The average number of bids per bank in a LTRO

Figure 3: Total Bid Volume of all Banks and Total Allotment



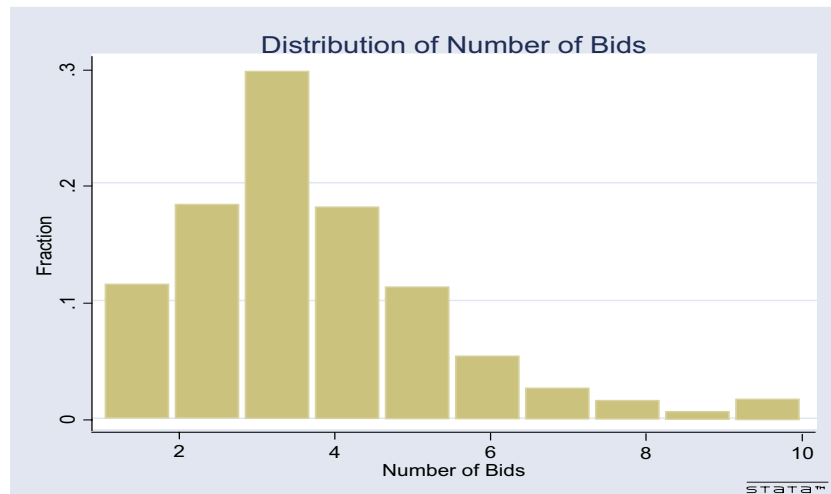
*Notes:* The total bid volume and the total allotment by the ECB shown in the Figure refers to all LTROs that have been conducted in the sample period from March 1999 until May 2003. After a reduction in autonomous factors, the ECB lowered the allotment volume from 20 to 15 billion Euros in July 2002.

is close to 4 while bank submit on average 2.4 bids in MRO auctions, see Nyborg, Bindseil and Strebulaev (2002). One immediate explanation for the higher number of bids in LTRO auctions is the absence of the minimum bid rate that constrains bidders in the MROs. The minimum bid rate also explains why the distribution of the number of bids submitted in MROs is strongly skewed, see Nyborg, Bindseil and Strebulaev (2002). In contrast, the LTRO bid distribution only slightly skewed to the right, compare Figure 4.

### Bid Rate Dispersion

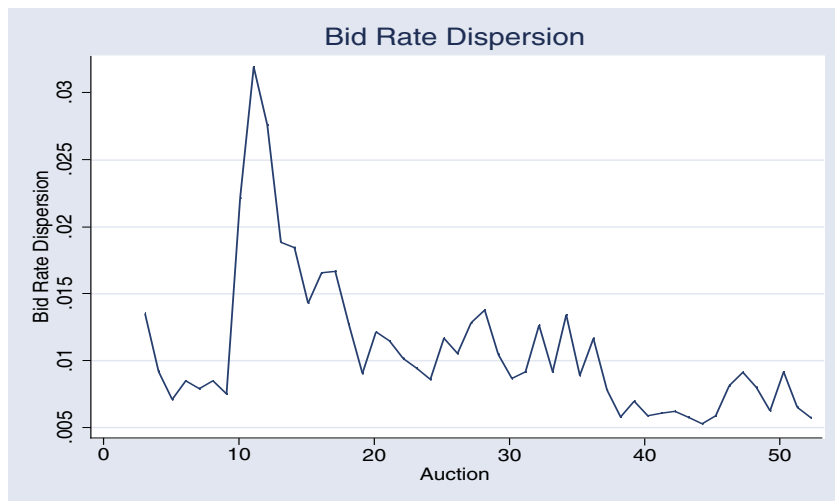
More information about the bidding strategies of banks is revealed in the variable *bid rate dispersion* defined as the quantity weighted standard deviation of a bank's bid rates. Figure 5 shows for each LTRO the (unweighted) average of all bank specific bid rate dispersions. The evolution of the average bid rate dispersion shows that banks place their bids in a range of 2-3 basis points. Remarkable exceptions are the three tenders prior to the turn of the century at the end of 1999 where the bid rate dispersion

Figure 4: The Distribution of the Number of Bids



*Notes:* The Figure displays an individual bank's number of bids of all banks that actually participate in an auction over the sample period from March 1999 to May 2003.

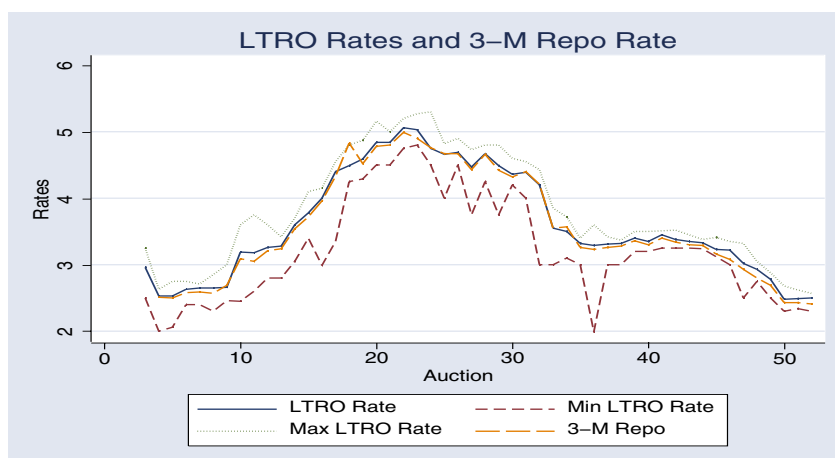
Figure 5: The Aggregate Bid Rate Dispersion



*Notes:* The aggregate bid rate dispersion is an unweighted average of all individual bid rate dispersions and is displayed over all LTROs in the sample period from March 1999 until May 2003.



Figure 6: LTRO Rates and 3-Month Repo Rate



*Notes:* The LTRO rate displayed refers to the marginal rate of the corresponding tender. The minimum and maximum LTRO rate are the minimum and maximum bid rate of an individual bank, respectively. The 3-month Repo is taken from the day of the deadline for counterparties' submission of bids. The rates are displayed from March 1999 to May 2003.

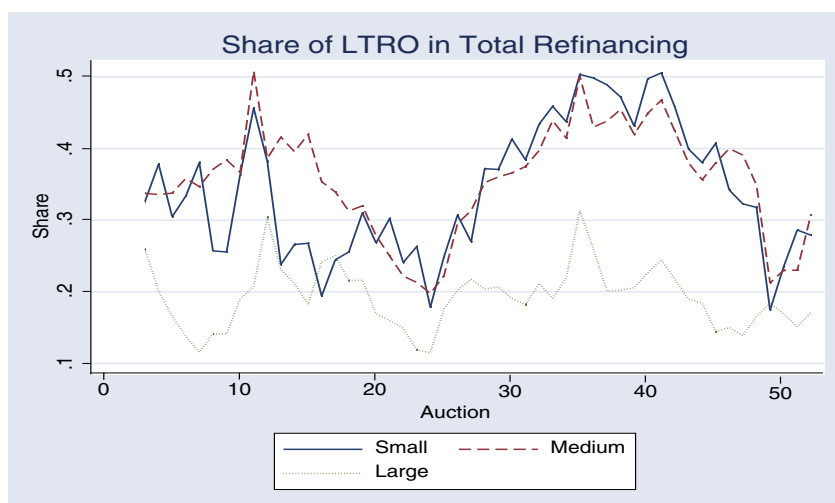
sharply increases. One might have expected that the pure variable rate tender format of the LTROs induces bidders to bid permanently on a wide range of interest rates. Yet the overall average of the bid rate dispersion (0.012) is only 0.2 basis points higher than in MROs (0.010), see Nyborg, Bindseil and Strebulaev (2002). Therefore, the relatively large number of bids submitted in LTROs exaggerates the extent to which banks distribute their bid amount at different interest rates.

### Bidding Rates and Opportunistic Bidding

The marginal rate of the LTRO auctions is very close to the corresponding money market rate, i.e. the 3 month repo valid at the allotment day of the auction, see Figure 6. The Figure exhibits also the minimum and the maximum of the rates that were placed by banks in LTROs. The resulting corridor seems to be quite large but in line with the results obtained for the average bid rate dispersion, its width is mainly due to a few small bids.

Being not constrained by a minimum bid rate, banks might bid "opportunistically",

Figure 7: Share of LTRO in Total Refinancing



*Notes:* The Figure displays the share of LTRO refinancing by banks in total refinancing through regular open market operations, i.e. the sum of LTRO and MRO refinancing. The shares are shown for our sample period from March 1999 until May 2003.

i.e. significantly below the market consensus to obtain refinancing at very low rates. This becomes a problem if collusion among bidders leads to distortions in the auction outcome, which would imply deviations from the competitive outcome. However, opportunistic bidding has not been an issue in the ECB's LTROs. There are only a few cases where banks submit bids at interest rates very much below the market consensus. Moreover, those bids were negligible in terms of the bid amount indicating that they stem from small uninformed and not from bidder rings. Needless to say that these bids were never successful.

### 3.2 Size and Experience Effects in LTRO Bidding

#### Size Effects

LTROs are often seen as a convenient longer-term source of refinancing with low administrative costs that allows a less active cash management strategy by the banks. In accordance with the original intentions of the ECB, LTROs should thus be particularly attractive for small banks. In the present study, we define a bank's size with

Table 1: Banks Participation by Size

	Number of Banks	Share of Never Participating Banks in LTRO	Mean Number of Bidders per LTRO	Participation Frequency LTRO	Participation Frequency MRO
Small	737	51.6%	65.42	8.8%	20.8%
Medium	650	34.9%	109.84	16.9%	38.6%
Large	141	16.7%	41.4	29.4%	51.5%
10-largest banks	10	0%	2.82	28.0%	64.3%
10-largest bidder	10	0%	6.84	68.4%	70.2%

*Notes:* Small banks are those with requirement below 10 Mio. Euro. Banks with reserve requirements ranging from 10 Mio. to 100 Mio. were grouped as medium and banks with reserve requirements above 100 Mio. were classified as large banks.

respect to its average reserve requirement. Specifically, 737 banks are called *small* because their average reserve requirement is below 10 Mio. Euro. For 650 *medium* banks the reserve requirements ranges from 10 Mio. to 100 Mio. Euro and for 141 *large* banks the reserve requirements exceeds 100 Mio. Euro.<sup>4</sup>

In line with the ECB's original intention, LTROs are a relatively more important refinancing tool for small and medium banks. Figure 7 shows the development of the LTRO share in total refinancing (LTRO+MRO) over time by size group. On average, small banks satisfy 35% of their refinancing demand with LTROs while the share is only 20% for large banks. However, Table 1 shows that the average participation frequency of small banks is clearly lower in LTROs (8.8%) than in MROs (20.8%). Moreover, as in MROs, the mean participation in LTROs increases with a bank's size. Large banks use LTROs more often (29.4%) than small and medium banks. Table 2 depicting the bid and allotment volumes by size group underlines the impression from the participation frequencies that LTROs are not used particularly by small banks.<sup>5</sup>

<sup>4</sup> The reserve requirements refer to the period from February 1999 to August 2001. This data was available for 1528 of the 1809 banks under consideration. All statistics and regressions accounting for size effects are thus based on the data of these 1528 banks. It is important to note that this sample reduction does not imply an obvious selection bias. In particular, the banks that dropped out of the sample included small and large as well as active and inactive bidders coming from all over the euro area.

<sup>5</sup> See also Figure 13 in Appendix for the evolution of allotment shares over time.

Table 2: Shares in Total Volume and Allotment by Size

	Share in Total Bid Volume	Share in Total Allotment
Small	6.9%	9.3%
Medium	35.6%	46.5%
Large	57.5%	44.2%
10-largest banks	8%	5%
10-largest bidder	25%	23%

*Notes:* Small banks are those with requirement below 10 Mio. Euro. Banks with reserve requirements ranging from 10 Mio. to 100 Mio. were grouped as medium and banks with reserve requirements above 100 Mio. were classified as large banks.

For each bank size, the shares in total bids and total allotment differ. Compared to their bid volume, small banks receive a relatively high share (9.3% vs. 6.9%) of the total allotment whereas large banks get a small proportion (44.2% vs. 57.5%).<sup>6</sup> This already indicates that the bidding strategies of large banks differ from those of small banks. Obviously, since large banks receive relatively less repo credit, they must have bid at lower interest rates.

Table 3 provides more information on the different bidding strategies of small, medium and large banks. The first column of Table 3 presents the average spread between the quantity weighted bid rate and the marginal rate for the various size groups. While small banks bid on average very close to the marginal rate ( $-0.006$ ), large banks bid on average about 2 basis points lower. As a result, large banks tend to receive their allotment at lower cost. According to the second column of Table 3, the average interest rate paid on the allotment is two basis points higher for small banks than for large banks. The higher interest rates paid by small banks are also reflected in the relative refinancing cost (RRC) defined as the ratio of the average interest rate paid by a bank and the average allotment rate of the auction, see column 3. However, bidding at lower interest rates comes not without cost. For large banks, the average

<sup>6</sup> Note that the differences in bid and allotment volumes have to be seen in relation to the respective shares of the size groups in total reserve requirements. The share of small, medium, and large banks in total reserve requirements is 5%, 25% and 70%, respectively.

Table 3: Bidder Performance by Size

	Bid Rate minus Marginal Rate	Allotment Rate minus Marginal Rate	Cover to Bid Ratio LTRO	Cover to Bid Ratio MRO	Relative Refinancing Costs (RRC)
Small	-0.006	0.042	0.50	0.69	1.0023
Medium	-0.008	0.028	0.48	0.59	0.9985
Large	-0.023	0.020	0.28	0.62	0.9961
10-Largest banks	-0.028	0.023	0.24	0.60	0.9950
10-Largest bidder	-0.020	0.020	0.34	0.62	0.9972

*Notes:* The bid rate and the allotment rate are quantity weighted average rates. Small banks are those with requirement below 10 Mio. Euro. Banks with reserve requirements ranging from 10 Mio. to 100 Mio. were grouped as medium and banks with reserve requirements above 100 Mio. were classified as large banks. The cover to bid ratio for the MROs is calculated on the basis of the variable rate tender period only.

cover to bid ratio presented in column 4 is much lower than for small and medium banks. Therefore, bidding at lower interest rates decreases the volume allotted and increases the risk of going out empty handed. It is not clear which group of banks bids more "successful". While there are marked differences between small and large banks in LTROs, in MROs the differences in the cover to bid ratios across size groups are by far less distinct, see Table 3. Apparently, bidding strategies in MROs differ from those applied in LTROs, see column 5 in Table 3. In particular, size effects seems to be more important for banks' bidding behavior in LTROs.

### Experience Effects

In order to investigate the impact of experience effects on banks' bidding, we termed the 26 banks who participated in at least 90% of all LTROs *regular* bidders.<sup>7</sup> With shares of about 20% in both, total bids and total allotments, this small group of bidders has a significant impact on the auction outcome, see Table 4. Regular bidders seem to be well informed about the situation in the money market. They bid closer to the marginal rate than non-regular bidders and receive their allotment approximately

<sup>7</sup> Note that there are 5 small, 15 medium and 6 large banks that are considered to be regular bidders.

Table 4: Shares in Total Volume and Allotment

	Share in Total Bid Volume	Share in Total Allotment
Regular	18%	20%
Non-Regular	82%	80%
EONIA-Banks	32%	22%
Non-EONIA-Banks	68%	78%

*Notes:* Regular bidders are defined as bidders that participate in 45 or more of the 50 LTROs. The EONIA panel banks are a sample of 50 banks that are most active in the money market.

one basis point cheaper, see Table 5. Nevertheless, regular bidders still have a higher cover to bid ratio than non-regular bidders.

We also looked at the 50 banks that are part of the EONIA panel. Many of the 'EONIA-banks' are large banks that are very active in the money market. However, only 5 EONIA-banks belong to the group of regular bidders in LTROs. Table 4 shows that EONIA-banks come up to 32% of the total bid volume but receive only 22% of the total allotment. In fact, EONIA-banks bid at lower interest rates than Non-EONIA banks, see Table 5. However, in contrast to regular bidders they therefore receive only a small part of their bid. Similar to the results obtained for large banks, the average cover to bid ratio of EONIA-banks in LTROs is only 27%. The higher average cover to bid ratio of EONIA-banks in MROs suggests that EONIA-banks adopt a bidding strategy in LTROs that comes along with a higher risk to go out empty handed.

### 3.3 Country Differences in LTRO Bidding Performance

Every credit institution in the euro area, and thus every bidder in the Eurosystem's open market operations, can be assigned to a country, namely the one where it is legally established as a credit institution. If a bidder is established as a credit institution in e.g. Spain, we will call it a Spanish bank, even in case it would be fully owned by

Table 5: Bidder Performance: Regular and Eonia Panel Banks

	Bid Rate minus Marginal Rate	Allotment Rate minus Marginal Rate	Cover to Bid Ratio LTRO	Cover to Bid Ratio MRO	Relative Refinancing Costs (RRC)
Regular	0.002	0.025	0.51	0.59	0.9980
Non-Regular	-0.010	0.033	0.35	0.62	0.9998
EONIA-Banks	-0.003	0.019	0.27	0.60	0.996
Non-EONIA- Banks	-0.008	0.033	0.42	0.63	0.999

*Notes:* The bid rate and the allotment rate are quantity weighted average rates. Regular bidders are defined as bidders that participate in 45 or more of the 50 LTROs. The EONIA panel banks are a sample of 50 banks that are most active in the money market. The cover to bid ratio for the MRO is calculated on the basis of the variable rate tender period only.

a holding company established in another euro area country.<sup>8</sup> The number of banks taking part in the ECB's open market operations differs considerably across countries. The 1235 German banks form by far the largest group of bidders, see Table 6. The second largest group are Spanish banks (113) while only 10 banks come from Finland. However, the average German bank does not participate more often in LTROs than other countries' banks. According to Table 6 the average participation frequency of a German bank is 12.9% which is close to other banks' participation. The 37 Austrian banks in our sample participated most frequently in LTROs (29.7%).

Table 6 illustrates that for all countries the average participation frequency in LTROs is lower than in MROs. Note that the two rankings of the countries according to their average participation frequency in LTROs and MROs, respectively, look rather similar. Exceptions are the banks from Belgium and Italy, where, compared to the others, the average participation frequency is relatively higher in MROs than in LTROs. By contrast, banks from Portugal and Ireland bid relatively more often in LTROs than in MROs.

<sup>8</sup> Indeed, it is well known that especially in Luxembourg and in Ireland, many credit institutions have been established by foreign mother companies for the sake of some perceived advantages of these locations. This issue will not be further pursued here, but it should be kept in mind to not misinterpret the analysis of the "country of origin" suggested here.

Table 6: Banks Participation by Country

	Number of Banks	Share of Never Participating Banks in LTRO	Mean Number of Bidders per LTRO	Participation Frequency LTRO	Participation Frequency MRO
Austria (AT)	37	22%	11.0	29.7%	42.4%
Belgium (BE)	28	43%	2.94	10.5%	30.7%
Finland (FI)	10	50%	1.28	12.8%	24.6%
France (FR)	74	41%	11.04	14.9%	40.8%
Germany (GE)	1235	45%	159.6	12.9%	28.5%
Greece (GR)	12	67%	0.6	5.0%	15.2%
Ireland (IE)	34	29%	5.7	16.8%	28.0%
Italy (IT)	94	33%	10.5	6.3%	30.9%
Luxembourg (LU)	80	54%	11.3	14.1%	29.2%
Netherlands (NE)	54	44%	4.54	8.4%	17.0%
Portugal (PT)	38	28%	5.02	12.9%	14.8%
Spain (ES)	113	57%	8.94	7.8%	21.9%

Table 7 provides an overview on the preference of national banking systems for LTRO versus MRO refinancing. It displays the share in refinancing of each of the two instruments in the respective country. It should be recalled that on average in the period 1999-2002, the share of LTROs in total refinancing operations is around 26%. One may first distinguish a group of countries for which the share in LTROs is above average, namely Austria, Germany, Ireland and especially Portugal.<sup>9</sup> The relatively high share of LTROs in Germany, combined with the high share of German banks in total refinancing, implies a considerable share (56%) of German banks in total LTRO volumes. For Greece and Italy LTROs seem to play a negligible role in banks' refinancing with LTRO shares less than 5%.

Table 8 displays that banks who bid at low interest rates have to put up with lower allotments and thus, smaller cover to bid ratios. A notable exception in this respect

<sup>9</sup> The large share in Portugal of over 50% of refinancing has to be seen against the low total refinancing needs of the Portuguese banking system.



Table 7: LTRO and MRO Refinancing Shares by Country

	Total Refinancing (in Mio. Euro)	Share in MRO	Share in LTRO
Austria (AT)	4013	67%	33%
Belgium (BE)	9670	84%	16%
Finland (FI)	1124	75%	25%
France (FR)	17349	83%	17%
Germany (GE)	106822	68%	32%
Greece (GR)	918	99%	1%
Ireland (IE)	8375	39%	61%
Italy (IT)	16375	96%	4%
Luxembourg (LU)	16300	81%	19%
Netherlands (NE)	6940	86%	14%
Portugal (PT)	1765	38%	62%
Spain (ES)	14247	81%	19%
Eurosystem	190183	74%	26%

*Notes:* The numbers are based on balance sheet data of the national central banks showing the relative recourse to MRO and LTRO of banks from the particular country. The total refinancing sum in the second column refers to the average recourse to open market operations over the sample period from March 1999 to May 2003.

are the Dutch banks, which have both, a small cover to bid ratio and a high relative refinancing cost. In the following panel regressions, we will test the significance of country effects for banks' bidding behavior.

## 4 Variables and Theoretical Predictions

### 4.1 What to explain? Variables measuring bidder behavior

For a given size of liquidity needs, each bank has to decide whether to refinance through a LTRO or through an alternative source of refinancing, like a MRO or the interbank money market. In Section 5.1, we investigate how a bank's **participation decision**

Table 8: Bidder Performance by Country

	Bid Rate minus Marginal Rate	Allotment Rate minus Marginal Rate	Cover to Bid Ratio LTRO	Cover to Bid Ratio MRO	Relative Refinancing Costs (RRC)
Austria (AT)	0.003	0.037	0.32	0.48	1.001
Belgium (BE)	-0.023	0.030	0.13	0.67	0.996
Finland (FI)	-0.015	0.033	0.22	0.58	0.996
France (FR)	-0.029	0.027	0.21	0.52	0.996
Germany (GE)	-0.007	0.032	0.43	0.62	1.000
Greece (GR)	0.010	0.033	0.13	0.74	1.003
Ireland (IE)	0.017	0.031	0.68	0.82	1.001
Italy (IT)	-0.052	0.019	0.10	0.66	0.989
Luxembourg (LU)	-0.011	0.018	0.34	0.66	0.996
Netherlands (NE)	0.008	0.058	0.17	0.46	1.006
Portugal (PT)	0.012	0.048	0.60	0.68	1.002
Spain (ES)	-0.016	0.029	0.38	0.75	0.997

*Notes:* The bid rate and the allotment rate are quantity weighted average rates.

with regard to a LTRO depends on various auction as well as bidder-specific factors. In Section 5.2, we estimate the impact of these factors on the *quantity* of refinancing demanded by each bank, i.e. the log of the individual **bid amount**. Furthermore, we examine the determinants of the *price* at which banks demand reserves in a LTRO auction, measured as the quantity weighted average **bid rate**. In order to account for changes of the overall interest rate level, the actual variable explained in the regressions is the spread between the weighted average bid rate and the 3-month repo rate observed in the money market. Since banks are allowed to bid at up to ten different interest rates, the average bid rate of a bank neither determines the volume allotted nor the average interest rate to be paid. Understanding banks' bidding behavior in LTROs also requires an analysis of the distribution of bids. To that aim, we examine the factors influencing the individual **bid rate dispersion**, defined for each bank as the quantity weighted standard deviation of its bid rates.

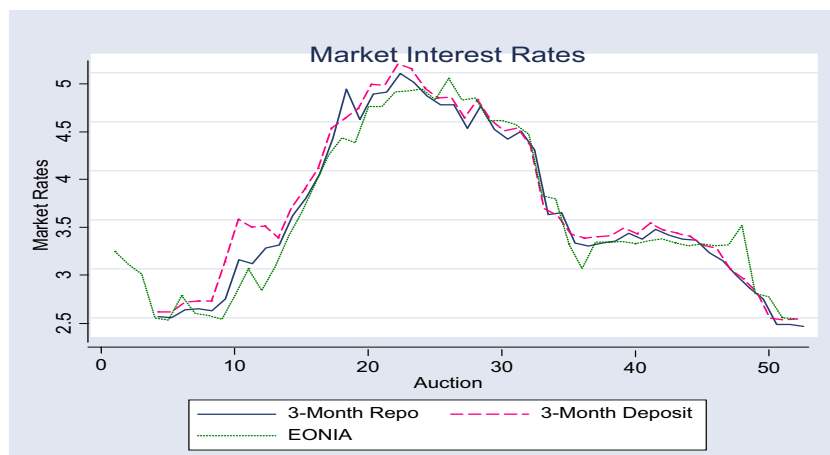
The principle of equal treatment is an important criteria of assessing the empirical performance of LTROs. Specifically, a bidder's size or its country should not have a severe impact on the bidding success of a bank. Unfortunately there is no straightforward way to measure the success of a bank because this would require the knowledge of a bank's true demand function which is only partly reflected in the bid function submitted in the auction. For example, suppose a bank left a LTRO empty handed because it bid only at interest rates below the marginal rate. From the bank's perspective, this auction was no success only if the low bidding rates resulted from a misperception of the situation in the money market. If, however, the bank bid seriously and the marginal rate of the LTRO simply exceeds the bank's willingness to pay then a zero allotment is a "successful" auction outcome.

In view of these problems we employ two different measures of banks' success. First, we assume that a banks' success increases with its individual **cover to bid ratio**. This measure captures the plausible idea that banks are the more successful the more refinancing they receive (relative to their bid). Notice, however, that according to this measure, bidding at unrealistically high interest rates would be an expensive but successful strategy. Therefore, as a complementary measure of a bank's success we constructed the variable **RRC** (relative refinancing cost) that relates the average rate paid by an individual bank to the average allotment rate of the auction. The lower the relative refinancing cost the more "successful" is a bank relative to its competitors. Yet this measure is not without problems either as, for example, RRC may indicate successful bidding even if a bank received only a disappointingly small part of its bid volume. Taking the two measures together, one can only be sure that a bidder is more successful than others if it achieves both, higher average cover to bid ratios and lower relative refinancing cost.

## 4.2 And How? Variables explaining bidder behavior

The costs of collateral should be of particular importance for banks' bidding since LTRO refinancing blocks collateral and makes it thus unavailable for alternative uses over a 3-month horizon. Due to data availability there is no exact measure of LTRO collateral cost. We define the variable **collateral** as the spread between the three month deposit and the three month repo rate valid at the bidding day of the auction,

Figure 8: Market Interest Rates: 3-M Repo, 3-M Deposit, and EONIA Rate



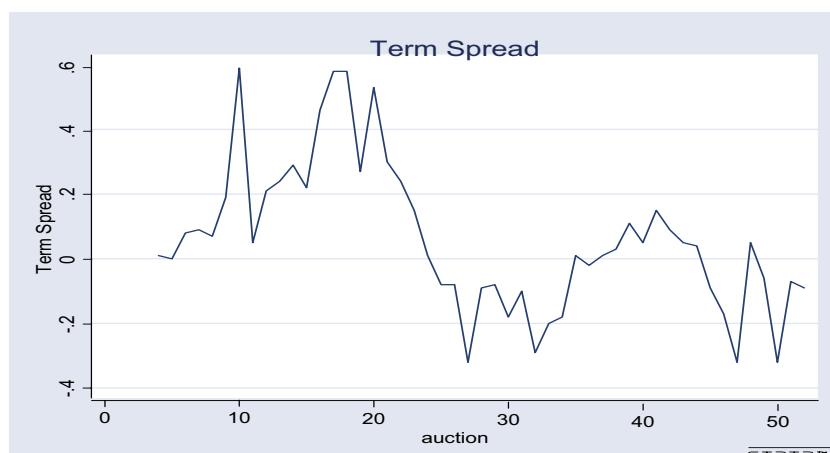
Notes: The market rates are quotes from 9:15 AM just prior to the deadline for counterparties' submission of bids at 9:30 AM. The market rates are displayed from January 1999 onwards.

see Figure 8. This spread measures the opportunity cost of *general* collateral which can be used not only in LTROs but also in interbank operations.<sup>10</sup> Therefore, an increase in cost of general collateral could induce banks to increase participation in LTROs.

In MROs, expectations about future interest rates are a crucial factor for explaining banks' bidding behavior. In particular, when banks expect decreasing interest rates, the pre-announced minimum bid rate leads banks to underbid, i.e. they refrain from bidding, see ECB (2003a). In order to investigate whether rate change expectations also affect bidder behavior in LTROs, we define the variable **term spread** as the difference between the three-month repo rate and the prevailing MRO minimum bid rate. The 3-month repo rate quotes are taken at 9:15 just prior to the end of the bidding period for the LTRO at 9:30. Indeed, most bids are submitted in the last 15 minutes of the auction. In accordance with the expectations theory of the term structure of interest rates, e.g. a negative term spread indicates that interest rates are

<sup>10</sup> Collateral useable for central bank operations additionally contains e.g. lower volume issues (Pfandbriefe) or non-marketable claims, which are not suitable for interbank repos which require standardization. It should also be noted that we could not account for the fact that availability of different types of collateral varies across countries.

Figure 9: The Term Spread between 3-Month Repo and MRO Minimum Bid Rate



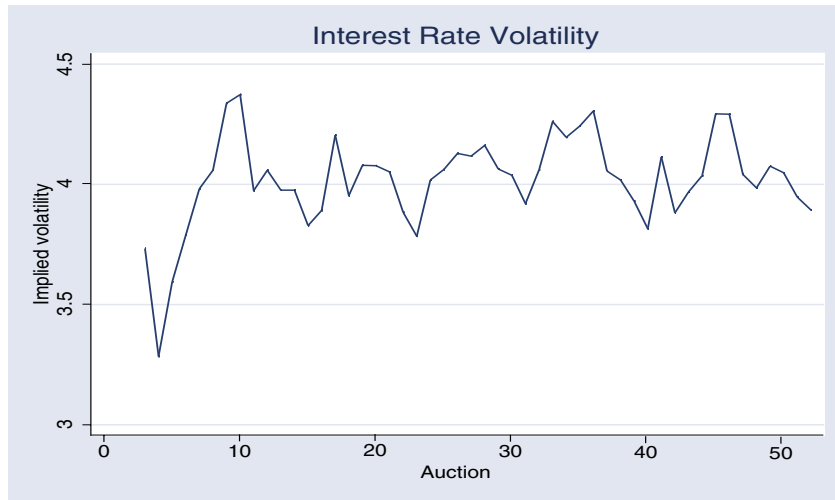
*Notes:* The marginal LTRO rate and minimum bid rate are displayed from 1999 onwards. The market 3-month repo rate quote is from 9:15 AM just prior to the deadline for counterparties' submission of bids at 9:30 AM. Prior to June 2002, the minimum bid rate corresponds to the pre-announced rate for the fixed rate tender.

expected to decline, see e.g. Figure 9.<sup>11</sup>

The following estimations will also shed light on how interest rate uncertainty affects banks bidding. Regarding the impact of uncertainty, auction theory predicts the winner's curse effect which implies that banks bid more cautiously when uncertainty increases. With increasing uncertainty, banks should mitigate the exposure to winner's curse by bidding at lower rates, reducing the quantity demanded and increasing the bid rate dispersion, see Nyborg, Rydqvist and Sundaresan (2002). However, Nyborg, Bindseil and Strebulaev (2002) obtain only poor evidence on the winner's curse effect in ECB's MROs. This suggests that banks' bidding is dominated by other considerations such as the fear of not obtaining any funds, see Scalia and Ordine (2003). In this case, higher uncertainty induces bidders to submit larger bids at higher rates. This behavior is also predicted by multi-period reserve management models where higher interest rate risk increases banks' demand for reserves, see Nautz (1998). In the following, interest rate uncertainty is proxied by the variable **volatility** measured as the implied volatility derived from options on 3-month EURIBOR futures, see Fig-

<sup>11</sup> See also Figure 14 in the Appendix.

Figure 10: Interest Rate Volatility



*Notes:* Volatility is measured as the implied volatility derived from options on 3-month EURIBOR futures. Following ECB (2002a), the implied volatility is a useful measure of the overall uncertainty associated with future movements in short-term interest rates.

ure 10.<sup>12</sup> Following ECB (2002a), the implied volatility is a useful measure of the overall uncertainty associated with future movements in short-term interest rates.

In order to investigate whether the preannounced LTROs volume influences the behavior of banks and the outcome of the auction we defined the variable **auction size** that equals the LTRO allotment volume. If the central bank increases the intended allotment volume, banks' might expect the price for liquidity to decrease, thus, increasing their participation and bid volume accordingly.

Finally, we consider several bidder-specific regressors. In order to investigate whether the outcome of the preceding MRO affects the bidding behavior in the following LTRO we include the change of a bank's cover to bid ratio ( $\Delta CBR_{MRO}$ ) of the previous two MRO tenders in the regressions. If  $\Delta CBR_{MRO} > 0$ , then a bank might have received more MRO repo credit than expected which might affect its bidding behavior in the upcoming LTRO.<sup>13</sup> A further variable that relates LTRO bidding to banks' behavior

<sup>12</sup> Note that *volatility* is measured at the day when the bidding period ends.

<sup>13</sup>  $\Delta CBR_{MRO}$  is set to zero when a bank did not participate in one of the two previous MROs. Note that the level  $CBR_{MRO}$  is severely distorted by banks' massive overbidding during the fixed rate tender period. For that reason, we defined  $\Delta CBR_{MRO}$  to be zero in the first LTRO after the

in MROs is **MRO frequency** that measures the average participation frequency of a bank in the MROs. It should reveal whether e.g. bidders which are especially active in MROs are less or more active in LTROs.

The variable **maturing allotment** is defined as the log of a bank's repo volume received three months before. If banks use LTROs on a revolving basis, the maturing amount of the repo credit should increase banks' participation probability and its bid volume.

The descriptive data analysis of banks' bidding in LTROs suggested that bidding behavior depends on a bank's size and its experience. In order to test whether these effects are statistically significant, we include dummy variables for **regular bidders** and for the various size groups (**small, medium, large**) in the regressions. We will also investigate the relevance of country effects. A bank's size or country of origin may not only influence the level of an auction variable. Therefore, we will also interact the size and country dummies with the variables volatility, term spread, and collateral to investigate how size and country of origin influences a bank's reaction to those variables.

## 5 A Panel Data Analysis

### 5.1 The Participation Decision

We analyze the participation decision of an individual bank using a panel version of the standard probit model. In this model, the dependent variable  $y_{it}$  equals one if bank  $i$  participates in auction  $t \in \{1, \dots, N = 50\}$  and is zero otherwise:

$$Pr(y_{it} = 1|x_{it}) = \Phi(\beta'x_{it})$$

where  $x_{it}$  denotes the vector of explanatory variables introduced in the previous section and  $\beta$  the corresponding coefficients.  $\Phi(\cdot)$  is the standard normal distribution function. We opted for the random effects probit model since it allows for the inclusion of time-invariant bidder-specific regressors.

Table 9 shows the results for the benchmark specification of the probit model. In line

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ECB's switch to the variable rate tender format in June 2000.

Table 9: LTRO Participation: A Probit Model

	Benchmark Probit Model	Size Dependent Coefficients	$H_0$ : no size effect (p-value)
Collateral Costs	0.39 (4.76)	-	
Term Spread	0.57 (16.25)	-	
Volatility	-0.61 (-13.93)	-	
Maturing Allotment	0.07 (55.05)	0.07 (55.03)	
MRO Frequency	2.33 (22.58)	2.33 (22.27)	
Auction Size	0.77 (11.92)	0.77 (15.23)	
Regular	1.88 (14.00)	1.88 (14.22)	
$\Delta CBR_{MRO}$	-0.25 (-6.39)	-0.25 (-6.42)	
Size <sub>medium</sub>	0.10 (1.76)	0.32 (0.86)	
Size <sub>large</sub>	0.40 (5.27)	2.21 (4.15)	
Collateral <sub>small</sub>	-	0.21 (1.63)	
Collateral <sub>medium</sub>	-	0.42 (3.57)	0.0675
Collateral <sub>large</sub>	-	0.79 (3.62)	
Term Spread <sub>small</sub>	-	0.74 (12.94)	
Term Spread <sub>medium</sub>	-	0.45 (8.98)	0.0006
Term Spread <sub>large</sub>	-	0.53 (5.80)	
Volatility <sub>small</sub>	-	-0.53 (-7.36)	
Volatility <sub>medium</sub>	-	-0.58 (-9.24)	0.0018
Volatility <sub>large</sub>	-	-0.98 (-8.67)	
Constant	-7.84 (-16.17)	-8.21 (-15.40)	

*Notes:* The t-values of the parameter estimates are reported in parenthesis. The F-test tests whether the size-specific coefficients are equal, i.e. whether there are significant differences in the response to collateral costs, interest expectation and interest rate uncertainty depending on a bank' size.



with the winner's curse hypothesis, banks decrease their participation significantly as interest rate *volatility* increases. If interest rate volatility is high, banks bid more reluctantly in LTROs because they fear to bid at interest rates above the uncertain market consensus. In contrast, Nyborg, Bindseil and Strebulaev (2002) and Scalia and Ordine (2003) found that interest rate volatility has a positive impact on banks' participation in ECB's MROs. The different response of banks to rate uncertainty suggests that the common value component of repo credit received from LTRO is more pronounced than in MROs.

The significant coefficient of the variable *term spread* implies that e.g. banks participation decreases if interest rates are expected to fall.<sup>14</sup> A strong impact of rate expectations on banks' bidding is well documented in MROs where the minimum bid rate makes bidding less attractive when repo rates are expected to fall. In LTROs, however, there is no minimum bid rate that prevents bid rates from falling. As a consequence, there is no obvious explanation for the role of rate expectations for the bidder behavior in LTROs. In fact, assuming a fairly large term spread of about 50 basis points would lead to a drop in participation by only 3% given the implied marginal effect of the term spread.

An increase in *collateral* which indicates higher opportunity cost of general collateral, increases the probability of participation in an LTRO. Since the ECB's requirements for eligible collateral in repo auctions are less restrictive than in the interbank repo market, an increase in *collateral* makes participation in LTROs more attractive. *Maturing allotment* has the expected positive effect on banks' participation. Thus, as in MROs, many banks use LTROs on a revolving basis.

The probit model further demonstrates that there are interesting relations between banks' bidding behavior in MROs and LTROs. The significantly negative coefficient of  $\Delta CBR_{MRO}$  shows that banks tend to participate less (more) when they realized an unexpectedly high (low) allotment amount in the previous MRO. This suggests that banks' demand for refinancing in LTROs depends on the refinancing they received in current MROs. Moreover, the variable *MRO frequency* shows that the higher a bank's

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<sup>14</sup> We also checked for the possibility that this effect might be asymmetric for interest rate hike and cut expectations which is not substantiated by the data. Notice further that the peak in the term spread in October 1999 is not due to rate hike expectations but stems from the Y2K effect. Leaving out the period until Dec 1999 from our sample does not change our estimates in a significant way.

average participation frequency in MROs the higher is the participation probability in LTROs. Thus, LTROs are used frequently by bidders who are also active in MROs.

Medium and large banks use LTROs significantly more often than small banks. Thus, the results from the probit analysis corroborates the impression that LTROs are not just a monetary policy instrument especially designed for small banks.

### 5.1.1 Size-specific Determinants of LTRO Participation

Table 9 also shows the results of an extended probit model where the influence of collateral costs, the term spread, and volatility on a bank's participation are allowed to dependent on the bank's size, as measured through its reserve requirement. These size-effects are implemented by interacting the size-dummies with the variables of interest. For example, the single variable volatility is replaced by the three size-specific variables  $volatility_{small}$ ,  $volatility_{medium}$ , and  $volatility_{large}$ . The p-values reported in column 3 of Table 9 correspond to the null-hypothesis that the three size-specific coefficients are equal, i.e. that the influence of a certain variable does not depend on a bank's size.

The extended probit model demonstrates that a bank's size does not only affect the average level of participation. In fact, size-dependent coefficients are significant for all three variables under consideration. First, small banks do not react significantly to a change in collateral cost, possibly indicating a less active collateral management. In contrast, if collateral cost in the interbank repo market rise, large banks will try harder to get funds from the central bank. Second, small banks react more pronounced to the term spread, i.e. on changes in interest rate expectations. However, even for small banks there is no evidence that rate cut expectations can lead to bidder strikes in LTROs. Finally, very much in line with the predictions implied by the winner's curse effect, the participation decision of large banks depends stronger on prevailing interest rate uncertainty. This indicates that large banks tend to be more active in the money market and are thus more interested in the common value component of reserves.

### 5.1.2 Country-specific Determinants of LTRO Participation

In this section we investigate the impact of a bank's country of origin on its participation decision. We first estimate a benchmark probit model which captures country-specific differences in the average *level* of LTRO participation. In Table 13 (in Appendix), differences across the 12 EMU countries are measured by 11 country-dummies and a constant. The model uses Germany as a reference country, such that the coefficients of the dummy variables show whether the average participation level in a certain country is higher or lower than in Germany. Interestingly, most of the country-specific differences in the participation frequencies suggested by the descriptive statistics are not statistically significant, compare Table 6. Austrian, Finnish and Portuguese banks, however, participate significantly more frequently in LTROs than banks from Germany. In contrast, the average participation frequency of Spanish banks is significantly lower.

In a second step, we estimate an extended probit model to examine whether banks from different countries behave differently if market conditions change. Specifically, a bank's response to collateral cost, term spread, and volatility is allowed to depend on its country of origin. According to Table 14 there are several notable differences in the determinants of banks' participation across countries. For example, Italian banks react most pronounced towards changes in collateral costs and interest rate expectations. Moreover, the bid function of Italian banks is more elastic with respect to interest rate uncertainty than bids from German banks. The general impression is that the response to changing market conditions is the weaker the larger the country-specific share of LTROs in total refinancing, compare Table 7. The differences across countries may also help to assess the relevance of restrictions regarding the maturity match of assets and liabilities.<sup>15</sup>

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<sup>15</sup> For example, the strictest liquidity regulations prevail in Germany. The "Liquidity Principle II" in the German banking law prescribes that liabilities maturing within one month need to be matched by as many assets maturing within a months time, whereby different weights are given to different sorts of liabilities (e.g. 10% for sight liabilities to non-banks). There are weaker regulation in Austria, Italy, and the Netherlands, while no binding liquidity restrictions exist in Belgium, Spain, Greece, Ireland, Portugal, and Finland. A bank subject to liquidity regulations will probably have strong preferences for LTROs.

## 5.2 Bid Volume, Bid Rate, and Bid Rate Dispersion in LTROs

In this section, we investigate the determinants of a bank's bid volume, its weighted average bid rate, and its bid rate dispersion. These variables are left-censored since they can only be observed if the bank decided to participate in the auction. Regressions that explain the bidding behavior of a bank have to account for this property of the data in order to avoid biased estimates. Following Jofre-Bonet and Pesendorfer (2003) we apply the two step estimator introduced by Heckman (1976) to account for the censoring problem.<sup>16</sup>

Table 10 summarizes the results of the benchmark models for a bank's bid volume, the average bid rate, and the bid rate dispersion. As expected, the larger the bank the higher is its average bid volume.<sup>17</sup> While a bank's size has no influence on its bid rate dispersion, the benchmark specification for the bid rate confirms that large banks bid on average 2 basis points lower than smaller banks, compare Table 3. In contrast to the impression obtained from the descriptive statistics shown in Table 5, the estimation results reveal that bidding experience in LTROs does not play an important role for banks' bidding behavior. In fact, the variable *regular bidder* neither has a significant impact on a bank's bid rate nor on its bid rate dispersion. Similarly, very active bidders in MROs (*MRO frequency*) do not significantly bid at lower rates or on a wider range.

There is a significant influence of the results of recent MRO auctions on a bank's behavior in LTROs. If the cover to bid ratio has increased in the current MRO ( $\Delta CBR_{MRO} > 0$ ) the bid volume and the bid rate decrease. Apparently, a bank's demand for longer term refinancing decreases if its current MRO allotment has increased. If the central bank increase the preannounced allotment volume (*auction size*), banks bid higher volumes and at lower rates presumably because they expect liquidity to be more abundant. Increasing collateral cost in the interbank repo market

<sup>16</sup> The first step of the Heckman procedure uses the probit participation models estimated in the previous section to construct inverse Mills ratios. The corresponding inverse Mills ratio is included into a standard panel GLS regression in the second step. The empirical auction literature typically ignores the selection bias problem inherent to the bidding data. Exceptions are e.g. Ayuso and Repullo (2001) and Linzert, Nautz and Breitung (2003) where the bid volume follows a traditional Tobit model.

<sup>17</sup> Recall, however, that a bank's size is defined with respect to its average reserve requirement and not with respect to its bid volume.

Table 10: Benchmark Model for Bid Volume, Bid Rate and Bid Rate Dispersion

	Bid Volume	Bid Rate	Bid Rate Dispersion
Collateral Costs	0.11 (1.76)	0.64 (81.37)	0.02 (10.82)
Term Spread	0.26 (8.06)	-0.05 (-11.43)	0.007 (7.60)
Volatility	-0.25 (-6.43)	-0.05 (-9.78)	-0.004 (-4.20)
Maturing Allotment	0.02 (7.64)	0.001 (4.33)	0.0001 (1.55)
MRO Frequency	1.18 (6.74)	0.02 (1.36)	0.003 (1.04)
Auction Size	0.23 (5.22)	-0.07 (-12.34)	0.02 (19.04)
Regular	0.46 (1.99)	0.02 (1.49)	0.003 (1.94)
$\Delta CBR_{MRO}$	-0.15 (-5.72)	-0.007 (-2.29)	-0.001 (-2.18)
$Size_{medium}$	1.51 (17.66)	0.003 (0.52)	-0.001 (-1.03)
$Size_{large}$	3.27 (25.59)	-0.02 (-1.98)	-0.001 (-1.25)
Constant	13.896 (29.74)	0.78 (13.87)	-0.199 (-16.47)
Mills Ratio	0.10 (2.70)	0.006 (1.29)	0.001 (0.84)

*Notes:* The t-values of the parameter estimates are reported in parenthesis. The inverted Mills ratio corrects for possible distortions stemming from the censored data problem was calculated from the previous probit model in Table 9.

appears to drive up the bid rates but does not affect the volume of bids.

The significant influence of volatility on the banks' bid volume and their average bid rate confirms the evidence for the winner's curse effect obtained from the probit analysis. In line with auction theoretical predictions, banks bid at lower rates and reduce their bid volume as interest rate uncertainty increases. As mentioned, the evidence for the winner's curse effect is much weaker in the ECB's MROs, see Nyborg, Bindseil and Strebulaev (2002). However, as in MRO auctions the positive effect of volatility on the bid rate dispersion somewhat blurs the evidence for the winners curse effect.

Overall, with respect to the sign and significance of the estimated parameters, the benchmark models for the determinants of a bank's bid volume, its bid rate and its bid rate dispersion results are very much in line with the plausible results obtained for the participation decision. In particular, each factor that e.g. increases a bank's probability of participation in LTROs also increases its bid volume.

### 5.2.1 Size-specific Bidding Behavior

This section sheds more light on how a bank's response to collateral cost, interest rate expectations and volatility depends on its size. Table 11 presents the extended models allowing for size specific coefficients for the bid volume, the bid rate and bid rate dispersion. Generally, a bank's size seems to be less important for the bidding variables than for the participation decision. In particular, the coefficients in the bid volume equation do not depend on a bank's size at all. Moreover, the equations estimated for the bid rate and the bid rate dispersion do not support a size-specific influence of volatility on banks' bidding. In contrast, the impact of rate expectations is size-dependent for the bid rate and the bid rate dispersion. In both cases, there is a weaker response to the term spread of large banks. This constitutes a further interesting difference between banks' bidding behavior in MROs and in LTROs. Breitung and Nautz (2001) and Scalia and Ordine (2003) found that larger banks react in a more elastic way to interest rate expectations in the MROs. In MROs, the existence of a minimum bid rate implies that a strong reaction to rate expectations points to sophisticated bidding. In LTROs, where no minimum bid rate is set, it is far less obvious why a bank's bidding strategy should depend on the term spread.

The influence of collateral cost on banks' bid rate and its dispersion is also size-specific. Especially large and medium banks spread their bids more when collateral becomes more expensive in the interbank repo market. In line with results obtained for banks' participation decision, this points to a less active collateral management of small banks.

Table 11: Bidding Behavior with Size Dependent Coefficients

	Bid Volume	$H_0$ : no Size effect	Bid Rate	$H_0$ : no Size effect	Bid Rate Dispersion	$H_0$ : no Size effect
Collateral Costs	0.11 (1.76)		-		-	
Term Spread	0.26 (8.06)		-		-	
Volatility	-0.25 (-6.43)		-0.04 (-9.49)		-0.004 (-4.22)	
Maturing Allotment	0.02 (7.64)		0.0003 (4.13)		0.0001 (1.76)	
MRO Frequency	1.18 (6.74)		0.01 (1.17)		0.003 (1.19)	
Auction Size	0.23 (5.22)		-0.01 (-12.58)		0.02 (19.08)	
Regular	0.46 (1.99)		0.01 (1.49)		0.003 (1.97)	
$\Delta CBR_{MRO}$	-0.15 (-5.72)		-0.007 (-2.19)		-0.002 (-2.30)	
Size <sub>medium</sub>	1.51 (17.66)		-0.006 (-0.30)		-0.003 (-3.26)	
Size <sub>large</sub>	3.27 (25.59)		-0.008 (-0.66)		-0.002 (-1.94)	
Collateral <sub>small</sub>	0.10 (2.70)		0.65 (48.99)		0.005 (1.72)	
Collateral <sub>medium</sub>	-	0.6956	0.66 (62.70)	0.0000	0.025 (11.05)	0.0000
Collateral <sub>large</sub>	-		0.53 (31.82)		0.022 (6.21)	
Term Spread <sub>small</sub>	-		-0.06 (-8.86)		0.009 (6.00)	
Term Spread <sub>medium</sub>	-	0.059	-0.04 (-8.19)	0.0000	0.008 (7.05)	0.0000
Term Spread <sub>large</sub>	-		0.03 (-4.48)		0.0001 (0.07)	
Volatility <sub>small</sub>	-		-		-	
Volatility <sub>medium</sub>	-	0.1549	-	0.6254	-	
Volatility <sub>large</sub>	-		-		-	
Constant	13.93 (29.92)		0.79 (14.12)		-0.198 (-16.47)	
Mills Ratio	0.092 (2.59)		0.004 (1.03)		0.0009 (0.98)	

*Notes:* The t-values of the parameter estimates are reported in parenthesis. The inverted Mills ratio that corrects for possible distortions stemming from the censored data problem was calculated from a corresponding probit model. The F-test tests whether the size-specific coefficients are equal, i.e. whether there are significant differences in the response to collateral costs, interest expectation and interest rate uncertainty depending on a bank' size.

### 5.2.2 Country-specific Bidding Behavior

We included country dummies into the benchmark models for the bid volume, bid rate, and the bid rate dispersion. According to Table 13 (in Appendix), there are significant differences in the average level of LTRO participation depending on a bank's country of origin. The results show that, for example, Italian banks bid significantly smaller volumes and at lower rates than banks from the reference country Germany. Confirming the descriptive statistics (Table 8), Dutch banks bid at higher interest rates than German banks.

In Tables 15-17 (in Appendix), we extend the benchmark model to size dependent coefficients for the variables *collateral costs*, *term spread* and *volatility*. It appears that banks from different countries differ in their response to changes in collateral costs. For example, Belgium and Italian banks cut back on their bid volumes stronger than, for example, German banks when collateral costs increase. Moreover, while banks from countries with lower liquidity restrictions, such as Italy, spread their bids significantly more than German and French banks there is no visible difference in the reaction of the bid rate when collateral costs increase. When interest expectations signal rising interest rates, Italian banks spread their bids significantly more than German and French banks.

The results do not provide clear cut evidence that countries with less strict liquidity regulations bid significantly different than, for example, German and French banks. However, it appears that especially the behavior of Italian banks differs from the behavior of German banks. Italian banks react much stronger on changes in collateral costs, interest rate expectations and uncertainty than German banks suggesting the latter to be more dependent on LTROs.

### 5.3 Bidding Success

In the preceding sections, the analysis of bidder behavior in the ECB's LTRO auctions revealed that a bank's bidding strategy can depend on its size, its country of origin, and its bidding experience. In this section, we investigate whether the observed bidder heterogeneity implies that certain types of bidders are systematically more successful than others. In this case, LTRO auctions may be seen as unfair and the principle of



equal treatment might be violated. Moreover, bidding in LTROs should be sufficiently simple to ensure an appropriate access to longer term refinancing even for less informed or less sophisticated bidders. In particular, unexperienced bidders should not be discouraged in LTROs by disappointing auction outcomes. In the following panel regressions we therefore investigate whether regular bidders in LTROs or bidders with a high participation frequency in MROs are significantly more successful than others.

Since a bank's true demand for repo credit is only partly revealed in its bid, measuring the success of a bank in a LTRO auction is not straightforward. In accordance with Section 4.1, we proxy the success of a bank's bidding strategy by two complementary measures: the individual *cover to bid ratio* (defined as the ratio between realized allotment and total bid volume) and the *relative refinancing cost* (RRC) where the average interest rate paid by the bank is compared with the average rate paid by all bidders. The larger the cover to bid ratio and the lower the relative refinancing cost the more successful is the bank. Of course, a bank can always increase its cover to bid ratio by bidding at higher interest rates thereby increasing its refinancing cost. As a consequence, a bank is identified to be more successful than others only if it achieves higher average cover to bid ratios [lower RRC] *without* higher refinancing cost [lower cover to bid ratios].

The results from the two random effects panel regressions explaining banks' individual cover to bid ratios and their relative refinancing cost are presented in Table 12. As expected, for most regressors the signs of the estimated coefficients are the same in both equations. In particular, medium and large banks have both, significantly lower refinancing cost as well as lower cover to bid ratios than small banks. As a result, the different bidding strategies of e.g. small and large banks are hard to evaluate in terms of success. Small banks prefer a secure allotment by realizing higher cover to bid ratios, while large banks are more flexible with respect to the allotment volume caring more about their refinancing cost. This bidding behavior can also be observed for banks participating very frequently in MROs (*MRO frequency*). In contrast to the preliminary evidence suggested by the descriptive statistics presented in Table 5, the panel regressions reveal that there is only weak evidence in favor of an experience effect on the auction outcome. The *regular bidders* dummy neither has a significant influence on the cover to bid ratio nor on a bank's relative refinancing cost.

Table 12: Benchmark Model for Individual Cover to Bid Ratio and Relative Refinancing Cost (RRC)

	Cover to Bid Ratio	RRC
Collateral Costs	0.05 (1.30)	-0.001 (-1.20)
Term Spread	<b>-0.20</b> (-12.20)	<b>-0.002</b> (-4.14)
Volatility	0.22 (11.18)	0.0003 (0.59)
Maturing Allotment	<b>0.01</b> (18.05)	<b>0.0001</b> (4.90)
MRO Frequency	<b>-0.15</b> (-4.78)	<b>-0.004</b> (-3.24)
Auction Size	<b>0.15</b> (6.58)	0.001 (1.92)
Regular	0.05 (1.43)	-0.0005 (-0.29)
$\Delta CBR_{MRO}$	0.006 (0.42)	-0.0001 (-0.11)
$Size_{medium}$	<b>-0.053</b> (-3.12)	<b>-0.003</b> (-3.98)
$Size_{large}$	<b>-0.15</b> (-5.77)	<b>-0.003</b> (-2.88)
AT	0.03 (0.71)	0.001 (0.88)
BE	<b>-0.20</b> (-3.01)	-0.001 (-0.23)
ES	-0.05 (-1.31)	-0.003 (-1.60)
FI	-0.17 (-1.89)	-0.001 (-0.34)
FR	-0.08 (-1.94)	-0.003 (-1.66)
GR	<b>-0.35</b> (-2.21)	-0.008 (-0.77)
IE	<b>0.19</b> (3.10)	0.003 (1.26)
IT	<b>-0.24</b> (-7.58)	<b>-0.01</b> (-8.68)
LU	-0.02 (-0.70)	-0.002 (-1.51)
NE	0.03 (0.60)	<b>0.006</b> (2.84)
PT	0.12 (1.41)	0.002 (0.53)
Constant	<b>-1.84</b> (-8.36)	<b>0.99</b> (161.79)

*Notes:* The t-values of the parameter estimates are reported in parenthesis. Significance on the 5% level is indicated by bold numbers. Germany is taken as the base country so the respective dummy is omitted.

Finally, we included country dummies into the regressions in order to investigate how the auction outcome depends on a bank's country of origin. Taking Germany as the reference country, we found that relative refinancing cost for Italian banks are on average about one basis point lower. However, Italian banks cannot be seen to be more successful than their German counterparts because they also realize significantly smaller cover to bid ratios. Apparently, Italian banks have different preferences regarding their means of refinancing and hence pursue different bidding strategies. This is also reflected in the different country shares in refinancing in LTROs, see Table 7.

There are three countries where banks appear to bid less successful than those from Germany. Banks from Belgium and Greece realize significantly lower cover to bid ratios but their refinancing cost are not significantly lower. Banks from Netherland pay a higher interest rate without receiving a higher allotment. By contrast, bidders from Ireland seem to bid particularly successful in LTRO auctions. While their relative refinancing cost is not significantly higher than those from German bidders, Irish banks nevertheless achieve a significantly higher cover to bid ratio. Although there are thus some statistically significant differences in success, the economic significance of the differences appears marginal.

## 6 Concluding Remarks

In the Eurosystem, on average over the first five years, around 55 bln Euro, i.e. about 25% of banks' total repo credit was provided through longer term refinancing operations (LTROs). The role of LTROs in the ECB's operational framework is thus far from negligible. Yet, the empirical performance of LTRO auctions, i.e. banks' bidding behavior and the determinants of the auction outcomes have not been well researched so far. On the one hand, it has been argued that LTROs should be suspended since they would unnecessarily complicate monetary policy implementation. On the other hand, one could take the view that the volume of LTROs could even be increased if that would improve the efficiency of banks' reserve management without introducing market distortions. This paper analyzed the individual bidding data of the LTRO auctions performed until May 2003 in order to shed light on these issues.

One of the original intentions of the ECB when establishing LTROs was to give smaller

banks with only limited access to the interbank market a comfortable source of longer term refinancing, see ECB (2002b). Certainly, in terms of their total refinancing volume, LTROs are more important for smaller and medium size banks than for large banks. However, our results do not substantiate the notion that LTROs are especially designed for and used by smaller banks. In particular, the results from a panel probit model reveal that a bank's participation probability in a LTRO increases with its size.

Our results demonstrate that a bank's size does not only affect the average level of participation. In fact, size-dependent coefficients are significant for all three variables under consideration. First, small banks do not react significantly to a change in collateral cost, possibly indicating a less active collateral management. In contrast, if collateral cost in the interbank repo market rise, large banks will try harder to get funds from the central bank. Second, small banks react more pronounced to the term spread, i.e. on changes in interest rate expectations. This seems to indicate that small banks are less sophisticated in their cash management as interest rate expectations should not be important in a pure variable rate tender. However, even for small banks there is no evidence that rate cut expectations can lead to bidder strikes in LTROs.

We found that a bank's average participation in LTROs increases with its participation frequency in the ECB's main refinancing operations (MROs). Thus, banks' use of LTROs and MROs cannot be seen as independent. Many banks use both refinancing instruments to diversify the maturity of their liabilities. Moreover, a surprisingly low allotment in a recent MRO, increases both, a bank's participation probability and its bid volume in the subsequent LTRO.

An important requirement for a smooth functioning of LTROs is that the auction procedure does not violate the principle of equal treatment. In particular, certain types of banks should not bid *a priori* more successful in LTROs than others. Although we find significant differences in the bidding behavior across banks of different size and from different countries, the resulting differences in terms of bidding success were astonishingly small. In addition, the analysis of banks' cover to bid ratio and their relative refinancing cost showed that different bidding strategies in most cases do not imply an obvious ranking of banks in terms of bidding success. For example, small banks bid on average two basis points higher than large banks. On the one hand this implies that small banks realize higher cover to bid ratios in LTROs. On the other

hand, however, they also tend to have higher refinancing cost.

While the preannounced minimum bid rate is an important feature of the ECB's MROs, LTROs are conducted as pure variable rate tenders. One might expect that without the guidance of a minimum bid rate, bidding in LTRO auctions would be particularly difficult. In fact, in contrast to MROs where most banks place their whole bid volume at a single interest rate, banks typically submit several bids in LTROs. Yet, the weighted standard deviation of bid rates in LTROs is only one basis point which is very close to the bid rate dispersion observed in MROs. Moreover, there is no indication that a pure variable rate tender induces bidders to act "opportunisticly" by bidding on a large scale deliberately below the market consensus. We also found that experienced bidders are not significantly more successful in LTROs than less experienced ones. Apparently, the LTRO auctions are sufficiently simple and transparent even without a minimum bid rate.

The analysis of banks' bidding behavior provided strong evidence for the winner's curse effect in LTROs. In line with the theoretical predictions, banks reduce their participation, bid at lower interest rates, and reduce their bid volume as interest rate uncertainty increases. Interestingly, large banks react stronger to rate uncertainty than small banks. This indicates that large banks are particularly interested in the common value component of the longer term refinancing since they have on average a more active interbank money market desk. The finding of a winner's curse effect in LTROs is in marked contrast to the absence of a winner's curse effect in the ECB's main refinancing operations, see e.g. Nyborg, Bindseil and Strebulaev (2002). In contrast to MROs, which can be seen as the "last resort" of open market operations, a failure to get funds in LTROs can still be compensated by bidding more aggressively in MROs. This suggests that the private value component is more pronounced in MROs than in LTROs.

In sum, this study demonstrated that the longer term repo auctions of the European Central Bank do neither lead to market distortions nor to unfair auction outcomes. This may explain why banks nearly unanimously opposed in fall 2002 the idea, raised by the ECB in a public consultation, to suspend this type of open market operations.

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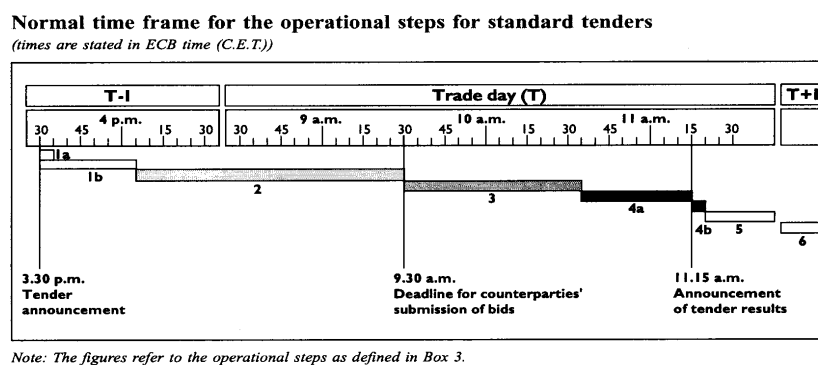
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## A The Timing of the LTRO Tenders

LTROs are normally allotted on the Wednesday during the first week of each reserve maintenance period (i.e. between the 23 and the end of the month).<sup>18</sup> Banks submit bids from 15:30 on Tuesday to 9:30 on Wednesday. The allotment result is published on Thursday at 11:20. The operation is settled one day after the allotment. The operations mature on the settlement days of the operations being conducted three months later, such that at any moment in time, exactly three operations are outstanding in the market.

Figure 11:



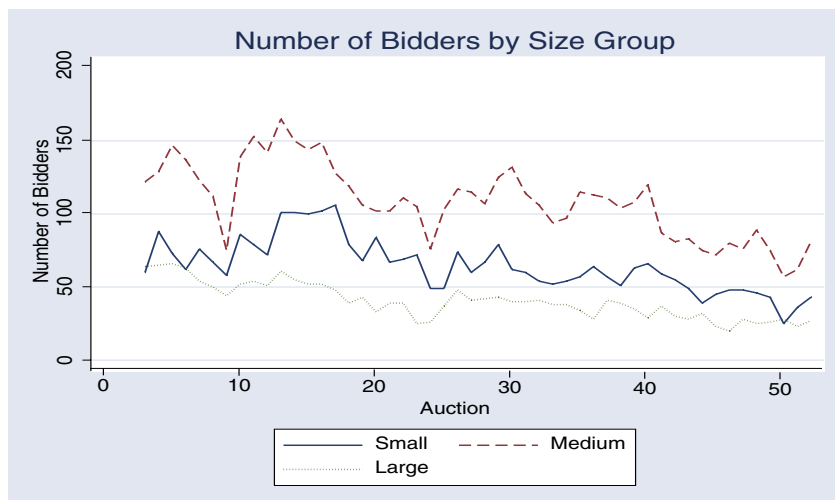
Notes: This Figure was taken from ECB (2000) and shows the specific timing of ECB's LTROs.

<sup>18</sup> Starting in April 2004, LTROs will be conducted at the last Wednesday of each month.



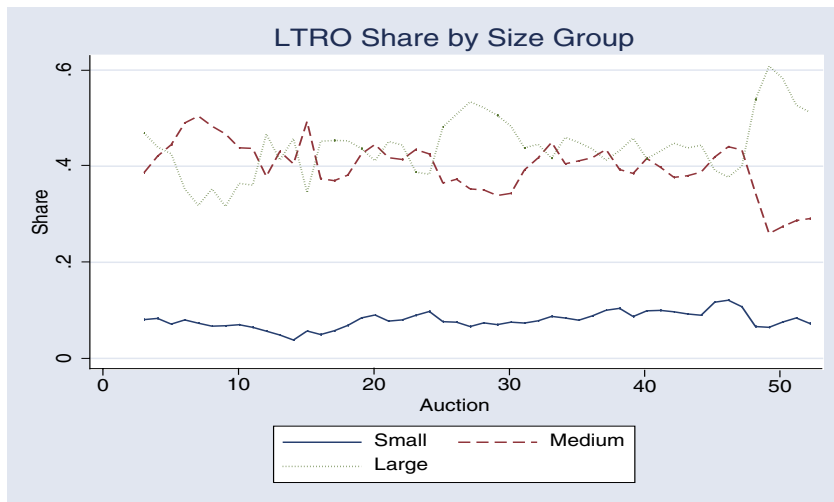
## B Figures+Tables

Figure 12: The Number of Bidders in ECB's LTROs by Size Group



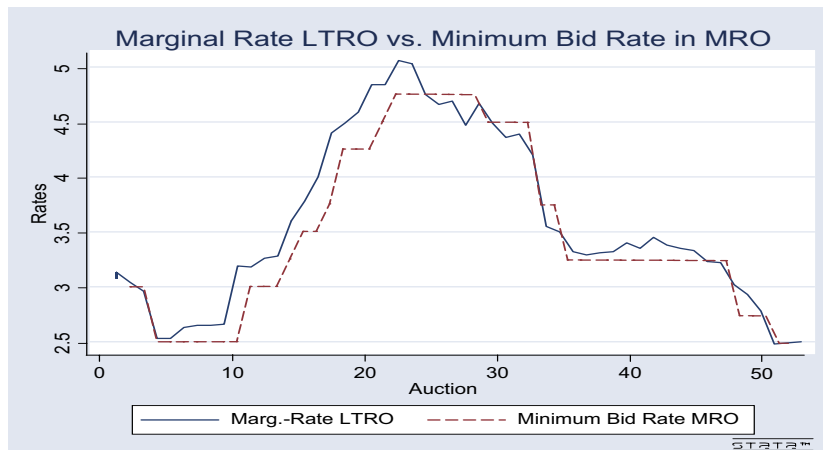
*Notes:* The number of bidders shown in the Figure refers to LTROs conducted from March 1999 until May 2003.

Figure 13: LTRO Share by Size Group



*Notes:* The Figure shows the allotment shares of the size groups small, medium and large in total LTRO allotment. The shares are displayed over the sample period from March 1999 until May 2003.

Figure 14: Marginal LTRO Rate and Minimum Bid Rate from MRO



*Notes:* The marginal LTRO rate and minimum bid rate are displayed from January 1999 onwards. Prior to June 2002, the minimum bid rate corresponds to the pre-announced rate for the fixed rate tender.

Table 13: Benchmark Model including Country Effects in Levels

	Probit Model	Bid Volume	Bid Rate	Bid Rate Dispersion
Collateral Costs	<b>0.38</b> (4.75)	0.11 (1.65)	<b>0.64</b> (81.60)	<b>0.02</b> (10.90)
Term Spread	<b>0.57</b> (16.22)	<b>0.26</b> (7.91)	<b>-0.04</b> (-11.31)	<b>0.007</b> (7.63)
Volatility	<b>-0.61</b> (-13.93)	<b>-0.24</b> (-6.24)	<b>-0.05</b> (-9.89)	<b>-0.004</b> (-4.31)
Maturing Allotment	<b>0.07</b> (55.66)	<b>0.02</b> (7.39)	<b>0.001</b> (4.32)	0.0001 (1.54)
MRO Frequency	<b>2.23</b> (24.13)	<b>1.21</b> (6.90)	0.02 (1.40)	0.002 (0.83)
Auction Size	<b>0.77</b> (15.24)	<b>0.23</b> (5.09)	<b>-0.07</b> (-12.29)	<b>0.02</b> (19.10)
Regular	<b>1.86</b> (13.90)	<b>0.59</b> (2.58)	0.02 (1.46)	0.003 (1.69)
$\Delta CBR_{MRO}$	<b>-0.26</b> (-6.60)	<b>-0.14</b> (-5.68)	<b>-0.007</b> (-2.27)	<b>-0.001</b> (-2.14)
Size <sub>medium</sub>	<b>0.23</b> (4.16)	<b>1.41</b> (15.96)	0.005 (0.95)	-0.004 (-0.44)
Size <sub>large</sub>	<b>0.50</b> (6.43)	<b>2.93</b> (20.29)	-0.007 (-0.81)	-0.002 (-0.16)
AT	<b>0.35</b> (4.29)	0.13 (0.59)	0.02 (1.46)	0.003 (1.71)
BE	-0.04 (-0.43)	<b>0.86</b> (2.62)	-0.01 (-0.58)	-0.007 (-2.29)
ES	<b>-0.40</b> (-5.06)	0.19 (1.08)	<b>-0.04</b> (-3.14)	<b>-0.004</b> (-2.29)
FI	<b>0.52</b> (4.17)	0.88 (1.77)	0.007 (0.24)	0.002 (0.54)
FR	-0.11 (-1.33)	<b>0.72</b> (3.42)	-0.02 (-1.24)	0.001 (0.30)
GR	-0.34 (-1.03)	0.21 (0.32)	-0.02 (-0.48)	-0.001 (-0.08)
IE	-0.42 (-)	<b>0.92</b> (2.64)	0.02 (1.38)	0.002 (0.56)
IT	0.08 (1.07)	<b>0.36</b> (2.22)	<b>-0.04</b> (-4.31)	-0.001 (-0.32)
LU	-0.38 (-)	<b>0.80</b> (4.22)	0.01 (0.50)	-0.002 (-1.50)
NE	-0.05 (-0.37)	0.46 (1.87)	<b>0.03</b> (2.20)	-0.003 (-1.54)
PT	<b>0.36</b> (3.18)	0.61 (1.65)	0.04 (1.70)	-0.002 (-0.46)
Constant	<b>-7.83</b> (-16.15)	<b>13.88</b> (29.68)	<b>0.77</b> (13.82)	<b>-0.19</b> (-16.47)
Mills Ratio	-	<b>0.09</b> (2.45)	0.01 (1.36)	0.001 (0.83)

Notes: The t-values of the parameter estimates are reported in parenthesis. Significance on the 5% level is indicated by bold numbers. Germany is taken as the base country so the respective dummy is omitted. The inverted Mills ratio that corrects for possible distortions stemming from the censored data problem was calculated from a corresponding probit model.

Table 14: Probit Model with Country Specific Coefficients

Coefficient		Coefficient		Coefficient	
Collateral		Volatility		Maturing Allotment	
AT	0.12 (0.28)	AT	<b>-0.498</b> (-2.10)		<b>0.07</b> (54.77)
BE	1.04 (1.50)	BE	<b>-1.04</b> (-2.95)	MRO Frequency	<b>2.36</b> (25.58)
GE	0.005 0.05	GE	<b>-1.10</b> <b>-1.10</b>	Auction Size	<b>0.77</b> (15.08)
ES	<b>1.73</b> (4.78)	ES	<b>-1.10</b> (-5.73)	Regular	<b>1.88</b> (16.11)
FI	1.42 (1.30)	FI	-0.94 (-1.90)	$\Delta CBR_{MRO}$	-0.26 (-6.63)
FR	<b>1.29</b> (3.19)	FR	<b>-0.90</b> (-4.17)	Size <sub>medium</sub>	<b>0.16</b> (2.84)
GR	4.72 (0.64)	GR	-1.78 (-1.06)	Size <sub>large</sub>	<b>0.30</b> (3.70)
IE	0.96 (1.24)	IE	-0.24 (-0.57)		
IT	<b>2.68</b> (8.07)	IT	<b>-1.22</b> (-6.85)		
LU	0.25 (0.64)	LU	<b>-1.07</b> (-5.31)		
NE	0.83 (1.55)	NE	-0.54 (-1.94)		
PT	0.14 (0.10)	PT	<b>-1.88</b> (-4.68)		
p-value	0.000	p-value	0.000		
Term Spread		Constant			
AT	<b>1.31</b> (6.92)	AT	<b>-8.32</b> (-16.64)		
BE	<b>1.05</b> (3.44)	BE	0.46 (0.48)		
GE	<b>0.49</b> (11.68)		1.67 (1.19)		
ES	<b>0.96</b> (5.83)	ES	<b>1.94</b> (2.47)		
FI	-0.72 (-1.62)	FI	1.71 (0.87)		
FR	<b>0.81</b> (4.57)	FR	1.27 (1.44)		
GR	-0.95 (-0.63)	GR	4.48 (0.67)		
IE	0.397 (1.20)	IE	-0.93 (-0.56)		
IT	<b>1.42</b> (9.35)	IT	<b>2.77</b> (3.80)		
LU	0.24 (1.51)	LU	<b>2.28</b> (2.77)		
NE	0.44 (1.86)	NE	0.07 (0.06)		
PT	<b>-2.19</b> (-4.00)	PT	<b>6.13</b> (3.85)		
p-value	0.000	p-value	0.000		

Notes: The t-values of the parameter estimates are reported in parenthesis. Significance on the 5% level is indicated by bold numbers. Germany is taken as the base country so the respective dummy is omitted. The reported p-value is computed from an F-test that tests whether the country-specific coefficients are equal, i.e. whether there are significant differences in the response to collateral costs, interest expectation and interest rate uncertainty depending on a bank's country of origin.

Table 15: Bid Volume Regression with Country Specific Coefficients

Coefficient		Coefficient		Coefficient	
Collateral		Volatility		Maturing Allotment	
AT	-0.40 (-1.54)	AT	-0.02 (-0.15)		<b>0.02</b> (7.94)
BE	<b>1.22</b> (1.98)	BE	<b>-1.15</b> (-3.58)	MRO Frequency	<b>1.26</b> (7.14)
GE	<b>-0.01</b> (-0.16)	GE	<b>-0.22</b> (-5.29)	Auction Size	<b>0.24</b> (5.26)
ES	0.21 (0.72)	ES	-0.31 (-1.91)	Regular	<b>0.595</b> (2.64)
FI	-1.55 (-1.53)	FI	0.49 (1.14)	$\Delta CBR_{MRO}$	<b>-0.15</b> (-5.81)
FR	<b>1.04</b> (3.35)	FR	<b>-0.71</b> (-4.13)	Size <sub>medium</sub>	<b>1.41</b> (16.08)
GR	7.74 (0.54))	GR	0.14 (0.04)	Size <sub>large</sub>	<b>2.91</b> (20.40)
IE	0.34 (0.71)	IE	-0.20 (-0.70)	Mills Ratio	<b>0.11</b> (2.95)
IT	<b>1.38</b> (5.31)	IT	<b>-0.57</b> (-3.89)		
LU	-0.26 (-0.87)	LU	-0.16 (-1.22)		
NE	0.63 (1.40)	NE	-0.29 (-0.98)		
PT	-3.71 (-0.99)	PT	0.63 (1.26)		
p-value	0.000	p-value	0.000		
Term Spread		Constant			
AT	<b>0.38</b> (3.13)	AT	-0.64 (-0.95)		
BE	<b>1.24</b> (4.47)	BE	<b>4.18</b> (3.23)		
GE	<b>0.26</b> (7.39)				
ES	0.25 (1.78)	ES	0.53 (0.80)		
FI	<b>-0.85</b> (-2.23)	FI	-1.77 (-1.03)		
FR	<b>0.42</b> (2.87)	FR	<b>2.49</b> (3.53)		
GR	0.029 (0.01)	GR	-2.02 (-0.15)		
IE	0.31 (1.40)	IE	0.85 (0.69)		
IT	0.26 (1.83)	IT	<b>1.54</b> (2.61)		
LU	-0.007 (-0.05)	LU	0.64 (1.13)		
NE	<b>0.48</b> (2.30)	NE	0.61 (0.51)		
PT	-1.04 (-1.68)	PT	-2.26 (-1.28)		
p-value	0.000	p-value	0.000		

Notes: The t-values of the parameter estimates are reported in parenthesis. Significance on the 5% level is indicated by bold numbers. Germany is taken as the base country so the respective dummy is omitted. The reported p-value is computed from an F-test that tests whether the country-specific coefficients are equal, i.e. whether there are significant differences in the response to collateral costs, interest expectation and interest rate uncertainty depending on a bank's country of origin.

Table 16: Bid Rate Regression with Country Specific Coefficients

Coefficient		Coefficient		Coefficient	
Collateral		Volatility	<b>-0.04</b> (-10.07)	Maturing Allotment	<b>0.001</b> (8.49)
AT	<b>0.78</b> (27.18)	AT	-	MRO Frequency	0.007 (0.71)
BE	<b>0.62</b> (9.91)	BE	-	Auction Size	<b>-0.07</b> (-14.55)
GE	<b>0.65</b> (71.45)	GE	-		
ES	<b>0.56</b> (18.93)	ES	-	Regular	0.01 (0.93)
FI	<b>0.58</b> (5.53)	FI	-	$\Delta CBR_{MRO}$	-0.006 (-1.88)
FR	<b>0.51</b> (15.52)	FR	-	Size <sub>medium</sub>	0.003 (0.64)
GR	0.23 (0.41)	GR	-	Size <sub>large</sub>	-0.01 (-1.40)
IE	<b>0.88</b> (17.06)	IE	-		
IT	<b>0.39</b> (15.26)	IT	-		
LU	<b>0.63</b> (19.24)	LU	-		
NE	<b>0.77</b> (16.16)	NE	-		
PT	<b>1.09</b> (4.84)	PT	-		
p-value	0.015	p-value	0.167		
Term Spread		Constant	<b>0.796</b> (17.43)		
AT	0.02 (1.17)	AT	-		
BE	-0.04 (-1.38)	BE	-		
GE	<b>-0.49</b> (-12.55)				
ES	<b>-0.05</b> (-3.28)	ES	-		
FI	0.08 (1.75)	FI	-		
FR	<b>-0.10</b> (-5.91)	FR	-		
GR	-0.30 (-0.70)	GR	-		
IE	0.01 (0.29)	IE	-		
IT	<b>-0.08</b> (-5.22)	IT	-		
LU	<b>-0.03</b> (-2.35)	LU	-		
NE	-0.01 (-0.50)	NE	-		
PT	0.04 (0.58)	PT	-		
p-value	0.000	p-value	0.299		

Notes: The t-values of the parameter estimates are reported in parenthesis. Significance on the 5% level is indicated by bold numbers. Germany is taken as the base country so the respective dummy is omitted. The reported p-value is computed from an F-test that tests whether the country-specific coefficients are equal, i.e. whether there are significant differences in the response to collateral costs, interest expectation and interest rate uncertainty depending on a bank's country of origin.

Table 17: Bid Rate Dispersion Regression with Country Specific Coefficients

Coefficient		Coefficient		Coefficient	
Collateral		Volatility	<b>-0.004</b> (-4.59)	Maturing Allotment	<b>0.00005</b> (2.39)
AT	<b>0.016</b> (2.68)	AT	-	MRO Frequency	0.0006 (0.44)
BE	-0.021 (-1.64)	BE	-	Auction Size	<b>0.022</b> (21.20)
GE	<b>0.02</b> (9.10)	GE	-	Regular	0.003 (1.92)
ES	0.009 (1.44)	ES	-	$\Delta CBR_{MRO}$	<b>-0.001</b> (-2.12)
FI	<b>0.061</b> (2.96)	FI	-	Size <sub>medium</sub>	-0.0008 (-1.13)
FR	<b>0.019</b> (2.83)	FR	-	Size <sub>large</sub>	-0.0016 (-1.51)
GR	0.023 (0.23)	GR	-		
IE	<b>0.027</b> (2.50)	IE	-		
IT	<b>0.029</b> (5.54)	IT	-		
LU	<b>0.018</b> (2.72)	LU	-		
NE	0.016 (1.63)	NE	-		
PT	0.002 (0.05)	PT	-		
p-value	0.000	p-value	0.682		
Term Spread		Constant	<b>-0.192</b> (-19.33)		
AT	0.003 (0.89)	AT	-		
BE	0.005 (0.72)	BE	-		
GE	<b>0.006</b> (7.06)				
ES	0.004 (1.18)	ES	-		
FI	-0.019 (-1.88)	FI	-		
FR	<b>0.014</b> (3.82)	FR	-		
GR	0.006 (0.08)	GR	-		
IE	-0.001 (-0.18)	IE	-		
IT	<b>0.019</b> (5.66)	IT	-		
LU	0.004 (1.26)	LU	-		
NE	-0.003 (-0.62)	NE	-		
PT	-0.019 (-1.14)	PT	-		
p-value	0.000	p-value	0.569		

Notes: The t-values of the parameter estimates are reported in parenthesis. Significance on the 5% level is indicated by bold numbers. Germany is taken as the base country so the respective dummy is omitted. The reported p-value is computed from an F-test that tests whether the country-specific coefficients are equal, i.e. whether there are significant differences in the response to collateral costs, interest expectation and interest rate uncertainty depending on a bank's country of origin.

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