BANKS' PARTICIPATION IN THE EUROSYSTEM AUCTIONS AND MONEY MARKET INTEGRATION

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Abstract

We perform a panel study of banks' participation and bidding in the Eurosystem weekly repo auctions during June 2000-August 2001, employing a data set of individual bids that includes the bidder code, size, nationality and participation in a banking group. We find that short rate volatility has a direct impact on the probability of bidding, average rate and dispersion. The bidder size plays an important role on auction participation and bid amount. Large bidders disperse rates more in response to an increase in the expected allotment amount, consistently with superior collateral management and better use of the bidding schedule. Bidders that participate in a banking group do not react to the liquidity conditions of their country and are more likely to enter the auction when volatility is high. We also document several country effects.

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1. Introduction

The structure and performance of the money market are key elements for the effectiveness of the transmission mechanism of monetary policy, in consideration of the pivotal role played by short term rates for the whole yield curve. Achieving a high level of integration and efficiency of the money market in the euro area has been among the priorities of the Eurosystem (see e.g. ECB, 2001b). This is reflected in particular in the set up of the Target system, which allows for fast and secure settlement of cross-border interbank transactions, and in the choice of an operational framework that supplies central bank refinancing to all banks in the area fulfilling minimum financial and operational standards, against a very wide pool of collateral (ECB, 2002b). Once a week several hundreds of banks in the euro area participate in the Eurosystem repo auctions, the so-called main refinancing operations (MROs), which inject reserve money with a maturity of two weeks in the banking system. The auctions take place in a decentralised fashion, whereby the collection of bids and the provision of funds are carried out at local level by the National Central Banks (NCBs). Through the interbank market the successful bidders channel the allotted funds to over 7,000 credit institutions in the area, for their day-to-day liquidity management and the fulfilment of the reserve requirement. Although not the unique vehicle of refinancing for the Eurosystem[1], the MROs are the primary instrument for the implementation of the single monetary policy. After an initial period in which the MROs were conducted through fixed rate tenders, in June 2000 the Eurosystem switched to a variable rate, discriminatory (pay what you bid) auction where each bidder can submit up to 10 rate-quantity bids. The present auction format retains some flavour of the old format because, in order to preserve the announcement effect, the ECB Governing Council sets the minimum bid rate which acts as the indicator of the monetary policy stance, a role played in the US by the Federal funds target rate.

Yet, in spite of the dimension of the euro interbank market and the wide participation to the Eurosystem auctions, banks' activity in the money market may in principle be diversified in a number of ways. The detection of frictions in the money market, and thus in the banks' access to liquidity, might have far reaching consequences. As recently argued by Bean, Larsen and Nikolov (2002), financial frictions in the banking system play an important role in the transmission mechanism. In particular, the liquidity position of banks may affect their response to a monetary policy tightening. Recent empirical studies shed light on the monetary transmission

[1] The so-called longer term refinancing operations (LTROs) are held by the Eurosystem once a month with a maturity of three months, through a variable-rate, discriminatory auction. LTROs, accounting on average for one quarter of the aggregate stock of refinancing, are not used for short term rate management.

mechanism in the euro area countries (see e.g. Angeloni, Kashyap, Mojon and Terlizzese, 2002). A remarkable feature of the European banking structure (see Ehrmann et al., 2001) is the atomistic configuration of banks in some nations, notably Germany, Austria and Finland, characterised by a large number of credit cooperatives and savings banks in comparison to the other member countries. This in turn generates a network, or two-tier, banking structure, where large banks in the upper tier serve as head institutions for small, lower-tier banks[2]. The distinguishing feature of banks in other EMU countries, like France, Italy and Spain, is a larger availability of capital and liquid assets[3].

The existence of a two-tier structure of the money market is explicitly modelled by Freixas and Holthausen (2001), who show that if banks have asymmetric information on the credit standing of counterparties in the area, the single currency does not warrant the integration of money markets. However, it is also shown that big banks having access to information in several countries may achieve cross-border liquidity smoothing, thus overcoming the welfare-reducing effects of information asymmetries. The authors argue that a high level of cross-border information is essential for an integrated interbank market to exist, and advance the hypothesis that over time information should become more evenly spread across the euro area, thus fostering an integrated equilibrium in which also small banks participate actively in cross-border transactions.

In the fourth year since the inception of the single monetary policy, the quest of public authorities and market players for the integration of the euro-area money market seems on the whole rewarded. The recent empirical studies reach three broad conclusions. First, each of the unsecured and overnight swap segment have quickly merged into an area-wide market (ECB, 2001a; Galati and Tsatsaronis, 2001; Gaspar, Pérez Quirós and Sicilia, 2001; Hartmann, Manna and Manzanares, 2001; Santillan, Bayle and Thygesen, 2000). This ensures a smooth time-series path for the reference overnight rate, the EONIA[4] (Pérez Quirós and Rodriguez Mendizábal, 2001), as well as negligible interest rate differentials among different countries Second, the development of the market for short term securities and repo contracts lags behind, owing mainly to legal and administrative segmentation, although cross-border repo trading shows an increasing trend as traders make a growing use of links among Central Securities Depositories (ECB, 2001a; Galati and Tsatsaronis, 2001; Giovannini Group, 2002). Third, larger banks with a mul-

[2] The role of bank size in the money market has been documented also in non-European countries. For the US see e.g. Allen, Peristiani and Saunders, 1989.
[3] The above cited study and others (for example De Bandt and Davis, 1999) formulate the hypothesis that the monetary union will bring about a structural adjustment in the banking sector with a considerable increase in competition.

tinational dimension tend to centralise their liquidity management activities; however, they weigh the benefit of centralisation against the advantage of accessing collateral on a local basis, since the cross-border transfer of assets still comes at a cost (ECB, 2001a).

What do we know about the primary market for liquidity, that is the Eurosystem repo auctions? The initial choice of the fixed-rate tender, successfully aimed at conveying a strong signal on the stance of monetary policy, involved some distortions in bidding behaviour at times of strong interest rate change expectations (Ayuso and Repullo, 2001 and 2002; Catalao, 2001; Nautz and Oechssler, 1999). Under the current auction format, the evidence on aggregate bidding behaviour is reassuring (ECB, 2001c), showing in particular that bidding is highly competitive and most of the early problems have been overcome. These findings, coupled with the fact that money market rates trade in normal circumstances at a small spread above the ECB reference rate, speak in favour of the appropriateness of design and overall performance of the current Eurosystem repo auctions.

Still the question remains: what is the degree of efficiency and integration in the primary market for euro area liquidity at the microeconomic level? Or, put differently, who bids and why in the Eurosystem auctions? This market is by construction standardised and very open, yet participation may reflect various types of segmentation, related in particular to country effects, size effects and bank group effects. The conjecture that country may matter is based on the available evidence, showing that the daily demand for reserves in member countries displays different degrees of interest–rate elasticity (Angelini, 2001) and that some regional effects are present in the interbank market's response to liquidity shocks (Angeloni and Bisagni, 2002). It may further be hypothesised that size and participation in a bank group matter, on the basis of the recent theoretical models on the euro-area money market and the evidence on the two-tier structure, at least in some countries. We believe that an analysis of the microeconomic behaviour in the MROs is important not only *per se* or on operational grounds, but also on account of the link with the studies on the integration of the euro-area money market and the transmission channels of the single monetary policy.

A microeconomic investigation of the Eurosystem repo auctions is undertaken by Nyborg, Bindseil and Strebulaev (2002) in the light of auction theory. They measure the extent of underpricing, i.e. the possibility that bidders place their bids below market prices (rates) to adjust for the winner's curse (Milgrom and Weber, 1982). Their finding that the (modest) underpricing

[4] EONIA is the acronym of Euro Over-Night Index Average.

varies inversely with market rate volatility would seem at odds with the winner's curse hypothesis and some of the evidence on treasury auctions (e.g. Nyborg, Rydqvist and Sundaresan, 2002; however Scalia, 1998 finds the opposite).

In the present paper we take a different perspective. We develop an analytical framework, drawing mainly on the hypotheses of the models of banks' reserve management and auction theory, that enables us to perform a full-blown panel study of participation and bidding in the Eurosystem repo auctions[5]. Our first objective is thus to test whether a rich set of theoretical predictions is supported by high-quality individual data. To this extent we examine the period June 2000-August 2001 employing a data set that tracks the complete individual bids throughout the euro area, and carry out regressions of (i) the probability of bidding, (ii) the individual bid amount, (iii) average bid rate and (iv) bid rate dispersion. Our second objective is to specialise our investigation along three directions. Using the information on the bidders' nationality, size and possible membership in a multi-country banking group, we examine whether and how the behaviour of bidders is affected by each of these three variables in turn. The first part of our analysis has implications for the issue of efficiency of bidders' behaviour, whereas the second part may shed some light on the degree of market integration.

The remainder of the paper is organised as follows. Section 2 derives the testable predictions for bidding behaviour in the Eurosystem auctions. Section 3 describes the data and provides summary statistics. Section 4 shows the empirical results from the general panel regression model of participation and bidding. Section 5 presents the estimates on country effects. The evidence on size effects is given in Section 6. Section 7 contains the estimates on the effect of participation in a banking group. Section 8 summarises our findings and discusses their implications for the efficiency and integration of the euro-area money market. The Appendix shows the details of the EGARCH estimates of money market rate volatility, employed as explanatory variable in the regressions.

2. Theoretical predictions

[5] To our knowledge, among past studies the one closest to ours is by Breitung and Nautz (2000), who perform a panel study on individual bidding by German banks under the Eurosystem fixed rate tenders.

Before reviewing the theoretical considerations (par. 2.2) that lie behind the choice of the empirical regression model of sections 4-7, in the following subsection we briefly describe the operational framework of the Eurosystem auctions.

2.1 The auction environment

The MROs are regular liquidity-providing operations that allow the Eurosystem to resettle the desired amount of bank reserves once a week. The low frequency of central bank interventions compared to other countries is made possible by the large amount of the reserve requirement compared to settlement balances. The minimum bid rate is established by the ECB Governing Council in its monetary policy meetings. The Council also sets the rates on the two end-of-day standing facilities, marginal lending and deposit, which delimit the "corridor" of short term interbank rates. In the sample period the minimum MRO rate was raised from 4.25 percent to 4.50 on 31 August 2000 and up again to 4.75 on 5 October; it was then cut back to 4.50 on 10 May 2001 (see Figure 1). The reserve maintenance period starts on the 24th of each month and ends on the 23rd of the following month. The requirement must be fulfilled on the average of the end-of-day reserve account balances of each bank and no carry-over is allowed from one period to the next. With a view to making the requirement as neutral as possible to banks, minimum reserves are remunerated by the Eurosystem at the average marginal rate of the MROs conducted in the maintenance period. Excess reserves are not remunerated, whereas deficiencies incur a financial penalty.

The announcement of the auction takes place as a rule on Monday at 15:00, together with the publication of the autonomous liquidity factors of the euro area, i.e. the forecast stock of items in the Eurosystem's balance sheet that cause a net absorption of bank reserves, e.g. banknotes and government deposits. The published figure, covering a weekly horizon, enables the market to compute the "neutral" amount of the auction and thus formulate a forecast on the allotment, which is decided and announced by the ECB only ex post. The neutral amount is defined as the amount of reserves that, based on past fulfilment and on the projected autonomous factors, would bring the average reserve holdings one week ahead in line with the reserve requirement.

Bids may be submitted until 9:30 on Tuesday by all euro-area banks presenting adequate operational and financial standards. Out of the 7,000 credit institutions operating in the area, around 2,400 are eligible counterparties. In practice, in the 61 auctions covered by our data set the actual number of bidders was way below the potential and showed a diminishing trend, ranging

between 798 and 240, as shown in Figure 2. In the sample period the total bid amount ranged between 25 and 258 billion euro, with an average of 145.billion euro (Figure 3). The allotment varied between 5 and 172 billion euro, with an average of 88 billion euro. The average bid-to-cover ratio is equal to 1.65.

After the collection of bids by the NCBs, the ECB ranks all bids in descending rate order and decides on the allotment. Bids below the marginal, or stop-out, rate are dropped; bids above the marginal rate win the auction, whereas bids at the stop-out rate are allotted pro-rata. The result of the auction is published by the ECB on wire services at 11:20 on the auction day. The announcement gives the total allotment, total bid amount, number of bidders, minimum and maximum bid rates, weighted average allotment rate, marginal rate and percentage of allotment at the margin. Settlement of the auction is on the day following the auction, i.e. normally on Wednesday.

The actual allotment tends to lie close to the neutral amount (ECB, 2002a). The spread between the marginal rate and the minimum rate was between 0 and 43 basis points, the differential between the average allotment rate and the marginal rate was between 0 and 6 basis points (Figure 4). The standard deviation ranged between 4 and 19 basis points for the bid rates, and between 4 and 18 basis points for the allotment rates (Figure 5).

2.2 Testable hypotheses

The first and obvious guide for the behaviour of bidders in the Eurosystem auctions should be sought in the models of banks' reserve management (see among others Campbell, 1987; Hamilton, 1996; Furfine, 2000; Bartolini, Bertola and Prati, 2001; Taylor, 2001; Angelini, 2001). In a simple two-period setting characterised by a minimum reserve requirement with averaging, exogenous liquidity shocks and stochastic interbank interest rates, the bank's optimum demand for reserves in the first period is directly related to the forecast liquidity need and to the difference between the expected interest rate in the next period and the current interest rate, i.e. to the forward rate spread (Taylor, 2001). Under the hypothesis that banks are risk averse, it may further be shown (Angelini, 2001) that an increase in short term rate volatility will induce the representative bank to demand a larger amount of reserves in the first period. We note that bidding in the Eurosystem auctions is a key part of the bank's overall demand for reserves, the remainder being given by trading in the interbank market, and we expect the former to be driven in the first place by the economic forces described by the theory. When we translate the theoretical

hypotheses into our bidding environment, we note that each bank is no longer a rate-taker as in the stylised models, because it may bid a rate as well as a quantity of reserves. Hence, we conclude that the three explanatory variables, namely liquidity need, forward rate spread and interest rate volatility, should all have a positive effect on the decision to participate in the auction, on the total bid amount and on the average bid rate of each bank.

We list these testable hypotheses in Table 1, where the first column gives the candidate explanatory variables for each of our dependent variables, namely participation (column P), bid amount (column B), average interest rate (column R) and bid rate dispersion (column D). Each cell reports a +/- sign showing the effect of the explanatory variables onto each dependent variable and a symbol indicating the relevant theory.

In a multi-period world with reserve averaging it can be argued (e.g. Furfine, 2000) that the endowment of reserves inherited from the past enters into play, affecting inversely today's demand for balances. In our empirical framework, this hypothesis is captured by the reserve fulfilment ratio of a bank, given by the average reserve holdings (until the day before the auction) divided by the bank's reserve requirement. The reserve fulfilment should arguably have the opposite effect of liquidity needs on the dependent variables P, B and R.

An additional feature of the reserve management model as it becomes increasingly realistic is that banks may have a target level of end-of-day reserves, related to the need for working balances and the desire to fulfil the requirement smoothly (Canpbell, 1987; Hamilton, 1996; Bartolini. Bertola and Prati, 2001). We cast the last hypothesis in our setting by postulating that the bidder seeks to some extent to roll over the amount of the MRO that expires on the settlement day of the auction. Hence his decision to participate in the auction, bid amount and average bid rate should be directly related to the explanatory variable Maturing MRO amount. The above hypotheses are summarised in Table 1.

The second yardstick for participation and bidding in the MROs derives from the auction literature. A classical argument is that in a discriminatory auction with private information on the resale value of the good, bidders adjust their bids for the winner's curse. As noted by Nyborg et al. (2002), in our setting that would imply that bidders respond to an increase in interest rate volatility by reducing quantity demanded, reducing the average bid rate and increasing rate dispersion. It may also be argued that small, marginal bidders facing increased volatility could even decide to stay away from the auction, and make recourse instead to the interbank market.

We note however that the "loser's nightmare" argument may be invoked against the prediction of the winner's curse on bid amount and rate. Namely, if the risk of losing, *not* winning, the auction is a concern for the participants, then it is possible that interest rate volatility may induce them to submit larger bids at higher rates (Scalia, 1998). That the loser's nightmare may prevail over the winner's curse is suggested by the peculiar nature of the MRO auction, where the auctioneer is also able to impose an intertemporal budget constraint on the minimum amount of the good (i.e. reserves) that bidders have to hold. Interestingly, the predictions of the loser's nightmare would be consistent with those of the reserve management models under risk aversion. Summing up, auction theory does not offer unambiguous hypotheses on the effect of volatility, and that is reflected in Table 1.

An important feature of our bidding environment is the possibility that after the auction some bidders are "squeezed", thus being forced to borrow in the interbank market at very high interest rates to fulfil the reserve requirement. The squeeze may result from lower than expected supply in the auction, such as to make liquidity tight at the aggregate level. A model in which bidders face the risk of a squeeze subsequent to the auction is developed by Nyborg and Strebulaev (2001), who formulate in particular the hypothesis that a bidder entering the auction with a short liquidity position will increase the variance of bids. In the absence of data on the relative liquidity positions of bidders in our sample, there is no straightforward translation of the above proposition in our setting. However, based on an extensive consideration of the above hypothesis across different auctions, it may be argued that an increase in the probability of a short squeeze is likely to make the short position of bidders even worse. Thus we hypothesise that the likelihood of a short squeeze would increase the variance of bid rates, together with participation and bid amount. There predictions are reflected in Table 1, along the row for the explanatory variable Short squeeze likelihood.

Together with reserve management theory and auction theory, other strands of research and empirical considerations may be brought to bear on the construction of our regression model. In particular, we believe that the Freixas-Holthausen hypothesis, namely that larger banks with a multinational role will use their informational advantage to arbitrage out the differences in interest rates across countries, has an important implication for bidding in the Eurosystem auctions. Ceteris paribus, we would expect larger banks to participate more actively in the auctions and submit larger bids compared to smaller banks with a local profile and limited information. This suggests that the bidder's size and participation in a multi-country banking group may be

included among the set of explanatory variables. Accordingly, we plug the relevant predictions in Table 1.

Finally, we move into the territory of empirical considerations. The use of collateral to be pledged against the Eurosystem's refinancing obviously involves an opportunity cost for banks, related to the liquidity of the assets. As we have noted, there is a great variety in the list of eligible collateral. However it may be argued that, as the auction size increases, corresponding to an increase in the aggregate liquidity need, the use of "dear" collateral is likely to increase as well. Other things being equal, the increase in the marginal cost of collateral would in turn cause a downward pressure on the individual bid amount and rates, along with a tendency to disperse more (Nyborg et al., 2002). On the other hand, using a standard cost-of-carry argument, it may be argued that the cost of marketable collateral is inversely related to the spread between long term yields and the minimum rate set by the Eurosystem. An increase in the long term spread would indeed make it more profitable for banks to buy or repo-in collateral and fund it with short term money from the Eurosystem. This is particularly true of assets with an active interbank repo market, like treasuries and asset-backed securities, which represent the bulk of eligible collateral in the euro area. Hence, we would expect the long term spread to have a positive impact on banks' participation and bid amount.

Lastly, we note that participation and bidding should also be affected by the spread between the short term money market rate, represented by the 2-week EONIA swap rate, and the Eurosystem's minimum bid rate, which incorporates the expectations on the stance of monetary policy. For instance, the expectation of an imminent rate cut by the ECB, bringing the value of the short term spread close to or below zero, would involve a reduction in the number of bidders, bid amount, rates and dispersion. The opposite would hold under expectations of monetary policy tightening and a large value of the short rate spread.

3. Market and data

In the empirical analysis we will consider the bidding behaviour of each bank, ignoring the amounts allotted ex post by the ECB and the resulting rates. We do that because, as we pointed out earlier, we are interested in the determinants of the demand for liquidity in the auctions, whereas the allotments would reflect the preferences of the Eurosystem as well as those of the bidders.

Figures 6a-c give the breakdown of the number of bidders by country. All countries show a decreasing trend in the number of participants, although this phenomenon is more pronounced in Germany, France, Italy and Austria. The country with the largest number of participants is by far Germany, with 381 bidders per auction on average, followed by Italy (31), France (30), Luxembourg (26), Spain (21), Austria (16), Ireland (9), the Netherlands (9), Belgium (8), Greece (5)[6], Portugal (4) and Finland (2). The country shares of bidding are shown in Figures 7a-c.

We made some rearrangements on the raw data set of the individual bid schedules. First, we omitted the bidders from Greece, which took part in the auctions only from January 2001 onwards. Second, to avoid breaks in the time series of bid schedules, we aggregated the bid arrays of a small number of bidders which merged at some stage in the sample period, thus treating them as if they had been a single bidder from the start of the period. We thus ended up with 1033 bidders which took part in at least one auction in the sample period. The frequency of bidding is given in Table 2, which shows that 214 bidders placed bids in 10 auctions or less, 168 placed bids between 11 and 20 times, and so forth. The number of bidders which were present throughout the 61 auctions in the sample is 25. Table 3 gives the distribution of the average bid size across auctions by (active) bidder. Bid size is expressed as a percentage of our scale variable, namely the area reserve requirement. In the sample period this variable, which represents a relatively stable component of the system's liquidity need, was equal on average to 118.6 billion euro, with a minimum of 111.8 billion euro and a maximum of 127.2 billion euro. 469 bidders, i.e. the largest fraction, place bids which represent only one hundredth of a percentage point or less of the area reserve requirement. Bidders with average bids above 2 percent of the area requirement are 12.

Table 4 provides summary statistics on the variables that will be employed in the panel regressions. For simplicity, in Table 4 we take summary statistics across bidders and auctions. After participation in the auctions (see Table 2), the second dependent variable is the individual bid amount, as a percentage of the area requirement, with a mean value of 0.2245. The third dependent variable is the average bid rate, taken as a spread over the minimum bid rate set by the ECB. Its mean value is 0.0542, i.e. over 5 basis points above the floor rate. The last dependent variable is the dispersion of bid rates, given by their standard deviation weighted by the corresponding amounts; this is equal on average to 0.0066, i.e. to below 1 basis point, reflecting the

[6] The figure for Greece refers to January-.August 2001.

fact that the majority of bidders does not avail itself of the possibility to submit up to 10 rate-quantity pairs in the auction, and uses just one or very few bids.

Next we turn to the candidate explanatory variables. The first such variable is the expected amount of the MRO. This is meant to proxy for the aggregate liquidity need, and is given by the neutral MRO amount as defined in the previous section. Its mean value corresponds to 75.7 percent of the total reserve requirement We do not have data on the individual reserve fulfilment of each bidder at the time of the auction, and our best proxy is the reserve fulfilment ratio of the bidder's country as of the day before the auction The simple average of the national fulfilment ratio is equal to 98.95 percent. As concerns the bidder's size, we have accurate data on each bidder's reserve requirement during the fourteen monthly maintenance periods, which we use as the measure of size (independently of the bank's bid amount). Again, we express this variable as a percentage of the area reserve requirement. The variable's mean across bidders and over time is equal to 0.0623 percent of the aggregate requirement. The maturing MRO amount of a bidder is equal on average to 0.0671 of the area requirement.

The interest rate variables are all bidder-invariant, and we thus have just 61 observations. The average short rate spread which enters our regressions is defined as the difference between the 2-week EONIA (overnight) swap rate and the minimum auction rate on the day before the auction. Its mean value is equal to 7.34 basis points, and it ranges between –6 and +45 basis points. The mean of the long rate spread, defined as the difference between the 10-year Bund yield and the minimum bid rate on the day before the auction, is equal to 42.97 basis points, and it ranges between –10 and +107 basis points. The forward rate spread is given by the difference between the 2-week forward swap rate one week ahead and the current 2-week rate. This spread captures the difference between the expectation of the interest rate of the next MRO and that on the current MRO, and it gives the intertemporal trade-off between consecutive auctions. Its mean value is –2.36 basis points, with a range between –30 and +9 basis points. It might be argued that the three interest rate explanatory variables could show some degree of correlation, with adverse consequences for the precision of estimates. It turns out that the correlation between the short spread and the forward spread is equal to 0.13; the correlation between the short spread and the long spread, although significant, is modest and equal to 0.51; the correlation between the forward spread and the long spread is only 0.37. In the presence of such a low degree of correlation among the three market rate variables, we feel authorised to keep all of them in the regressions.

Following Bartolini, Bertola and Prati (2000), we estimate short rate volatility using an EGARCH(1,1) model on the 2-week swap rate (see the Appendix for details). The resulting conditional variance on the day before the auction is equal on average to 0.0031 percent, and to 5.6 basis points if we take the square root. The variance ranges between 0.0019 and 0.0111 percent.

We construct an explanatory variable taking the value 1 if the bank belongs to a bank group. Among our bidders, based on Gouteron (2001) we record 31 multinational banking groups with a minimum of 2 bidders and a maximum of 6 bidders each. Finally, we include in the list of explanatory variables two other dummies. The first one, called "Post underbidding", is equal to 1 in the MRO that followed the underbidding episodes of 13 February and, respectively, 10 April 2001 (see ECB, 2001c). This dummy captures the fact that, after those underbid auctions, bidders feared that the ECB might have squeezed liquidity by providing an amount of refinancing below the neutral value, as it indeed happened. The second dummy is a period-end dummy variable taking the value 1 if the MRO is the last-to-be-settled in the maintenance period. In light of the discussion in the previous section, both dummies capture the increased likelihood that some bidders may end up squeezed after the auction.

4. The general model

4.1 Participation

We estimate the probability of bidding with a panel probit regression of the type:

$$\Pr\left(y_{i,t} > 0 \mid \mathrm{x}_{i,t}\right) = \Phi\left(\mathrm{x}'_{i,t}\ \mathrm{b}\right) \qquad (1)$$

where $y_{i,t}$ is the aggregate bid amount of bidder *i* in auction *t*, as a percentage of the scale variable given by the area requirement. We recall that we have 1,033 bidders in the data set and 59 auctions; compared to the original data set, we give up 2 auctions at the beginning of the sample for the computation of the maturing MRO amount of each bidder. Φ is the standard normal distribution function; $\mathrm{x}_{i,t}$ denotes the vector of explanatory variables for bidder *i* at time *t*, including also the time series variables that do not change across bidders and the dummy variables, and b is the coefficients vector. Equation (1) says that the probability that a bidder par-

ticipates in the auction is distributed as a standard normal and its argument is a linear function of our explanatory variables.

We regress equation (1) with a population-averaged model, because we found evidence of second-order serial correlation in the errors. We thus account for an AR(2) disturbance process and employ robust standard errors for the coefficients estimates. The regression results are given in Table 5, panel P. For simplicity, we omit the standard errors and report only the significance levels aside each estimate. All but one of the explanatory variables are statistically significant at the 1 percent level. The expected MRO amount has a positive effect (0.0014) on the probability of bidding, consistent with the hypothesis of the reserve management theory that the larger the liquidity need, the larger the likelihood that bidders will enter the auction (see Table 1). The country fulfilment ratio, although not statistically significant, has the predicted sign (-0.001). In words, the larger the past fulfilment of the reserve requirement, the lower the probability that bidders will participate in the auction. The bidder size has a positive effect on the likelihood of bidding (0.8038). This is consistent with the two-tier or transnational market hypothesis: other things equal, larger banks are more likely to participate in the auction owing to their role as liquidity dealers in the domestic and cross-border market. The coefficient estimate for the maturing MRO amount, equal to 0.1221, shows a direct effect on participation. This is consistent with the hypothesis that bidders have a target for the level of reserves, related to the demand for settlement balances and the pursuit of a smooth fulfilment pattern.

Both the short and long rate spreads have a direct effect on the probability of participating in the auction, with coefficient estimates equal to 0.822 and, respectively, 0.384. As predicted by the theory, the forward rate spread has a positive effect on the likelihood of bidding, with a coefficient of 0.4706. This means that when the forward short rate is larger than its spot value, reflecting for instance a slack in liquidity today or the expectation of a monetary policy hike, then more bidders enter into play in the current auction, and vice versa. Short rate volatility or, to be precise, the conditional variance, has a positive and highly significant effect on the probability of bidding. This finding is consistent with the hypothesis that banks are risk averse and, facing an intertemporal constraint on the minimum amount of reserves that they have to hold, they react to increased volatility on the cost of their funding by bidding more actively. As we will see later on, this behaviour goes together with a precise strategy on the bid amount and rates. The opposite hypothesis based on the winner's curse, namely that volatility should cause a decrease in participation, is rejected by the data.

Lastly, the coefficients for the post underbidding and period end dummies are both positive, and equal to 0.133 and respectively 0.0946. The sign of the coefficients is as expected, based on the hypothesis that an increase in the likelihood of a short squeeze causes more bidders with a short position to bid in the auction.

4.2 Bid amount

The regression equation for the (scaled) individual bid amount is as follows:

$$y_{i,t} = \mathrm{x}'_{i,t}\,ß + u_i + e_{i,t} \qquad (2)$$

where $\mathrm{x}_{i,t}$ is again the vector of explanatory variables for the scaled bid amount $y_{i,t}$ of bidder i in auction t and ß is the coefficients vector. u_i denotes the individual-specific errors, while $e_{i,t}$ is the time-varying error. We adopt a fixed-effects model to account for the correlation between the regressors and the unobservable variables. We made this choice compared to the alternative of the random-effects model because the Hausman test showed that the hypothesis on the absence of correlation between the regressors and the unobservable component is rejected, and hence the random-effects estimation would yield inconsistent estimates (see for example Wooldridge, 2002).

The regression results are given in Table 5, Panel B. The constant term is equal to 0.0757 per cent of the area reserve requirement. The effects of the expected amount of the MRO and the country fulfilment are not significantly different from 0. The bidder size, with a coefficient estimate of 0.8476, is highly significant and consistent with the prediction. We recall that this variable corresponds to the percentage of the area requirement that is accounted for by the individual bidder. This means that on average each bidder demands in the auction an amount corresponding to 85 per cent of his requirement. The coefficient of the maturing MRO amount, equal to 0.5322, is also highly significant and consistent with the hypothesis that bidders have a target level of reserves. The effects of the short and long rate spreads are both highly significant. The coefficient of the former, equal to 0.1247, lends support to the prediction that bidders´ demand is elastic to short term rate expectations. The coefficient estimate of the long rate spread, at 0.0677, is consistent with the "cost of carry" hypothesis, namely that when the long rate increases relative to the monetary policy rate it becomes more convenient to acquire collateral and

thus participate in the auction, compared to the alternative of e.g. borrowing in the unsecured market.

The effect of the forward rate spread on bid amount, estimated at –0.0876, is the opposite of what we expected on the basis of the reserve management model. In other words, when the forward 2-week rate is larger than the spot rate, demand decreases. We took the forward rate one-week ahead because we wanted to capture the trade-off between bidding today and bidding in the following auction. Keeping in mind that we introduced already a variable that embeds the effect of policy rate change expectations, that is the short rate spread, we believe that the interpretation of the forward spread should be of a technical nature, and related to the liquidity situation at the time of the auction, rather than to more fundamental rate change expectations. To illustrate this point, let's take the example of a negative forward spread, which is true on average and by a small amount (see Table 4). This might be viewed as deriving from a slightly tighter liquidity situation today compared to what the market expects it to be in a week's time, which causes the forward rate to quote marginally below the spot rate. If that is the case, then the coefficient estimate says that bidders demand more in the current auction, giving up the possible rate reduction that is priced in the forward rate. This effect, which is relatively small, would be consistent with risk aversion on the part of bidders.

Short rate volatility displays a negative effect on individual bid amount, with a coefficient of –0.8885. This looks at first sight consistent with the winner's curse. However, bearing in mind the earlier result, that volatility has a positive effect on participation, and the lack of significance of the coefficient, the prevalence of the winner's curse over the alternative hypothesis of the "loser's nightmare" is not obvious. Lastly, the two dummies show the predicted sign, indicating that the bid amount increases when the likelihood of a short squeeze increases, namely after an underbidding episode and in the last auction of each maintenance period. However the latter effect is not statistically significant.

4.3 Average bid rate

The regression equation for the average individual bid rate is the same as equation (2), where we replace the dependent variable with $r_{i,t}$, i.e. the mean bid rate of bidder *i* in auction *t*. We adopt a fixed-effects model as with the bid amount. This choice follows again from the detection of correlation between the regressors and the unobservable component, based on the Hausman test.

The results are given in Table 5, Panel R. The expected amount of the MRO exerts a negative effect on the bid rate, with a coefficient of –0.0003. To obtain a full basis point move in the individual bid rate the neutral MRO amount would have to shift by 33 percent of the area requirement, corresponding to 39 billion euro. This effect is clearly consistent with the cost of collateral hypothesis. The country fulfilment ratio has a coefficient estimate of –0.0002. The negative effect lends support to the hypothesis advanced on the basis of the reserve management moodel. The effect of bidder size, with a coefficient of –0.0056, is not statistically significant. This suggests however that large banks tend to shade their bids compared to the bids of smaller participants, by half of a basis point for a percentage point of increase in the relative size of their requirement. The maturing MRO amount has a positive and significant effect of the bid rate, with a coefficient of 0.0025. This is consistent with the hypothesis that bidders have a target level of reserves in mind, and they are prepared to pay a price for it.

The short rate spread has a strong and significant effect, estimated at 0.7478 and consistent with the prediction of Table 1. The size of the coefficient implies that, controlling for the other decision variables, bidders are prepared to shade their bids below market rates, and translate on the bid rate only three quarters of the 2-week money market rate spread over the minimum auction rate. The effect of the long rate spread on bid rates is negative and small. This finding has no theoretical backing, although it would seem consistent with the idea that, as collateral becomes cheaper and more bidders enter into play (see section 4.1), the marginal bidders are less liquidity constrained than the "core" bidders, thus pushing bid rates down. The effect of the forward rate spread on bid rates is not statistically different from 0.

Short rate volatility displays a positive and significant effect on bid rates, with a coefficient of 2.9645. This finding is analogous to the evidence of Nyborg et al. (2002), obtained from average auction data. In our case, bearing in mind that the conditional variance of the short rate ranges between 2 and 11 tenths of a basis points (Table 4), a jump in volatility by one half of a basis point would cause an increase in individual bid rates by 1.5 basis points. As we argued in section 2, such a finding may be explained on the basis of the loser's nightmare hypothesis, as opposed to the winner's curse, and of bidders' risk aversion.

The effect of the post underbidding dummy on bid rates is negative and significant, at -0.0089, whereas the period end dummy has a positive effect. Thus in the auctions after an un-

derbidding episode bid rates tend to be lower by almost one basis point, whereas in the last auction of each maintenance period they increase by almost one half of a basis point.

4.4 Bid rate dispersion

The regression equation for bid rate dispersion is the same as equation (2), in which we replace the dependent variable with $d_{i,t}$, the bid rate dispersion of bidder *i* in auction *t*. Again, we adopt a fixed-effects model, because we detected correlation between the regressors and the unobservable variables, based on the Hausman test. The results are shown in table 5, panel D. The first prediction that we made (see Table 1), based on auction theory, is that short rate volatility will induce bidders to disperse more. This hypothesis is confirmed by the sign and significance of the coefficient for market rate volatility, equal to 0.2687. The prediction that the likelihood of a short squeeze has a direct effect on bid rate dispersion is also confirmed by the sign and significance of the two liquidity squeeze dummies. The effect of the post underbidding dummy, equal to 0.0051, is much larger than that of the period end dummy, at 0.0006.

The cost of collateral hypothesis implied a positive effect of the expected MRO amount on rate dispersion. This is not confirmed by the regression results, showing that the relevant coefficient is not statistically different from 0. The last hypothesis that we made is that an increase in the short rate spread should induce bidders to disperse more. This is confirmed by the sign and significance of the coefficient estimate, equal to 0.0295. We also note that the country fulfilment ratio, the maturing MRO amount and the long rate spread all display a positive and significant effect on bid rate dispersion. Finally we observe that the bidder size effect is not statistically significant, although its positive sign suggests that large bidders tend to disperse more.

5. Country effects

In order to shed light on the degree of integration of auction participants across the euro area, in this section we illustrate the results of panel regressions aimed at detecting possible differences in bidders' behaviour related to their country of establishment. We extend the basic model presented in the previous section by introducing the interaction of country dummies with each explanatory variable.

5.1 Participation

We estimate the following equation using the population-averaged probit model, with AR(2) disturbances and semi-robust standard errors:

$$\Pr\left(y_{i,t} > 0 \mid \mathrm{x}_{i,t}\right) = \Phi\left(\mathrm{x}'_{i,t}\,\mathrm{b} + \sum_{j}\sum_{c} d_c^{\,j} \cdot x_{i,t}^{j} \cdot d_c\right) \qquad (3)$$

The first part of the right-hand side of equation (3) is like that in equation (1), while the double summation term describes the country interactions and the *d*'s are the coefficients to be estimated. For the model's identification we take German bidders, representing the prevalent group, as our baseline and omit the interaction of the variables with the country dummy for Germany. For simplicity we do not interact at all the two dummies that capture the likelihood of a short squeeze. The country dummies are denoted by d_c. We thus have that j runs from 1 (the constant term) to 9 (short rate volatility), while the country index c runs from 1 to 10.

Table 6 provides the regression results of equation (3). We rank the country dummies in alphabetical order as follows: AT for Austria, BE for Belgium, ES for Spain, FI for Finland, FR for France, IE for Ireland, IT for Italy, LU for Luxembourg, NL for the Netherlands, PT for Portugal. The average behaviour of German bidders is captured by the non interacted terms. The behaviour of bidders from any other country is given by the sum of the baseline coefficient plus the coefficient of the relevant interaction, if the latter is significantly different from 0. For ease of presentation, we omit again the coefficients' standard errors and provide the significance levels. Besides, to facilitate the calculation of the national effects, we group each variable and its national interactions into a box, omitting the interactions when the F-test that they are jointly equal to 0 is not rejected

The first remark based on Table 6 is that a number of countries show a lower constant term for the probability of bidding compared to Germany. The latter has a constant equal to -0.0604. On the other hand, Austria for instance has a constant equal to (-0.0604-1.9136=) –1.974. The smallest absolute country effect, always negative, is for Italy, yielding a compounded constant equal to -0.6534. This finding indicates that, other things equal, bidders from AT, BE, ES, IE, IT, NL and PT have a lower probability of bidding in the auction compared to bidders from DE. This phenomenon would seem consistent with the view that German bidders make a lower re-

course to the interbank market and have to rely more heavily on the Eurosystem refinancing compared to bidders from the former group of countries.

The second finding is that the effect of the expected MRO amount on participation is larger in a group of countries: IT banks have a +0.0017 coefficient on top of the baseline of 0.0012 for German banks, ES banks have a +0.0023, FR banks have a +0.0026, PT banks have a +0.0043. This indicates that, when making the decision to bid or not in the MRO, bidders in the latter countries give a bigger weight to the forecast liquidity need, consistently with the reserve management model. A third finding is that the short rate spread has a larger effect on the willingness to enter the auction in Spain and Portugal compared to the baseline.

A number of other country interactions display a significant effect. Among them, we note that the effect of the maturing MRO amount on the probability of bidding is strongest for bidders from LU, and equal to 0.4160 on top of the baseline of 0.1328. We do not have any specific intuition on the remaining effects.

5.2 Bid amount

We estimate the following equation using the fixed effects panel regression:

$$y_{i,t} = \mathrm{x}'_{i,t}\,ß + \sum_j \sum_c g_c^j \cdot x_{i,t}^j \cdot d_c + u_i + e_{i,t} \qquad (4)$$

where the country interactions are added to the basic structure of equation (2) and the ?'s are the coefficients to be estimated. As is known, the adoption of the fixed effects model prevents the inclusion of country interactions for the constant term.

Table 7 shows the regression results. The liquidity need, as proxied by the expected MRO amount, is a driving factor of the bid amount in France (+0.0015) and, more heavily, in Belgium (+0.0039), compared to a baseline value not statistically different from 0.

Perhaps the main finding of Table 7 us that the bidder size, showing a remarkable effect in the case of German banks, equal to 3.6222, is watered down considerably in all other countries with the exception of Spanish banks (this is of course related to the finding of Table 5 that the overall effect is 0.8476). In Spain the effect is more than doubled, to 7.993. In Italy the effect of size is

equal to 1.1995. Interestingly, there are countries where the size effect is reversed compared to the baseline, indicating that an increase in the individual requirement brings about a significant reduction in bid amount .This is the case of bidders from FR, LU, IE and, marginally, NL and PT. For instance, in France the effect of size is -1.3004 after compounding. In our view, these findings may be interpreted as follows. First, in the case of Spain and Germany, the evidence lends support to the two-tier market hypothesis at the domestic level, and to the view that large banks from those countries play an active role as cross-border money dealers. Second, the evidence for France, Luxembourg and, to a lesser extent, Ireland indicates that the largest bidders are not necessarily large in terms of reserve requirement. This might be consistent with the notion that those three countries provide a suitable marketplace for money market dealers, possibly with foreign control, having a relatively small reserve base. To complete the picture, the remaining countries provide mild support to the two-tier market hypothesis (Austria, Belgium, Finland and Italy) or no support at all (the Netherlands and Portugal).

In section 2 we related the effect of the maturing MRO on the bid amount to the willingness of bidders to meet a target level of reserves. From Table 7 we note that such effect is strongest in the case of German bidders, at 0.5672. All other countries display a reduction, and a significant one in many cases, compared to the baseline coefficient (in Finland this effect is even reversed). As concerns the short rate spread, we note that bidders from France and Italy display a higher-than-average elasticity of demand to money market rates. This is equal to 0.0957 in the case of Germany, to 0.4736 for France after compounding, to 0.3202 for Italy. Not surprisingly, we note that a similar phenomenon occurs for the effect of the long rate spread, which is modest for German bidders (0.0384), whereas it significantly increases for bidders from Spain (0.2101 after compounding), France (0.2672), Italy (0.1222), Luxembourg (0.0997) and the Netherlands (0.1354).

As concerns the impact of volatility, we recall from section 4.2 and Table 5 that we did not find a significant effect on an area-wide level. However, when we look at the country effects, the picture becomes diversified. In the case of bidders from DE, AT, FI, IE, IT, LU, PT the effect is still not significantly different from 0. For Belgian and French bidders the effect is strong and significant, respectively at 27.36 and 17.54, which would be consistent with the reserve management model under banks' risk aversion. On the other hand, the effect for Spain and the Netherlands is negative, respectively at –15.66 and –13.99, and that would indicate the dominance of the winner's curse hypothesis.

5.3 Average bid rate

Table 8 provides the results of the fixed effects panel regression of equation (3), where the dependent variable is replaced by the mean bid rate of bidder *i* in auction *t*. The main finding is about the country response to the short rate spread. In the baseline case of Germany, which is valid also for Finland and Italy, bidders pass onto the bid rate, measured as a spread over the minimum rate, three quarters of the money market spread. This figure becomes higher for bidders from BE, IE, NL and PT, whereas bidders from AT, ES, FR and LU shade their rates a bit more. As concerns the impact of volatility, we note that this variable pushes bid rates up in Germany, with a coefficient of 3.1292, and in other countries which do not differ statistically from it. This may be motivated by bidders' risk aversion. However, this effect is reduced somewhat in France and Italy, while it is halved in Belgium and Ireland.

Table 8 shows a number of other minor country effects, which we do not comment for the sake of brevity.

5.4 Bid rate dispersion

Table 9 gives the results of the fixed effects panel regression of equation (3), where the dependent variable is replaced by the dispersion of bid rates by bidder *i* in auction *t*. The main finding concerns the effect of the long rate spread. Compared to the baseline effect of Germany, with a coefficient of 0.0001, we notice a marked increase in the case of bidders from Austria (+0.0019), Spain (+0.0018), France (+0.0030) and Italy (+0.0022). This evidence supports the view that in the latter group of countries the cost of collateral is a key variable compared to the rest of the area.

We also observe that the effect of the short rate spread displays differences in several countries, although none of them alters the picture dramatically. Lastly, we note that one of the predictions that we could not support with the area-wide regression of Table 5, Panel D, namely that the expected MRO amount should induce bidders to disperse more, is indeed met in the case of Italian bidders, reinforcing the notion that collateral cost does matter in this country.

6. Size effects

In order to sharpen our analysis on the effect of the bidders' size, we restricted our data sample to two groups of bidders. The first group includes all bidders in the two lowest deciles ranked by size, the second group includes all bidders in the two highest deciles by size. We thus specialise the basic regressions (1) and (2) taking the "small" as the baseline case and interacting a Large bidder dummy (LBD), equal to 1 if the bidder belongs to the second group, with each of the explanatory variables. In the case of bidders' participation the equation is as follows:

$$\Pr\left(y_{i,t} > 0 \mid \mathrm{x}_{i,t}\right) = \Phi\left(\mathrm{x}'_{i,t}\ \mathrm{b} + \mathrm{x}'_{i,t} \cdot \mathrm{LBD} \cdot \mathrm{f}\right) \qquad (5)$$

We estimate equation (5) by means of a population-averaged probit regression, with AR(2) disturbances and semi-robust standard errors. The corresponding results are shown in Table 10, Panel P. The new finding compared to the basic regression (1) (see Table 5, Panel P) is that the large bidders' participation is directly influenced by the expected MRO amount, whereas the effect on small bidders' participation is nil.

Next we proceed with the bid amount, for which we use the following equation:

$$y_{i,t} = \mathrm{x}'_{i,t}\,ß + \mathrm{x}'_{i,t} \cdot \mathrm{LBD} \cdot ? + u_i + e_{i,t} \qquad (6)$$

The results are shown in Table 10, Panel B. The regression indicates that large bidders' demand tends to increase in response to an increase to the expected MRO amount, with a coefficient of +0.0007, and is much more elastic to the short spread (+0.2845) and long rate spread (+0.1763). At the same time, large bidders react to an increase in volatility by reducing the bid amount, with a coefficient of -11.6723. These findings seems to indicate that large bidders on average behave more efficiently than small bidders and that the former are less risk averse, probably on account of their better access to the money market.

Table 10, Panel R reports the results of the estimation of equation (6) as applied to the dependent variable Average bid rate. The main findings are that large bidders push bid rates up compared to small bidders in response to an increase in the short rate spread, with a differential effect of +0.0696. The former respond to an increase in volatility by raising rates less than the small players (-1.8797). The last finding is consistent with the hypothesis that large bidders have low risk aversion.

Finally, Panel D of Table 10 gives the results of equation (6) as applied to individual bid rate dispersion. Large bidders disperse rates in response to an increase in the expected amount of the MRO compared to the small bidders, consistently with the idea that the cost of collateral is a stronger concern for the former and that they make a better use of the possibility to submit up to 10 rate/quantity pairs. Besides, large bidders disperse rates less in response to an increase in short rate volatility.

7. Bank group effects

In order to investigate the effects of participation in a banking group, we constructed a variable called Bank group dummy (BGD), which takes the value 1 if the bidder belongs to one of the 31 multinational banking groups identified by Gouteron (2001), and is equal to 0 otherwise. This time we kept all bidders in the regression sample. We then ran the following equation for auction participation:

$$\Pr\left(y_{i,t} > 0 \mid \mathrm{x}_{i,t}\right) = \Phi\left(\mathrm{x}'_{i,t}\ \mathrm{b} + \mathrm{x}'_{i,t} \cdot \mathrm{BGD} \cdot ?\right) \qquad (7)$$

where the sign and significance of the ? coefficients show the differential effect, if any, related to participation in a bank group.

Table 11, Panel P gives the empirical estimates. We note that bidders belonging to a group, care much less about the maturing MRO amount, showing a compounded coefficient of 0.0468; this should be compared with the baseline effect, with a coefficient of 0.2344. Their willingness to participate in the auction increases, with a compounded coefficient of 36.0376, when short rate volatility increases and "single" bidders present a coefficient of 8.4251.

We then estimated the following panel regression for the individual bid amount:

$$y_{i,t} = \mathrm{x}'_{i,t}\,ß + \mathrm{x}'_{i,t} \cdot \mathrm{BGD} \cdot ? + u_i + e_{i,t} \qquad (8)$$

The results are shown in Table 11, Panel B. "Group" bidders significantly increase demand in the auction when the expected MRO amount increases, with a differential effect of 0.0012, whereas single bidders show no such effect. The former raise demand when the country fulfil-

ment increases (+0.0017), which is not intuitive, although it is consistent with the view that they do not feel constrained by the domestic liquidity situation. It is remarkable that the positive effect of the bidder's size on amount, which we found in section 4.2 (see Table 5, Panel B), seems attributable mainly to group bidders. In fact, we have a coefficient for single bidders which is not significantly different from 0, whereas the differential effect of being in a group is equal to +1.7026 and is highly significant. Demand from group bidders is much more elastic to the short and long rate spreads compared to the baseline case, by a factor of around 6. The short and long rate compounded coefficients of group bidders equal 0.5189 and respectively 0.2855, compared with baseline values of 0.0896 and 0.0473. In the case of the forward spread, the effect of group *vs* single bidders is the opposite. The latter respond to e.g. a positive forward spread by increasing their bid amount (0.0433), whereas group bidders lower their demand (with a compounded effect of –1.2888). Finally, the effect of volatility on bid amount by group bidders is negative and mildly significant.

We then ran equation (8) substituting for the average bid rate as our dependent variable. The main result of Table 11, Panel R is that when short rate volatility increases, group bidders shade their bids, by a coefficient of –1.0174, compared to single bidders, with a coefficient of 3.0563.

Finally, we ran equation (8) as applied to bid rate dispersion. From Table 11, Panel D, we note that an increase in the MRO amount induces group bidders to disperse more than the baseline case, analogously to what we found in the previous table for large bidders. We also find that the positive effect of the maturing MRO amount on rate dispersion vanishes in the case of group bidders, and that an increase in the short rate spread induces group bidders to disperse more compared to the baseline.

8. Conclusion

On the basis of a broad analytical framework, we formulated an empirical model for the decision to participate in the Eurosystem monetary policy auctions, the individual bid amount, the average bid rate and the dispersion of rates. The analysis of Section 4 was aimed at the first objective of our investigation, i.e. testing whether the theoretical predictions are supported by the individual bidders data in a panel study. Four explanatory variables derive from the microeconomic models of reserve management: (i) the minimum reserve fulfilment ratio of the bidder's country of establishment, which proxies for the unobserved individual fulfilment; (ii) the ma-

turing MRO amount; (iii) the forward rate spread; (iv) short rate volatility. The evidence is that the sign restrictions implied by reserve management theory, and described in Table 1, are supported in the majority of cases. In particular, the country fulfilment ratio has a negative impact on participation, amount and bid rate as hypothesised, although the coefficient is significant for the rate only. The amount of the maturing MRO displays a positive effect and the coefficients are all highly significant, supporting the hypothesis that banks have a target level of end-of-day reserves for settlement purposes or due to the preference for a smooth fulfilment pattern, which they pursue through a stable source of refinancing. As concerns the forward rate spread, reflecting the trade-off between bidding in today's auction as opposed to next week's, the evidence supports one prediction out of three, namely that a positive value of the spread increases the likelihood of bidding in the current auction. Short rate volatility has a positive and significant effect on the probability of bidding and the bid rate, consistently with the hypothesis that bidders are risk averse.

Auction theory contributed to our empirical model in two ways. In the first place, and in common with reserve management theory, through short rate volatility. We noted that the positive effect of market rate volatility on the probability of bidding and the bid rate is at odds with the classical winner's curse hypothesis, although it can be reconciled with the alternative view that bidders are averse to the risk of losing the auction. Second, we include two indicator variables reflecting the increased likelihood of a post-auction liquidity squeeze in the interbank market. They are related to the occurrence of an underbidding episode in the previous auction and, respectively, to the auction being the last one in the reserve maintenance period. Both variables display the predicted effect on participation, bid amount and dispersion, consistently with the hypothesis of Nyborg and Strebulaev (2001).

An additional underpinning of the model was provided by the transmational bank hypothesis developed by Freixas and Holthausen, according to which larger banks with a multinational profile may use their informational advantage to arbitrage out the differences in interest rates across countries. Other things being equal, this feature would induce transnational banks to participate and bid in the auction above the rest of banks. Indeed, the results of the general model show that the bidder size has a positive effect on both the likelihood of bidding and the amount.

We further hypothesised that the cost of collateral plays an important role in the bidding strategy, owing to the variety of eligible assets in the MROs and the non-uniform distribution across countries. To capture this effect we formulated a set of sign hypotheses on two explanatory

variables, the expected amount of the MRO and the yield curve spread. We find support to these conjectures from the estimated impact of the expected MRO amount on the bid rate, which is negative and significant, and the long rate spread, which exerts a positive and significant effect on participation and bid amount. The evidence indicates that when the cost-of-carry of liquid collateral becomes favourable, more bidders enter the auction and the average bid amount increases. These results should be explained by the bidders' attempt to make an efficient use of collateral.

The last building block of the general model was the inclusion of monetary policy expectations. Under the hypothesis that bidders behave efficiently, an increase (decrease) in the spread between the interbank market rate and the minimum auction rate set by the ECB should affect positively (negatively) participation, amount, average rate and dispersion. We note that the reasoning behind this hypothesis bears some similarity to an argument of reserve management theory, which led to the inclusion of the forward rate spread. However, from an empirical viewpoint the two explanatory variables display different distributions and are uncorrelated, which allowed us to include both. In the case of the short rate spread the evidence is strongly in favour of all theoretical predictions.

Our second objective was to investigate the existence of country effects, size effects and bank group effects (Sections 5-7). The analysis of the behaviour of the 20 percent largest bidders as opposed to the 20 percent smallest ones reveals that the former tend to participate more often and bid larger amounts when the forecast liquidity need increases, and that their demand is much more elastic to the short and long rate spreads. Large bidders react to an increase in volatility by reducing the bid amount and raising rates less than the small players. Large bidders disperse rates a lot more in response to an increase in the expected amount of the MRO, consistently with the idea that they seek to optimise the use of collateral and make a better use of the possibility to submit up to 10 rate-quantity pairs. These findings seem consistent with the notion that large bidders on average behave more efficiently and are less risk averse than small bidders, probably on account of a better access to the money market.

Not surprisingly, bidders that participate in a banking group present similarities with the sample of large bidders. Compared to bidders acting in isolation, group bidders do not seem concerned about meeting a target level of end-of-day reserves nor about the specific liquidity conditions of their country of location, and they enter the auction when volatility is high. When that is the case, they tend to demand lower amounts at lower rates compared to bidders acting in isolation.

These findings yield additional support to the view that group bidders play a multinational role and apply smarter bidding strategies compared to single bidders.

The analysis of country effects rested mainly on empirical considerations. The banking systems of the EMU countries present national differences, and so could in principle the behaviour of counterparties. Indeed, we document a number of country effects. Among them, banks from Germany display ceteris paribus a larger probability of bidding in the Eurosystem auctions, which would seem consistent with the view that the development of the interbank market in that country is hindered by the atomistic structure of the banking system. We find that the impact of the bank's size on bid amount varies considerably across countries. In the case of Spain and Germany, the evidence lends support to the two-tier market hypothesis at the domestic level, and to the view that large banks from those countries play an active role as cross-border money dealers. On the other hand, the evidence for France, Luxembourg and Ireland indicates that the largest bidders are not necessarily large in terms of reserve requirement. This might be consistent with the notion that these countries provide a convenient marketplace for money market dealers, possibly with foreign control, having a relatively small reserve base. The remaining countries provide mild support to the two-tier market hypothesis (Austria, Belgium, Finland and Italy) or no support at all (the Netherlands and Portugal). As concerns rate dispersion, we note that the impact of the long rate spread grows significantly in Austria, Spain, France and Italy, revealing that in these countries the cost of collateral is a key variable for the bidding strategy.

All in all, our assessment of the general model's results is twofold. In the first place, using very detailed data, we found substantial evidence in favour of predictions derived from various strands of research. Our findings lend support to the view that bidders in the Eurosystem auctions display risk aversion and, what is more important, they behave efficiently. Thus, our microeconomic evidence is complementary to earlier results on the overall performance of the present MRO auction format as an effective tool for monetary policy implementation by the Eurosystem. Second, we note that a relatively simple model characterises well the four key decision variables of individual participation in the MROs. Our estimates are free from sample selection biases, because they are obtained from the universe of bidders and through different phases of the monetary policy cycle, including a tightening, a period of stability and a subsequent easing. We believe that such a model might possibly provide a benchmark for future analyses of the bidding behaviour of the Eurosystem counterparties, e.g. following the enlargement of the monetary union.

Which lessons do we derive for the issue of money market integration in the euro area? Although the documented effects of size, group and country clearly rule out the assimilation of bidders' behaviour to the pure "representative agent" model, most of these effects may be meaningfully interpreted in the light of theories of rational individual behaviour and well-known institutional differences at country level, like those in the financial structure, the composition of available collateral, the competitive advantage of some marketplaces. National idiosyncrasies are present, and to some extent they are likely to persist in the future, but it seems fair to conclude that the supply of refinancing by the Eurosystem through the MRO auctions and the demand behaviour of the multitude of bidders are themselves a vehicle of integration of the area-wide money market.

Appendix – EGARCH estimates of interest rate volatility

The conditional volatility of the 2-week EONIA swap rate is estimated as an EGARCH process (Nelson, 1991) on the weekly series of the data taken on the day before the auction, i.e. normally on Monday. A specification search, details of which are available from the authors, led to the following parsimonious model:

$$\underset{(0.0018)}{r_t = 0.9986 \cdot r_{t-1}} + \underset{(0.0150)}{0.0402 \cdot MED_t} + \underset{(0.0317)}{0.1258 \cdot UND_t} - \underset{(0.0015)}{0.2333 \cdot D010511_t} + e_t \qquad \text{(A.1)}$$

$$\underset{(1.645)}{\ln s_t^2 = -10.39} - \underset{(0.2645)}{0.7055 \cdot \ln s_{t-1}^2} + \underset{(49.57)}{91.63 \cdot e_{t-1}^2} \qquad \text{(A.2)}$$

where the coefficient standard errors are reported in parentheses and:

r_t is the 2-week EONIA swap rate;

MED_t is a calendar month-end dummy, which captures the increase in the swap rate due to a well-known window-dressing effect;

UND_t is a post-underbidding dummy, equal to 1 in the week following an underbidding episode;

$D010511_t$ is a dummy equal to 1 on 11 May 2001, after an unforeseen 25 basis points cut in monetary policy rates by the ECB Governing Council.

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Table 1

THEORETICAL PREDICTIONS

This table summarises the predicted effects on bank's participation and bidding in the Eurosystem auctions discussed in section 2.2. The hypotheses are derived from the reserve management models, unless otherwise specified. The symbol (a) stands for auction theory, (b) stands for the transnational bank hypothesis, (c) is the cost of collateral hypothesis, (d) is monetary policy expectations.

Explanatory variables	*Dependent variables and hypotheses*			
	Participation P	Bid amount B	Average bid rate R	Bid rate dispersion D
Liquidity need	+	+	+	
Forward rate spread	+	+	+	
Short rate volatility	+ -/+ (a)	+ -/+ (a)	+ -/+ (a)	+ (a)
Reserve fulfilment	-	-	-	
Maturing MRO amount	+	+	+	
Short squeeze likelihood	+ (a)	+(a)		+(a)
Size	+(b)	+(b)		
Participation in bank group	+ (b)	+ (b)		
Expected MRO amount		- (c)	- (c)	+ (c)
Long rate spread	+ (c)	+ (c)		
Short rate spread	+ (d)	+ (d)	+ (d)	+ (d)

Table 2

FREQUENCY OF BIDDING

No. of auctions	No. of bidders	Percent	Cum.
1-10	214	20.72	20.72
11-20	168	16.26	36.98
21-30	153	14.81	51.79
31-40	138	13.36	65.15
41-50	136	13.17	78.32
51-60	199	19.26	97.58
61	25	2.42	100.00
Total	1033	100.00	

Table 3

DISTRIBUTION OF AVERAGE BID SIZE BY BIDDER
(as a percentage of area reserve requirement)

Range	No. of bidders	Percent	Cum.
0 - .01	469	45.40	45.40
.01 - .025	177	17.13	62.54
.025 - .05	120	11.62	74.15
.05 - .075	56	5.42	79.57
.075 - .1	30	2.90	82.48
.1 - .25	91	8.81	91.29
.25 - .5	38	3.68	94.97
.5 - .75	13	1.26	96.22
.75 -1	11	1.06	97.29
1 -2	16	1.55	98.84
>2	12	1.16	100.00
Total	1033	100.00	

Table 4

SUMMARY STATISTICS

The variables Bid amount, Expected MRO amount, Size and Maturing MRO amount are all as a percentage of the area reserve requirement. The Short rate volatility is given by the conditional variance of the 2-week swap rate estimated with the EGARCH model. The Average bid rate, Short rate spread and Long rate spread are differences with respect to the minimum auction rate set by the ECB. The Country fulfilment ratio is as a percentage of the country reserve requirement.

	No. Of obs.	Mean	Min.	Max.	Std. dev.
Bid amount	31,253	0.2245	0.0008	18.1938	0.6330
Average bid rate	31,253	0.0542	0.0000	0.6500	0.0696
Std. dev. of bid rates	31,253	0.0066	0.0000	0.2828	0.0086
Expected MRO amount	63,013	75.7302	-3.5910	152.0402	26.6145
Country fulfilment ratio	63,013	98.9486	59.2200	145.5700	5.8735
Size (indiv. res. requirement)	63,013	0.0623	0.0000	3.2893	0.2203
Maturing MRO amount	60,947	0.0671	0.0000	17.8837	0.3210
Short rate spread	61	0.0734	-0.0600	0.4500	0.0840
Long rate spread	61	0.4297	-0.1000	1.0700	0.3451
Forward rate spread	61	-0.0236	-0.3000	0.0900	0.0616
Short rate volatility	61	0.0031	0.0019	0.0111	0.0017

Table 5

GENERAL MODEL
PROBABILITY OF BIDDING, BID AMOUNT, AVERAGE BID RATE AND BID RATE DISPERSION

Panel P reports the estimates of the population-averaged probit regression of equation (1) in the text, with AR(2) disturbances and semi-robust standard errors. Panels B, R and D report the estimates of the fixed-effect regression of equation (2) as applied to the relevant variables. The dependent variable Bid amount and the explanatory variables Expected amount of MRO, Bidder size and Maturing MRO amount are expressed as a percentage of the area reserve requirement. The Country fulfilment ratio is given by the average reserve account holdings of the bidder's country in the current maintenance period on the day before the auction (d.b.a.) as a percentage of the country's reserve requirement. The Short rate spread is the difference between the 2-week swap rate on the d.b.a. and the ECB's minimum bid rate. The Long rate spread is the difference between the 10-year Bund yield on the d.b.a. and the minimum rate. The Forward rate spread is the difference between the forward 2-week swap rate (one week ahead) and its spot value on the d.b.a. The coefficients' standard errors are omitted for simplicity. The symbol *** indicates a significance level of 1 percent or less, ** between 1 and 5 percent, * between 5 and 10 percent.

	Panel P Probability of bidding	Panel B Bid amount	Panel R Average interest rate	Panel D Interest rate dispersion
Constant	-0.3467 ***	0.0757 **	0.0344 ***	0.0004
Expected amount of MRO	0.0014 ***	3.1e -5	-0.0003 ***	1.5e –6
Country fulfilment ratio	-0.0010	-0.0004	-0.0002 ***	1.6e –5 **
Bidder size	0.8038 ***	0.8476 ***	-0.0056	0.0022
Maturing MRO amount	0.1221 ***	0.5322 ***	0.0025 ***	0.0006 ***
Short rate spread	0.8220 ***	0.1247 ***	0.7478 ***	0.0295 ***
Long rate spread	0.3840 ***	0.0677 ***	-0.0154 ***	0.0005 ***
Forward rate spread	0.4706 ***	-0.0876 **	-0.0048	0.0006
Short rate volatility	9.9137 ***	-0.8885	2.9645 ***	0.2687 ***
Post underbidding dummy	0.1330 ***	0.0662 ***	-0.0089 ***	0.0051 ***
Period end dummy	0.0946 ***	0.0028	0.0045 ***	0.0006 ***
No. of observations.	60947	29820	29820	29820
No. of groups	1033	1002	1002	1002
Obs per group: min	59	1	1	1
average	59.0	29.8	29.8	29.8
maximum	59	59	59	59
?2 test	874.61 ***			
R square		0.6101	0.7745	0.1419
F test		934.69 ***	11329.96 ***	652.06 ***
?		0.3683	0.3341	0.3675
F test that all u_i=0		18.93 ***	5.05 ***	10.51 ***

Table 6

COUNTRY EFFECTS
PROBABILITY OF BIDDING

The table reports the estimates of the population-averaged probit regression of equation (3) in the text, with AR(2) disturbances and semi-robust standard errors. The Country dummies AT through PT are equal to 1 if the bidder belongs to the relevant country and to 0 otherwise. The explanatory variables Expected MRO amount, Bidder size and Maturing MRO amount are expressed as a percentage of the area reserve requirement. The Country fulfilment ratio is the average reserve account holdings of the bidder's country in the current maintenance period on the day before the auction (d.b.a.) as a percentage of the country's reserve requirement. The Short rate spread is the difference between the 2-week swap rate on the d.b.a. and the ECB's minimum bid rate. The Long rate spread is the difference between the 10-year Bund yield on the d.b.a. and the minimum rate. The Forward rate spread is the difference between the forward 2-week swap rate (one week ahead) and its spot value on the d.b.a. The coefficients' standard errors are omitted for simplicity. The symbol *** indicates a significance level of 1 percent or less, ** between 1 and 5 percent, * between 5 and 10 percent. The coefficients of the interactions are omitted if the F-test fails to reject the null hypothesis that they are all 0.

Constant	-0.0604		Bidder size	1.4158		Long rate spread	0.3759	***
AT	-1.9136	***	AT * *x*	2.5993				
BE	-1.5189	***	BE * *x*	-0.8606				
ES	-1.1591	***	ES * *x*	-0.0100				
FI	0.3417		FI * *x*	-0.3432				
FR	-0.2599		FR * *x*	-1.2417				
IE	-0.7794	**	IE * *x*	-1.1216				
IT	-0.5930	*	IT * *x*	1.9045				
LU	0.2876		LU * *x*	1.5448				
NL	-0.8603	**	NL * *x*	-0.7029				
PT	-1.4599	**	PT * *x*	1.1791				
F test of variables	44.3	***	F test of interactions	52.4	***	F test of interactions	15.5	
Expected MRO amt	0.0012	***	Maturing MRO amt	0.1328	*	Forward rate spread	0.6327	***
AT * *x*	-0.0006		AT * *x*	-0.3526		AT * *x*	-0.7035	*
BE * *x*	0.0012		BE * *x*	-0.1137		BE * *x*	-0.4379	
ES * *x*	0.0023	**	ES * *x*	0.2840		ES * *x*	-0.5200	
FI * *x*	-0.0002		FI * *x*	0.0205		FI * *x*	0.4921	
FR * *x*	0.0026	***	FR * *x*	-0.0535		FR * *x*	-0.3979	
IE * *x*	0.0011		IE * *x*	0.9788		IE * *x*	-1.0464	
IT * *x*	0.0017	**	IT * *x*	0.1274		IT * *x*	-0.6139	**
LU * *x*	-0.0009		LU * *x*	0.4160	**	LU * *x*	-0.3662	
NL * *x*	0.0025		NL * *x*	-0.2621	***	NL * *x*	-0.8683	
PT * *x*	0.0043	**	PT * *x*	-1.3598	***	PT * *x*	2.5717	*
F test of interactions	26.0	***	F test of interactions	52.4	***	F test of interactions	18.2	*
Country fulfilment r.	-0.0036	***	Short rate spread	0.7905	***	Short rate volatility	7.9282	**
AT * *x*	0.0189	***	AT * *x*	0.0264				
BE * *x*	0.0107	**	BE * *x*	1.5058				
ES * *x*	0.0057	**	ES * *x*	1.1765	***			
FI * *x*	-0.0085	*	FI * *x*	-0.9482				
FR * *x*	4.5e –5		FR * *x*	-0.1549				
IE * *x*	0.0065	**	IE * *x*	-0.4545				
IT * *x*	0.0024		IT * *x*	-0.0578				
LU * *x*	-0.0004		LU * *x*	-0.2780				
NL * *x*	0.0012		NL * *x*	-1.0124	*			
PT * *x*	0.0030		PT * *x*	2.1127	***			
F test of interactions	33.0	***	F test of interactions	24.2	***	F test of interactions	13.0	
						Post underb dummy	0.1231	***
						Period end dummy	0.1015	***

No. of obs.	60947	
No. of groups	1033	
Obs per group min	59	
Avg	59.0	
Max	59	
?2 test	2.8e +9	***

Table 7

COUNTRY EFFECTS
BID AMOUNT

The table reports the estimates of the fixed-effect regression of equation (4) as applied to Bid amount. The Country dummies AT through PT are equal to 1 if the bidder belongs to the relevant country and to 0 otherwise. The dependent variable and the explanatory variables Expected MRO amount, Bidder size and Maturing MRO amount are expressed as a percentage of the area reserve requirement. The Country fulfilment ratio is given by the average reserve account holdings of the bidder's country in the current maintenance period on the day before the auction (d.b.a.) as a percentage of the country's reserve requirement. The Short rate spread is the difference between the 2-week swap rate on the d.b.a. and the ECB's minimum bid rate. The Long rate spread is the difference between the 10-year Bund yield on the d.b.a. and the minimum rate. The Forward rate spread is the difference between the forward 2-week swap rate (one week ahead) and its spot value on the d.b.a. The coefficients' standard errors are omitted for simplicity. The symbol *** indicates a significance level of 1 percent or less, ** between 1 and 5 percent, * between 5 and 10 percent. The coefficients of the interactions are omitted if the F-test fails to reject the null hypothesis that they are all 0.

Constant	-0.0686		Bidder size	3.6222	***	Long rate spread	0.0384	***
			AT * *x*	-2.6353	***	AT * *x*	0.0220	
			BE * *x*	-2.2504	***	BE * *x*	0.0184	
			ES * *x*	4.3908	***	ES * *x*	0.1717	***
			FI * *x*	-2.9035	**	FI * *x*	-0.0597	
			FR * *x*	-4.9026	***	FR * *x*	0.2288	***
			IE * *x*	-4.3313	**	IE * *x*	-0.4171	
			IT * *x*	-2.4027	***	IT * *x*	0.0838	***
			LU * *x*	-4.9808	***	LU * *x*	0.0613	**
			NL * *x*	-3.9383	***	NL * *x*	0.0970	*
			PT * *x*	-3.7110	***	PT * *x*	-0.0631	
			F test of interactions	51.5	***	F test of interactions	8.7	***
Expected MRO amt	-0.0001		Maturing MRO amt	0.5672	***	Forward rate spr	-0.07513	*
AT * *x*	0.0002		AT * *x*	-0.3005	***			
BE * *x*	0.0039	***	BE * *x*	-0.3009	***			
ES * *x*	0.0005		ES * *x*	-0.0373	*			
FI * *x*	0.0008		FI * *x*	-0.7744	***			
FR * *x*	0.0015	***	FR * *x*	-0.1843	***			
IE * *x*	0.0001		IE * *x*	-0.1815				
IT * *x*	0.0004		IT * *x*	-0.0147				
LU * *x*	0.0004		LU * *x*	-0.0353				
NL * *x*	0.0009		NL * *x*	-0.3612	***			
PT * *x*	0.0002		PT * *x*	-0.3372				
F test of interactions	5.5	***	F test of interactions	35.6	***	F test of interactions	1.4	
Country fulfilment r	0.0004		Short rate spread	0.0957	***	Sh rate volatility	-1.4079	
			AT * *x*	-0.0666		AT * *x*	-1.9379	
			BE * *x*	0.0199		BE * *x*	27.3638	***
			ES * *x*	0.1829		ES * *x*	-15.6636	***
			FI * *x*	-0.1595		FI * *x*	4.9875	
			FR * *x*	0.3779	***	FR * *x*	17.5372	***
			IE * *x*	0.0117		IE * *x*	3.7211	
			IT * *x*	0.2245	**	IT * *x*	0.4231	
			LU * *x*	0.0226		LU * *x*	0.5618	
			NL * *x*	-0.1246		NL * *x*	-13.9882	*
			PT * *x*	-0.0369		PT * *x*	4.6499	
F test of interactions	0.9		F test of interactions	1.7	*	F test of interactions	3.8	***
						Post underb dummy	0.0616	***
						Period end dummy	0.0023	

No. of obs.	29820	
No. of groups	1002	
Obs per group: min	1	
Avg	29.8	
Max	59	
R square	0.3430	
F test	121.28	***
?	0.7793	
F test that all u_i=0	15.84	***

Table 8

COUNTRY EFFECTS
AVERAGE INTEREST RATE

The table reports the estimates of the fixed-effect regression of equation (4) as applied to Average interest rate. The Country dummies AT through PT are equal to 1 if the bidder belongs to the relevant country and to 0 otherwise. The explanatory variables Expected MRO amount, Bidder size and Maturing MRO amount are expressed as a percentage of the area reserve requirement. The Country fulfilment ratio is given by the average reserve account holdings of the bidder's country in the current maintenance period on the day before the auction (d.b.a.) as a percentage of the country's reserve requirement. The Short rate spread is the difference between the 2-week swap rate on the d.b.a. and the ECB's minimum bid rate. The Long rate spread is the difference between the 10-year Bund yield on the d.b.a. and the minimum rate. The Forward rate spread is the difference between the forward 2-week swap rate (one week ahead) and its spot value on the d.b.a. The coefficients' standard errors are omitted for simplicity. The symbol *** indicates a significance level of 1 percent or less, ** between 1 and 5 percent, * between 5 and 10 percent. The coefficients of the interactions are omitted if the F-test fails to reject the null hypothesis that they are all 0.

Constant	0.0312	***	Bidder size	-0.0511	**	Long rate spread	-0.0165	***
			AT * *x*	0.0969				
			BE * *x*	0.1267				
			ES * *x*	0.0484				
			FI * *x*	0.2370	*			
			FR * *x*	0.03183				
			IE * *x*	0.07294				
			IT * *x*	-0.0589				
			LU * *x*	0.0580				
			NL * *x*	0.0730	***			
			PT * *x*	-0.0388				
			F test of interactions	2.1	**	F test of interactions	1.3	
Expected MRO	-0.0003	***	Maturing MRO amt	0.0023	***	Forward rate spr	0.0031	
						AT * *x*	-0.0064	
						BE * *x*	-0.0590	*
						ES * *x*	-0.4560	***
						FI * *x*	-0.0344	
						FR * *x*	-0.0332	**
						IE * *x*	0.0288	
						IT * *x*	-0.0226	*
						LU * *x*	0.0098	
						NL * *x*	-0.1142	***
						PT * *x*	-0.0595	
F test of interactions	1.5		F test of interactions	0.6		F test of interactions	4.0	***
Country fulfilment r	-0.0002	***	Short rate spread	0.7531	***	Sh rate volatility	3.1292	***
AT * *x*	-0.0005	**	AT * *x*	-0.0282	*	AT * *x*	-0.1480	
BE * *x*	0.0001		BE * *x*	0.1048	***	BE * *x*	-1.6087	*
ES * *x*	0.0008	***	ES * *x*	-0.0573	***	ES * *x*	0.3005	
FI * *x*	-0.0001		FI * *x*	0.0236		FI * *x*	0.6767	
FR * *x*	0.0001		FR * *x*	-0.1248	***	FR * *x*	-0.9973	**
IE * *x*	-0.0008	***	IE * *x*	0.0393	*	IE * *x*	-1.7257	*
IT * *x*	-0.0007	***	IT * *x*	0.0169		IT * *x*	-1.1834	***
LU * *x*	-0.0000		LU * *x*	-0.0284	**	LU * *x*	-0.7832	
NL * *x*	0.0002		NL * *x*	0.0638	***	NL * *x*	-0.4600	
PT * *x*	0.0004		PT * *x*	0.0961	***	PT * *x*	0.1457	
F test of interactions	11.1	***	F test of interactions	17.0	***	F test of interactions	1.8	*
						Post underb dummy	-0.0084	***
						Period end dummy	0.0046	***

No. of observa-	29820	
No. of groups	1002	
Obs per group: min	1	
Avg	29.8	
Max	59	
R square	0.6253	
F test	1279.76	***
?	0.5905	
F test that all u_i=0	4.81	***

COUNTRY EFFECTS
INTEREST RATE DISPERSION

The table reports the estimates of the fixed-effect regression of equation (4) as applied to Interest rate dispersion. The Country dummies AT through PT are equal to 1 if the bidder belongs to the relevant country and to 0 otherwise. The explanatory variables Expected MRO amount, Bidder size and Maturing MRO amount are expressed as a percentage of the area reserve requirement. The Country fulfilment ratio is given by the average reserve account holdings of the bidder's country in the current maintenance period on the day before the auction (d.b.a.) as a percentage of the country's reserve requirement. The Short rate spread is the difference between the 2-week swap rate on the d.b.a. and the ECB's minimum bid rate. The Long rate spread is the difference between the 10-year Bund yield on the d.b.a. and the minimum rate. The Forward rate spread is the difference between the forward 2-week swap rate (one week ahead) and its spot value on the d.b.a. The coefficients' standard errors are omitted for simplicity. The symbol *** indicates a significance level of 1 percent or less, ** between 1 and 5 percent, * between 5 and 10 percent. The coefficients of the interactions are omitted if the F-test fails to reject the null hypothesis that they are all 0.

Constant	-0.0012		Bidder size	-0.0043		Long rate spread	0.0001	
						AT * *x*	0.0019	**
						BE * *x*	0.0003	
						ES * *x*	0.0018	**
						FI * *x*	-0.0034	
						FR * *x*	0.0030	***
						IE * *x*	4.5e –5	
						IT * *x*	0.0022	***
						LU * *x*	0.0005	
						NL * *x*	0.0016	
						PT * *x*	-0.0025	
			F test of interactions	1.3		F test of interactions	4.2	***
Expected MRO	7.3e -7		Maturing MRO amt	0.0005	***	Forward rate spr	0.0015	*
AT * *x*	-1.2e –5					AT * *x*	-0.0049	
BE * *x*	-3.6e –6					BE * *x*	-0.0048	
ES * *x*	-1.3e –5					ES * *x*	-0.0005	
FI * *x*	3.7e –5					FI * *x*	0.0354	***
FR * *x*	-5.3e -7					FR * *x*	0.0007	
IE * *x*	-2.2e –5	*				IE * *x*	-0.0062	
IT * *x*	2.2e –5	***				IT * *x*	-0.0037	
LU * *x*	6.6e -6					LU * *x*	-0.0048	
NL * *x*	-7.0e -6					NL * *x*	-0.0018	
PT * *x*	-3.8e –5	**				PT * *x*	0.0069	
F test of interactions	2.7	***	F test of interactions	1.2		F test of interactions	1.9	**
Country fulfilment r	4.5e –5	***	Short rate spread	0.0295	***	Sh rate volatility	0.2796	***
AT * *x*	-2.2e –5		AT * *x*	0.0109	***			
BE * *x*	8.9e –7		BE * *x*	-0.0089	*			
ES * *x*	-0.0001	**	ES * *x*	-0.0034				
FI * *x*	-0.0001		FI * *x*	-0.0141				
FR * *x*	-0.0001	***	FR * *x*	0.0121	***			
IE * *x*	-5.5e –6		IE * *x*	-0.0096	**			
IT * *x*	-2.5e –5		IT * *x*	-0.0100	***			
LU * *x*	-3.1e –5		LU * *x*	0.0077	***			
NL * *x*	-4.1e –5		NL * *x*	-0.0061				
PT * *x*	4.3e -5		PT * *x*	0.0065				
F test of interactions	1.8	*	F test of interactions	7.5	***	F test of interactions	1.4	
						Post underbidding dummy	0.0052	***
						Period end dummy	0.0006	***

No. of observa-	29820	
No. of groups	1002	
Obs per group: min	1	
Avg	29.8	
Max	59	
R square	0.0869	
F test	76.15	***
?	0.4138	
F test that all u_i=0	10.11	***

Table 10

EFFECT OF BIDDER SIZE: PROBABILITY OF BIDDING, BID AMOUNT, AVERAGE BID RATE AND BID RATE DISPERSION

The regression sample includes the bidders in the two lowest and, respectively, the two highest deciles ranked by size. The Large bidder dummy LBD is equal to 1 if the bidder belongs to the top two deciles and to 0 otherwise. Panel P reports the estimates of the population-averaged probit regression of equation (5) in the text, with AR(2) disturbances and semi-robust standard errors. Panels B, R and D report the estimates of the fixed-effect regression of equation (6) as applied to the relevant variables. The dependent variable Bid amount and the explanatory variables Expected MRO amount, Bidder size and Maturing MRO amount are expressed as a percentage of the area reserve requirement. The Country fulfilment ratio is given by the average reserve account holdings of the bidder's country in the current maintenance period on the day before the auction (d.b.a.) as a percentage of the country's reserve requirement. The Short rate spread is the difference between the 2-week swap rate on the d.b.a. and the ECB's minimum bid rate. The Long rate spread is the difference between the 10-year Bund yield on the d.b.a. and the minimum rate. The Forward rate spread is the difference between the forward 2-week swap rate (one week ahead) and its spot value on the d.b.a. The coefficients' standard errors are omitted for simplicity. The symbol *** indicates a significance level of 1 percent or less, ** between 1 and 5 percent, * between 5 and 10 percent.

	Panel P	Panel B	Panel R	Panel D
	Probability of bidding	Bid amount	Average interest rate	Interest rate dispersion
Constant	-0.8135 ***	0.5074	0.4022 ***	-0.0001
Large bidder dummy (LBD)	0.5159 *			
Expected MRO amount	0.0001	-0.0003	-0.0003 ***	-8.8e -6 **
LBD * *x*	0.0020 ***	0.0007 *	-2.4e -6	2.1e –5 ***
Country fulfilment ratio	0.0028	-0.0002	-0.0004 ***	4.2e –5 *
LBD * *x*	-0.0016	4.4e –5 **	0.0001	-4.7e –5 *
Bidder size	14.9023	-0.6982 *	-0.1521	-0.0611
LBD * *x*	-14.2484	1.5821	0.1501	0.0632
Maturing MRO amount	0.2157 **	0.5005 ***	0.0040	0.0003
LBD * *x*	-0.1583	0.0434	-0.0015	0.0001
Short rate spread	0.7956 ***	0.0349	0.6964 ***	0.0272 ***
LBD * *x*	0.0898	0.2845 **	0.0696 ***	0.0045 **
Long rate spread	0.3293 ***	0.0422	-0.0129 ***	0.0001
LBD * *x*	0.0669	0.1763 ***	-0.0009	0.0009 *
Forward rate spread	0.5823 ***	0.1228	-0.0169 *	0.0020
LBD * *x*	-0.1167	-0.6304 ***	-0.0022	-0.0054 **
Short rate volatility	7.7344	4.5496	4.0526 ***	0.4076 ***
LBD * *x*	13.0165	-11.6723 **	-1.8797 ***	-0.2406 ***
AT	0.1951			
BE	-0.1462			
ES	-0.4619 **			
FI	-0.7085 ***			
FR	-0.2519			
IE	-0.7815 ***			
IT	-0.1592			
LU	0.1668			
NL	-0.9692			
PT	-0.8506 ***			
Post underbidding dummy	0.1695 ***	0.1290 ***	-0.0108 ***	0.0056 ***
Period end dummy	0.0822 ***	-0.0008	0.0037 ***	0.0006 ***
No. of observations.	23777	11641	11641	11641
No. of groups	403	387	387	387
Obs per group: minimum	59	1	1	1
Average	59.0	301.1	30.1	30.1
Maximum	59	59	59	59
?2 test	350.14 ***			
R square		0.5934	0.7593	0.1351
F test		221.96 ***	2389.60 ***	147.40 ***
?		0.3256	0.3167	0.3698
F test that all u_i=0		14.72 ***	4.74 ***	9.49 ***

EFFECT OF PARTERCIPATION IN A BANKING GROUP: PROBABILITY OF BIDDING, BID MOUNT, AVERAGE BID RATE DISPERSION

The Bank group dummy BGD is equal to 1 if the bidder belongs to a banking group and to 0 otherwise. Panel P reports the estimates of the population-averaged probit regression of equation (7) in the text, with AR(2) disturbances and semi-robust standard errors. Panels B, R and D report the estimates of the fixed-effect regression of equation (8) as applied to the relevant variables. The dependent variable Bid amount and the explanatory variables Expected MRO amount, Bidder size and Maturing MRO amount are expressed as a percentage of the area reserve requirement. The Country fulfilment ratio is given by the average reserve account holdings of the bidder's country in the current maintenance period on the day before the auction (d.b.a.) as a percentage of the country's reserve requirement. The Short rate spread is the difference between the 2-week swap rate on the d.b.a. and the ECB's minimum bid rate. The Long rate spread is the difference between the 10-year Bund yield on the d.b.a. and the minimum rate. The Forward rate spread is the difference between the forward 2-week swap rate (one week ahead) and its spot value on the d.b.a. The coefficients' standard errors are omitted for simplicity. The symbol *** indicates a significance level of 1 percent or less, ** between 1 and 5 percent, * between 5 and 10 percent.

	Panel P	Panel B	Panel R	Panel D
	Probability of bidding	Bid amount	Average interest rate	Interest rate dispersion
Constant	-0.3784 ***	0.0989 ***	0.0334 ***	8.3e –6
Bank group dummy (BGD)	0.0015			
Expected MRO amount	0.0015 ***	-3.2e –5	-0.0003 ***	-9.3e -7
BGD * *x*	-0.0001	0.0012 ***	1.5e –5	2.2e –5 ***
Country fulfilment ratio	-0.0006	-0.0004	-0.0002 ***	2.3e –5 ***
BGD * *x*	-0.0028	0.0017 **	-0.0001	-2.7e –5
Bidder size	0.9916 **	-0.1846	-0.0263 *	0.0021
BGD * *x*	-0.1314	1.7026 ***	0.0360 *	0.0009
Maturing MRO amount	0.2344 ***	0.4553 ***	0.0031 ***	0.0013 ***
BGD * *x*	-0.1876 **	0.1001 ***	-0.0008	-0.0011 ***
Short rate spread	0.8256 ***	0.0896 ***	0.7462 ***	0.0292 ***
BGD * *x*	0.1534	0.4293 ***	0.0203 **	0.0034 *
Long rate spread	0.3850 ***	0.0473 ***	-0.0157 ***	0.0005 ***
BGD * *x*	0.0374	0.2382 ***	0.0037	0.0001
Forward rate spread	0.4884 ***	0.0433	-0.0035	0.0014 *
BGD * *x*	-0.0651	-1.3321 ***	-0.0111	-0.0079 ***
Short rate volatility	8.4251 ***	-0.3258	3.0563 ***	0.2795 ***
BGD * *x*	26.6125 **	-5.9338 *	-1.0174 ***	-0.1252
AT	0.2007			
BE	-0.0317			
ES	-0.2345 *			
FI	-0.5001 ***			
FR	-0.0810			
IE	-0.2432			
IT	0.0174			
LU	0.3539 ***			
NL	-0.6049 ***			
PT	-0.6743 ***			
Post underbidding dummy	0.1385 ***	0.0634 ***	-0.0088 ***	0.0051 ***
Period end dummy	0.0947 ***	0.0025	0.0044 ***	0.0006 ***
No. of observations.	60947	29820	29820	29820
No. of groups	1033	1002	1002	1002
Obs per group: minimum	59	1	1	1
average	59.0	29.8	29.8	29.8
maximum	59	59	59	59
?2 test	938.53 ***			
R square		0.5068	0.7707	0.1417
F test		555.78 ***	6297.73 ***	366.51 ***
?		0.4858	0.3403	0.3686
F test that all u_i=0		16.29 ***	4.81 ***	10.11 ***

Fig. 1

ECB interest rates and money market rates
(June 2000 - August 2001)

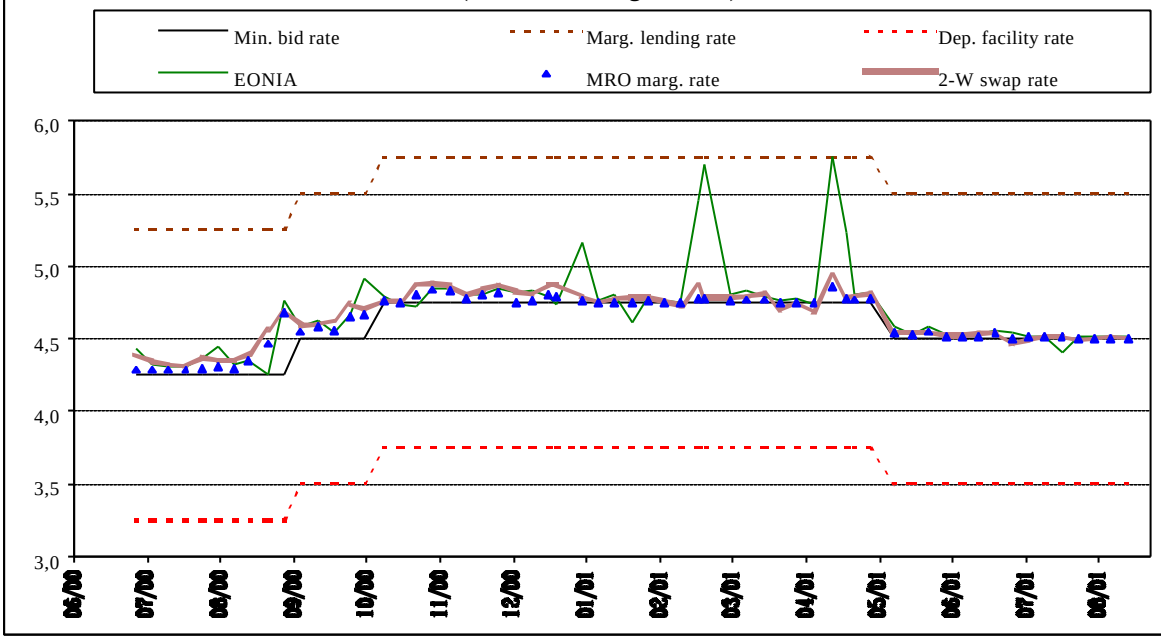

Fig. 2

Total number of bidders
(June 2000 - August 2001)

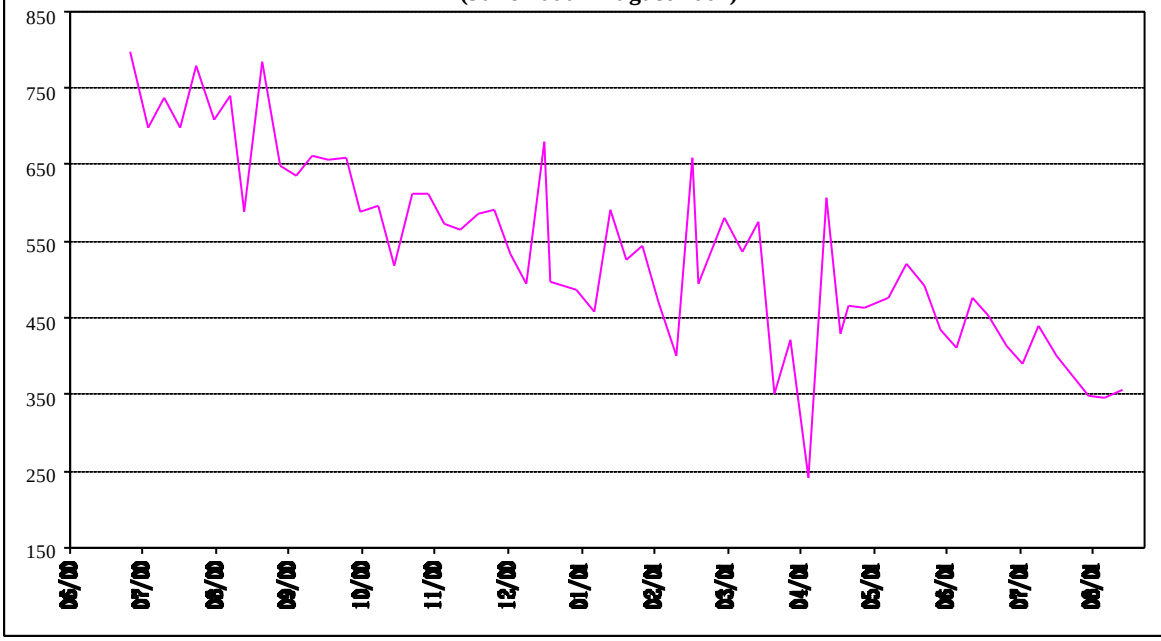

Fig. 3

Aggregate bid amount and allotment
(June 2000 - August 2001)

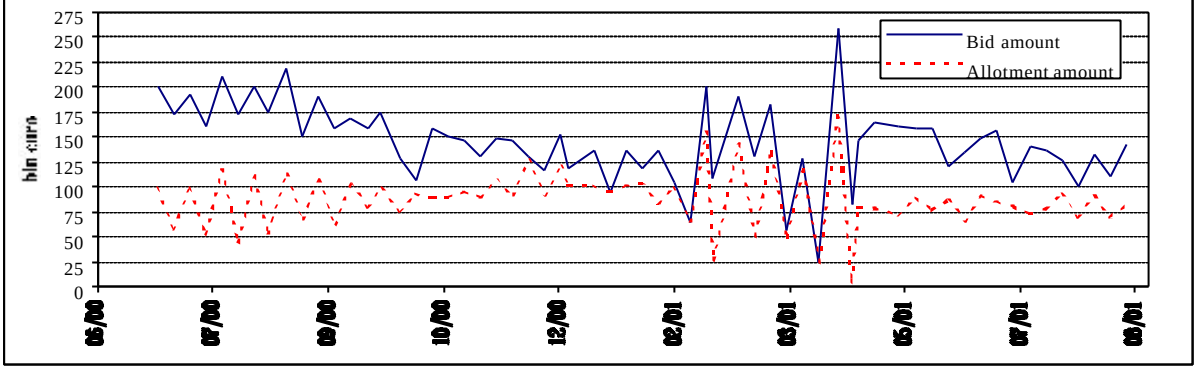

Fig. 4

Minimum rate, avg bid rate, avg allotment rate, marginal allotment rate
(June 2000 - August 2001)

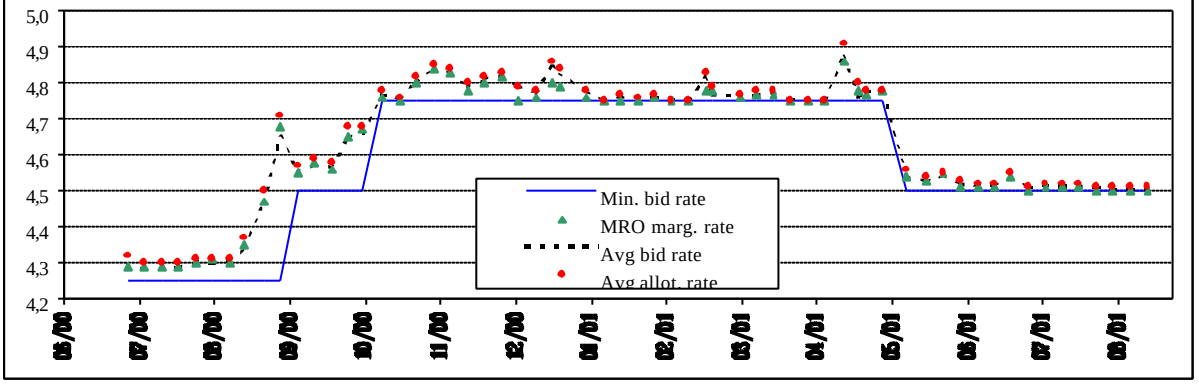

Fig. 5

Weighted standard deviation of bid and allotment rates
(June 2000 - August 2001)

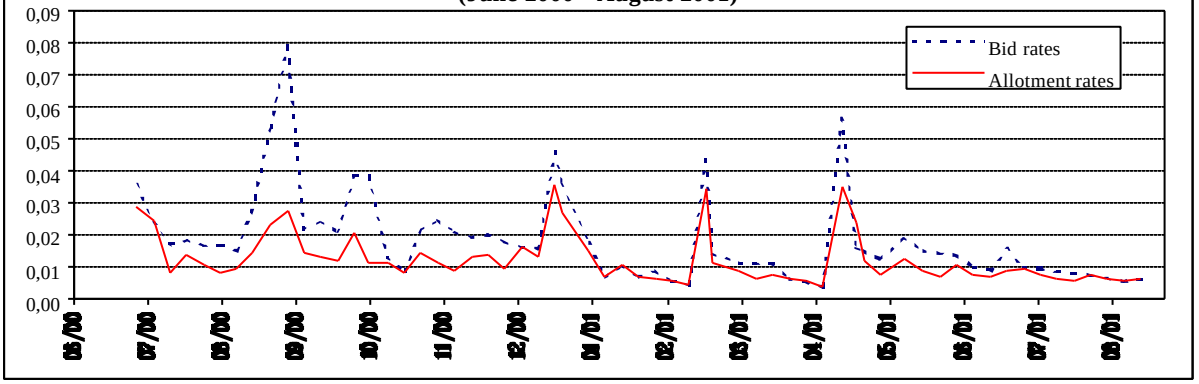

Fig. 6a

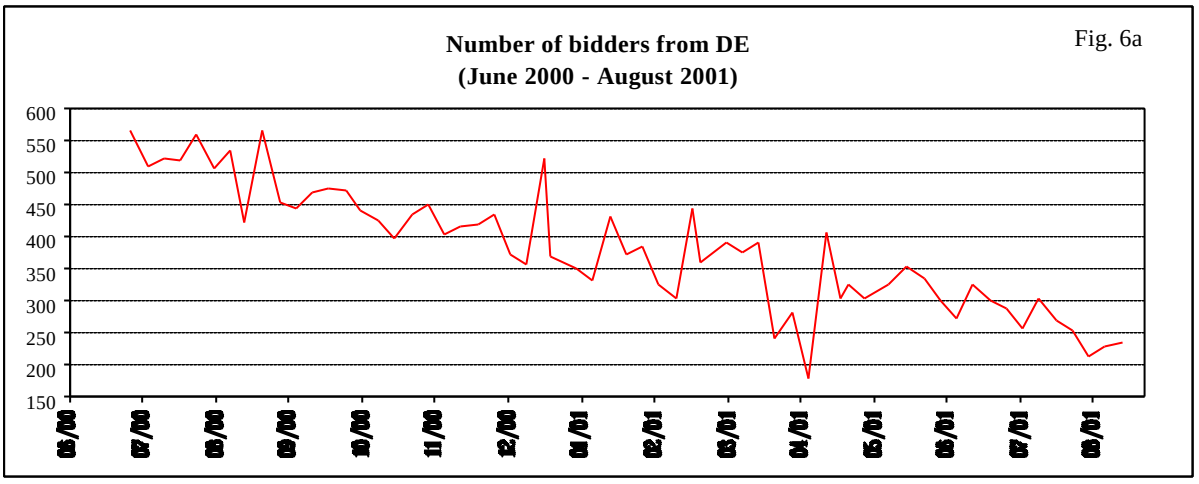

Fig. 6b

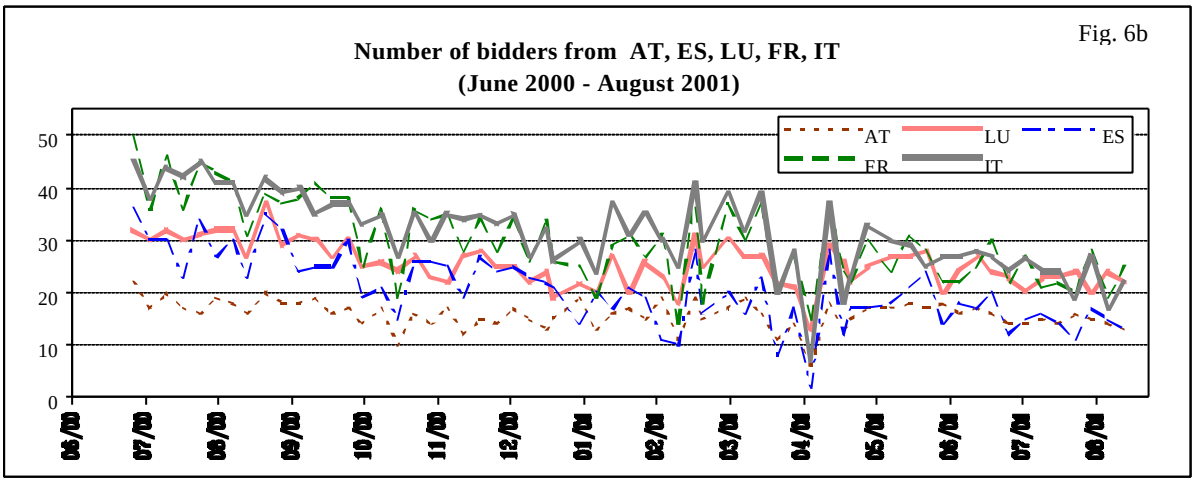

Fig. 6c

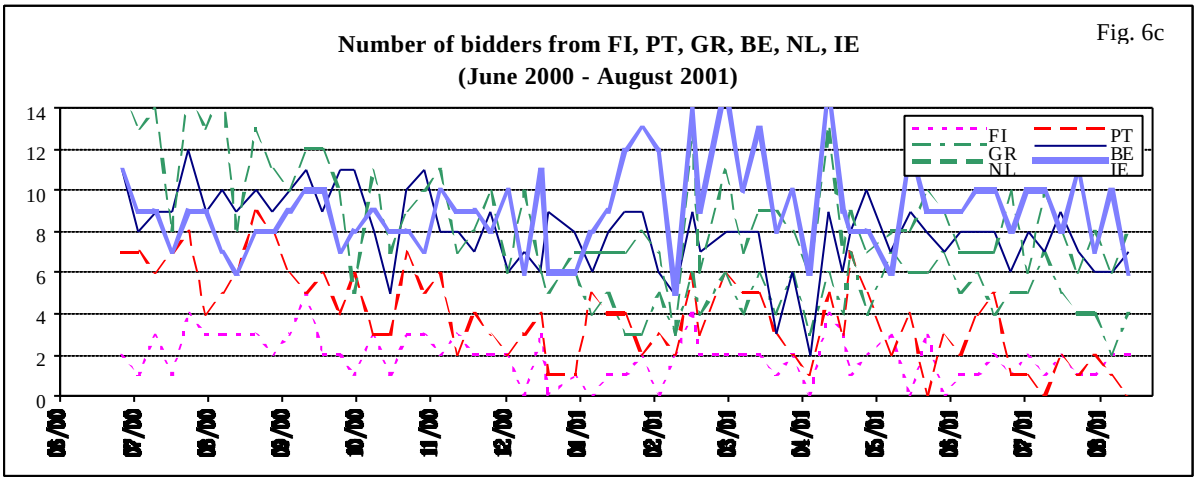

Fig. 7a

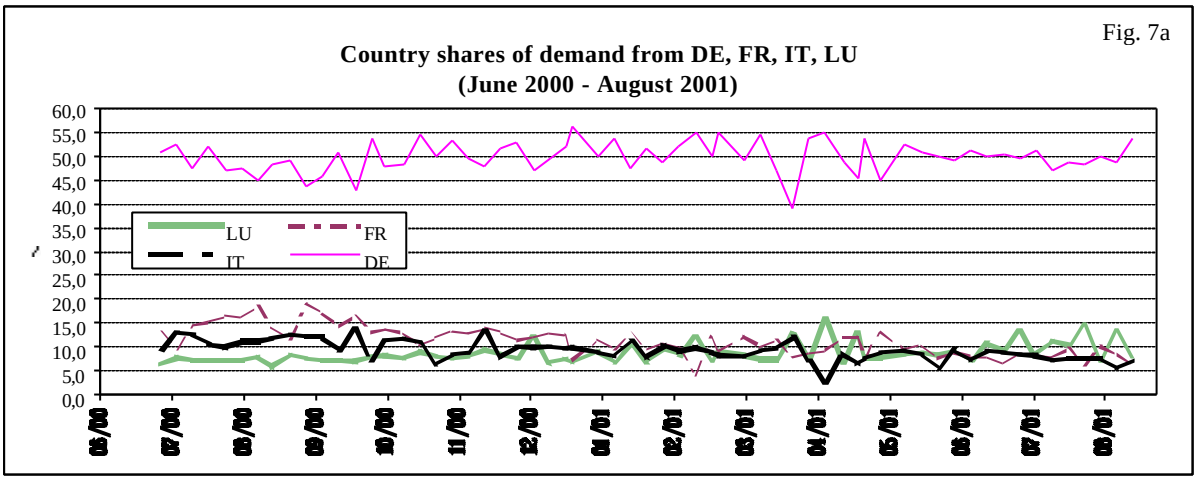

Fig. 7b

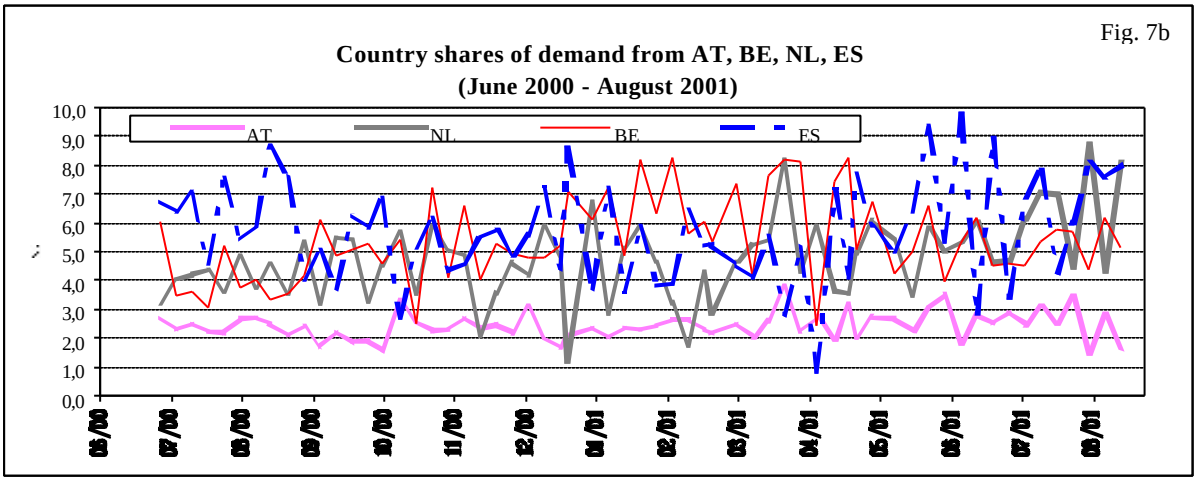

Fig. 7c