



# Declining valuations and equilibrium bidding in central bank refinancing operations ☆

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## ABSTRACT

Among the most puzzling observations on the euro money market are the discount in the weekly refinancing operations, the more aggressive bidding under uncertainty, the temporary flatness of bid schedules, and the development of interest rate spreads. To explain these observations, we consider a standard divisible-good auction with either uniform or discriminatory pricing, and place it in the context of a secondary market for interbank credit. The analysis links the empirical evidence to the endogenous choice of collateral in credit transactions. We also discuss the Eurosystem's preference for the discriminatory auction, the remuneration of reserves, and the impact of the recent market turmoil.

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## 1. Introduction

The euro money market, defined here as the market for euro-denominated short-term credit between counterparties of the Eurosystem, has been challenging economists by exhibiting a variety of puzzling features right from the market's inception in January 1999.<sup>1</sup> One of these features has been that credit seems to be obtainable at more attractive conditions in the primary market, i.e., in central bank operations, than in the secondary market, i.e., in the interbank market.

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<sup>1</sup> Background information on the Eurosystem auctions and the euro money market is provided in Appendix A.

This is counterintuitive because the regular central bank operations in the euro area, the so-called main refinancing operations, are effectively highest-price auctions involving several hundred bidders. How is a discount possible under such tight competition?<sup>2</sup>

The first account and explanation of the discount has been given in a seminal contribution by Ayuso and Repullo (2003) who assume that the central bank has an *asymmetric objective function* and penalizes downwards deviations of the market rate more heavily than upwards deviations. As a consequence, the central bank follows a tight allotment policy, driving the market rate above the policy rate, which explains excessive bidding for central bank reserves. However, the explanation depends on the central bank's use of the so-called fixed-rate tender, through which funds are offered to market participants below market conditions. The model, therefore, cannot account for the spread between primary and secondary market conditions under the variable-tender regime which has been in place following June 2000.

Another potential explanation of the spread between primary and secondary market conditions might be *intermediation* within the banking sector.<sup>3</sup> Indeed, Freixas and Holthausen (2004) have pointed out the role of money centers to distribute unexpected liquidity shocks within the euro area. Intermediation is useful in this context because it reduces the informational frictions of unsecured lending, especially in a cross-border context. However, in contrast to the case of unsecured

<sup>2</sup> See Section 2 for an overview over the empirical evidence.

<sup>3</sup> Neyer and Wiemers (2004) have developed a model along these lines.

interbank lending considered by Freixas and Holthausen, all loans vis-à-vis the Eurosystem have to be fully collateralized. This suggests that informational frictions are not a central feature of lending allotted through Eurosystem tenders.<sup>4</sup> To the contrary, such intermediation is likely to cause unnecessary costs, for instance in terms of regulatory capital usage,<sup>5</sup> counterparty risk, or collateral handling. In sum, this suggests that we should find actually only limited intermediation, at least outside of banking groups, of refinancing that had been received in the Eurosystem tenders.<sup>6</sup> We conclude that intermediation is not likely to fully explain the spread in money market conditions.<sup>7</sup>

To better understand this and other pieces of evidence, the present paper offers a theoretical framework that integrates two institutional features of the Eurosystem's variable-rate tenders. The first element, adopted from Klemperer and Meyer's (1989) analysis of oligopolistic competition, is an *aggregate uncertainty* (potentially small, but not negligible) about the quantity that is eventually allotted in the auction.<sup>8</sup> The second element is an *endogenous choice of collateral* pledged to secure the individual funding transaction. The framework is then used to study equilibrium bidding of commercial banks in Eurosystem auctions in the context of a competitive secondary market, where we allow both the uniform and the discriminatory pricing rule.<sup>9</sup>

The characterization of the equilibrium is shown to have a number of testable implications, which are compared to the empirical evidence. First, we look at the discount between primary and secondary market conditions, as discussed above. The model predicts here that conditions offered through the discriminatory auction are typically strictly below marginal valuations *even if there are many bidders*. This suggests an explanation for the obscure underpricing. Second, empirical research tells us that with more uncertainty in the market, bids are on average placed at higher interest rate levels. Intuitively, these findings reflect the bidder's concern of ending with insufficient liquidity, i.e., the so-called loser's nightmare (cf. Simon, 1994). Here again, the predictions of our theoretical framework are largely supportive of the evidence. We identify, however, also a new effect that might shed additional light on incentives for bid shading in discriminatory auctions. Third, during relatively calm periods, bidders in ECB repo auctions have tended to submit excessively flat bid schedules at the level of the expected stop-out rate. We show here that the slope of bid schedules is "nearly" vanishing when bidders face little uncertainty and the liquidity of collateral assets is high. Again, this matches the evidence. Finally, we

<sup>4</sup> There are also few other frictions. For eligible counterparties, participation in refinancing operations is absolutely free of charges and does not require any specific skills. Moreover, the Eurosystem accepts as collateral a broad range of assets including also very illiquid assets such as credit claims and asset-backed securities. A counterparty that is unable to forward even such collateral is unlikely to obtain any funding at reasonable conditions.

<sup>5</sup> Specifically, a capital charge applies to all unsecured interbank lending outstanding on reporting dates. Cf. Bindseil et al. (2003).

<sup>6</sup> A similar view is taken by Craig and Fecht (2007) who write that "...banks participating in the main refinancing operations only try to provide the liquidity they really need for themselves—particularly for fulfilling of their own minimum reserve requirements—instead of bidding to offer larger parts of the liquidity in the interbank market."

<sup>7</sup> The spread in conditions is also not explained by *differences in collateral standards* between primary and secondary markets. Specifically, the wider class of collateral accepted by the central bank compared to the private market is no reason whatsoever to explain the *lower* rates in central bank tenders compared to the interbank market. To the contrary, the difference in collateral standards between primary and secondary money markets just reinforces the puzzling evidence.

<sup>8</sup> In the euro area, several effects may cause uncertainty about the allotment for competitive bidders. First, aggregate liquidity demand may change between the publication of liquidity conditions and the actual allotment. Second, there may be counterparties with varying needs for liquidity that are constrained due to a lack of suitable collateral and credit rating, and may therefore bid at rates that win with probability one. A third possibility is the central bank's discretion about the allotment volume (on this last point, see also Section 8 and Appendix A).

<sup>9</sup> In either auction, bidders submit demand schedules, and a stop-out rate is determined by equating demand and supply. Then, with uniform pricing, the bidders pay the stop-out rate, while with discriminatory pricing, bidders pay their own bid rates.

discuss another observation, which is the unexpected increase in the so-called Eonia spread with the introduction of an adapted implementation framework in early 2004. Also here, the predictions are in line with the evidence. Specifically, we show that a *ceteris paribus* increase in the size of the auction will lead to a wider spread between conditions in the primary and secondary money markets.

We go on to study the central bank's decision on the pricing rule. Empirically, the ECB seems to have a clear preference for using discriminatory pricing in its main refinancing operations. Indeed, the uniform-pricing rule has been employed for the main operations only in early 1999. To explore this issue, we determine the revenue impact of the pricing rule, and find that in the identified equilibria, expected revenue is strictly higher in the discriminatory auction than in uniform-price auction. This is a somewhat unexpected result because the stronger bid shading in the discriminatory auction had sometimes been understood to actually reduce the auctioneer's expected profits. We also show that the difference may be even more pronounced when required reserves are, so the established terminology, remunerated at the marginal rate, which is the case in the euro area. Finally, we mention another advantage of the discriminatory format, which is related to the signaling role of tender rates.

A remarkable piece of evidence was revealed when market turmoil triggered by the U.S. subprime crisis hit the euro money market. Specifically, it was found that following August 2007, counterparties of the Eurosystem would be willing to pay a premium above benchmark rates for participating in the auction. We apply our formal framework to comment also on these developments.

The rest of the paper is structured as follows. Section 2 reviews the empirical evidence. Section 3 outlines the auction model. In Sections 4 and 5, we characterize bidding equilibria of the uniform-price and discriminatory auctions, respectively, covering the cases of few and many bidders. Section 6 relates our predictions for many bidders to empirical observations for the euro area, while Section 7 discusses the Eurosystem's potential motivation for using the discriminatory format. Section 8 reviews some related theoretical literature. In Section 9, we derive predictions for bidding under market distress. Section 10 concludes. Appendices A through D provide, respectively, background information on the euro money market, anecdotal evidence on bid schedules in the Eurosystem auctions, a mathematical description of the allotment rule, and formal proofs of the propositions.

## 2. Empirical evidence

This section reviews some evidence concerning the puzzles mentioned in the Introduction, i.e., concerning the spread between primary and secondary market conditions, the loser's nightmare, the flatness of bid schedules during calm periods, and the increase in the Eonia spread. We will report here only on those findings that appeared to us as most relevant given the purpose of the present discussion. For a more comprehensive picture, the interested reader is referred to the original contributions.

### 2.1. Discount in the primary market

Consistent with the objectives of the present analysis, we will focus on the period where the Eurosystem employed the discriminatory variable-rate tender for its main refinancing operations, i.e., following June 2000. During this period, the effective average interest rate paid by counterparties in the repo auctions has been the weighted average tender rate. Interbank conditions are more difficult to measure, so that several proxies are used. We know of two papers that test for a positive spread.

Ayuso and Repullo (2003) analyze data for the period June 2000 through September 2001. During this period, the Eurosystem conducted 63 variable-rate tenders with a 2-week maturity. Two alternative measures of the interbank rate have been employed,

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