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How Auctions Reveal Information: A Case Study on German REPO Rates

Securities repurchase agreements (REPOs) have become the Bundesbank's most important tool for its ongoing money market management and the control of the monetary base. In the fall of 1988, the Bundesbank changed the applied auction rule in order to prevent banks from submitting exaggerated bids. Focusing on the information content of a resulting REPO rate, this paper investigates how German money market rates react to auction results. Evidence is provided that the response of the money market to a new REPO rate reflects the applied auction rule.

SINCE THE BEGINNING OF THE EIGHTIES securities repurchase agreements (REPOs) have become the Bundesbank's most important tool of money market management and for the control of the monetary base.[1] The use of REPOs in the provision of central bank money increased dramatically in the second half of the 1980s.[2] As a consequence, the REPO rate governs the interest rates in the money market while the Bundesbank's "key interest rates" (that is, discount and Lombard rate) have lost much of their traditional significance (see Figure 1).

The Bundesbank offers REPOs usually as "interest rate tenders" where bidders submit multiple price-quantity sealed bids, similar to U.S. Treasury bill auctions.[3] Despite all similarities, however, there is a basic difference concerning the objective of the auctioneer: Whereas the U.S. Treasury wants to borrow as cheaply as pos-

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1. In a REPO the Bundesbank buys securities from credit institutions on condition that the seller simultaneously repurchases the securities forward. Similar procedures are applied by some other European central banks (see Kneeshaw and Van den Bergh 1989). For a detailed presentation of the Bundesbank's instruments of monetary policy, see Neumann and von Hagen (1993) or Deutsche Bundesbank (1985, 1994a, 1994b).

2. The corresponding share of REPOs increased from 4 percent in 1980 to more than 60 percent since 1990.

3. In exceptional cases the Bundesbank uses "volume tenders" where the REPO rate is already fixed at the outset.

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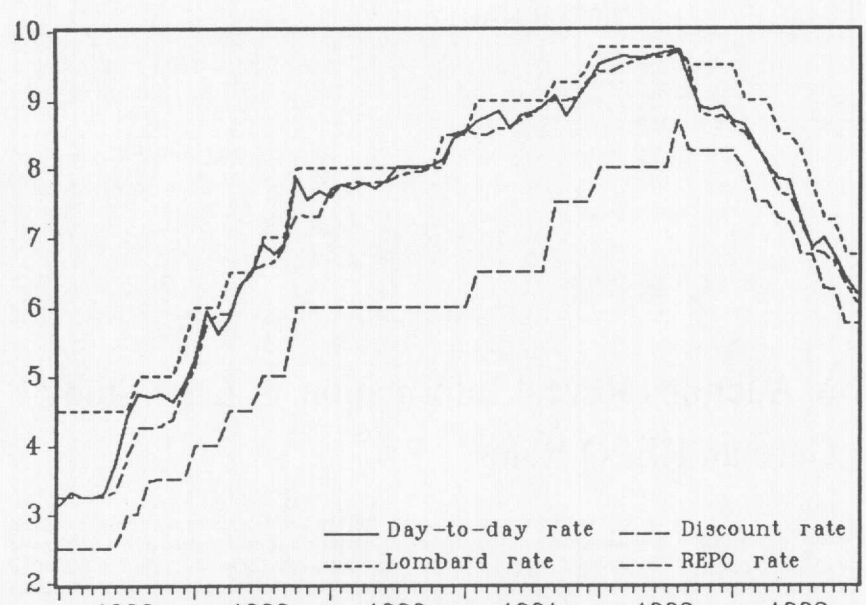

FIG. 1. Interest Rates in the German Money Market. Note: Monthly averages. Source: *Monthly Reports of the Deutsche Bundesbank*, Table VI.3.

sible, the Bundesbank is not a profit maximizer but considers the REPO rate as a fine-tuning instrument of the money market. Therefore, the Bundesbank wants bids to reveal banks' true demand for reserves. For if it is worthwhile bidding at unrealistically high or low interest rates, then there is a risk that neither the Bundesbank (observing the bids) nor the banks (observing the resulting REPO rates) obtain reliable information about the situation in the money market and its expected future trend. If, in the worst case, bids and the resulting REPO rates were completely detached from the actual situation in the money market, REPOs should be abandoned as an instrument of fine-tuning. From the Bundesbank's point of view, an appropriate *type* of auction induces banks to bid as closely as possible to their actual demand.

The Bundesbank has already experienced two different auction rules. Until the fall of 1988 the Bundesbank used the so-called Dutch or competitive auction where all bids are filled at a uniform market-clearing stop-out rate.[4] However, this pricing rule caused bidders to bid at unrealistically high interest rates. Atypical for an auctioneer, the Bundesbank disapproves of this bidding behavior. Switching in the fall of 1988 to the so-called "U.S.-style" auction, the Bundesbank adopted the current discriminatory Treasury bill auction mechanism, where every successful bidder has

4. Notice that in the auction theoretic literature a Dutch auction is a descending price open outcry auction.

to pay his bid.[5] Obviously, a discriminatory auction prevents bidders from exaggerating their bids. However, in the U.S.-style auction a bidder has to *understate* his willingness to pay in order to achieve a positive payoff. Hence, this bidding behavior should also be disapproved by the Bundesbank.

The goal of this paper is to shed some light on how different types of auctions reveal information and how the German money market reacts to that information. In section 1 some theoretical results concerning auctions will be briefly reviewed in order to derive testable hypotheses on the auction specific information content of a REPO rate. In section 2 it will be investigated whether the response of the money market to a new REPO rate depends on the applied auction rule. The last section includes a summary and concluding remarks.

1. THE INFORMATION CONTENT OF OPTIMAL BIDS

At first glance the theoretical results concerning optimal bidding in a Dutch auction contradict the Bundesbank's experience. In a recent paper Nautz (1995) showed that in a Dutch auction with many bidders[6] it is optimal to bid one's true demand. Yet, the Bundesbank has observed bidders to bid at unrealistically high interest rates.

This apparently poor prediction of auction theory stems from the assumption that bids at the stop-out rate are generally awarded the full amount bid.[7] However, similar to the rationing rule used in U.S. Treasury bill auctions, bids at the stop-out rate of REPO auctions are often scaled down by use of a standard allotment rate. Since only bids at the stop-out rate are rationed, submitting "exaggerated" bids at high interest rates avoids rationing. In a Dutch auction, where successful bidders always pay the stop-out rate, this bidding strategy has low expected cost. In fact, submitting exaggerated bids can be optimal in this case (see Nautz 1994). Therefore, optimal bidding reduces the information content of a REPO rate because an unexpectedly high REPO rate can be caused by exaggerated bids. Hence, not much information is revealed in this case, and only a weak reaction of money market rates is to be expected. In contrast, observing a relatively low REPO rate, the money market can be sure about the signal sent from the Bundesbank. This leads to the following testable hypothesis:

HYPOTHESIS 1: *Whenever a Dutch auction is applied, money market rates react particularly strong to an unexpectedly* low *REPO rate.*

A discriminatory auction, on the other hand, prevents bidders from submitting exaggerated bids because bidders have to pay exactly their own bid. However, in a discriminatory auction bidders are caught in a dilemma: in order to make a profit

5. By *the* REPO rate I always refer to the stop-out rate of the auction.

6. When the Bundesbank offers a REPO there are always several hundreds of bidders and a large number of units (that is, securities) for sale.

7. Similar assumptions are drawn from Scott and Wolf (1979).

they have to understate their willingness to pay, thus risking to go empty-handed. Nautz (1995) shows that the bids are actually understated at almost *all* possible interest rates. It follows that bids in the U.S.-style auction are biased downward. Therefore, the money market should obtain more reliable information when the REPO rate is unexpectedly *high*. Hence, due to the change in the pricing rule the reaction pattern of money market rates has been reversed:

HYPOTHESIS 2: *In case of a discriminatory auction money market rates react particularly strong to a relatively* high *REPO rate*.

Since REPOs should work as a fine-tuning instrument in any case, that is, for relatively high *and* low REPO rates, the discussed auction rules are not optimal from a theoretical point of view. Next, in order to analyze the empirical relevance of these effects, it will be examined whether the relation between money market rates and the REPO rate has actually been influenced in the way stated above.

2. THE REACTION OF THE MONEY MARKET: EMPIRICAL RESULTS

In Germany, the most important money market rate is the day-to-day money interest rate. Let me illustrate how the Bundesbank times a REPO auction. Suppose the Bundesbank invites banks to submit bids on Wednesday. Let R denote the rate for day-to-day money immediately *before* the auction, that is, on Wednesday. On Thursday morning the auction result—especially the new REPO rate P—is published. Due to the efficiency of the money market, this information is already reflected completely in the day-to-day money rate on Thursday.[8] To simplify notation, denote this daily change, from Wednesday to Thursday, by ΔR. Notice that, since intervals between subsequent REPO auctions are at least a week, ΔR is *not* the difference of the rate for day-to-day money between two different auction days.[9]

Signals sent through a new REPO rate should be measured by the difference between the REPO rate and the money market rate valid before the auction, that is, in $P - R$. Hence, it would be plausible to call a REPO rate *relatively high* if $P - R$ is above average and *relatively low* in the opposite case. The change of the money market rate, ΔR, would thus be explained by an adjustment to an observed "disequilibrium" between the money supply of the Bundesbank (that is, the REPO rate) and the money market. A reasonable approach to investigate this short-run adjustment process is an error correction model, with the spread $P - R$ as error correction term. As it will be demonstrated in the following, this specification is also justified by the data.[10]

8. On an auction day, bids have to be submitted until 3 P.M. The day after, the auction result is published at 11 A.M. or earlier, whereas most activities on the money market take place between 11 A.M. and 2 P.M.

9. The Bundesbank conducts REPOs at irregular time intervals, although in many periods weekly auctions were predominant.

10. A detailed description of the data can be found in the appendix.

TABLE 1

UNIT ROOT AND COINTEGRATION TESTS

	Unit root tests				Cointegration tests	
x_t	R_D	P_D	R_{dis}	P_{dis}	$(P-R)_D$	$(P-R)_{dis}$
t-value	−2.03	−1.78	−1.46	−1.18	−7.09**	−9.92**

NOTES: The t-value refers to the estimated ρ of the following equation:

$$\Delta x_t = \alpha_0 + \rho x_{t-1} + \sum_{i=1}^{k} \alpha_i \Delta x_{t-i} + u_t .$$

The unit root tests were conducted by taking account of one lag, but the results do not depend on the lag structure.
Subscripts D (that is, Dutch) and *dis* (that is, discriminatory) refer to the applied auction rule. According to MacKinnon (1991) the 1 percent [10 percent] critical value of the performed augmented Dickey-Fuller test statistic is −3.47 [−2.58]. ** denotes significance at the 1 percent level.

Unit Root Tests and Cointegration

Table I shows the results of the unit root tests. Both the rate for day-to-day money and the REPO rate are integrated of order one, while the spread $(P - R)$ is clearly stationary.[11]

Hence, independent of the applied auction rule, the rate for day-to-day money and the REPO rate are cointegrated with a unit cointegrating parameter. This implies (i) that the auction rule did not affect the long-run relation between the REPO rate and the money market rate, and (ii) that it makes sense to interpret unusual gaps between these interest rates as equilibrium errors. Moreover, due to the Granger representation theorem for cointegrated time series (Engle and Granger 1987), the short-run adjustment process of the money market rate *has to be* specified by an error correction model with $P - R$ as the error correction term.

Nonsymmetric Error Correction Models

According to the asymmetry hypotheses stated above, the reaction of the money market rate depends on the type of auction and the "sign" of the equilibrium error. In a traditional error correction model, however, the strength of the adjustment is independent of the sign of the preceding deviation from the long-run equilibrium. Therefore, we have to use the *nonsymmetric* error correction models introduced by Granger and Lee (1989).[12]

In order to guarantee robust results call a REPO rate relatively high whenever the spread $P - R$ is greater than its *median*, and relatively low in the opposite case.[13]

11. Note that the underlying time series are not equidistant due to the Bundesbank's irregular timing of REPOs. However, performing the test of Phillips and Perron (1988) that takes into account the possible heteroskedasticity that might result from this fact left the results unchanged.

12. Granger and Lee (1989, p. 153) argue that, "when choosing the level of production, or its change, it may well matter whether z_{t-1} (previous production–previous sales) was positive or negative. . . ."

13. Referring to the *mean* of the spread did not affect the essential results of the study. Due to the overall development of interest rates before, respectively, after the fall of 1988, the median belonging to the discriminatory auction (that is, −0.09) is slightly smaller than the one belonging to the Dutch auction (that is, −0.057).

TABLE 2

THE ADJUSTMENT PROCESS OF THE MONEY MARKET RATE IN CASE OF A DUTCH AUCTION

ΔR	=	0.05 (3.21)	+	0.75 $(P - R)_{low}$ (12.93)	−	0.02 $(P - R)_{high}$ (0.13)

$OBS = 73 \quad R^2 = 0.72 \quad DW = 1.66$

NOTES: P denotes the REPO rate, R the rate for day-to-day money before the auction, ΔR the (daily) change of the rate for day-to-day money observed after the result of the auction has been published, OBS the numbers of observations, and DW the Durbin-Watson statistic. Absolute values of t-values in brackets.

Thus, I define

$$(P - R)_{high} = \begin{cases} (P - R) & \text{if } (P - R) > \text{median } \{(P - R)\} \\ 0 & \text{otherwise,} \end{cases}$$

and $(P - R)_{low}$ analogously so that

$$(P - R)_{high} + (P - R)_{low} = (P - R) .$$

The Reaction of the Money Market to a Dutch Auction

Table 2 shows the estimation of the nonsymmetric error correction equation in case of a Dutch auction, that is, before the fall of 1988.[14]

The difference between the estimated adjustment parameters is striking, and highly significant. In case of a relatively low REPO rate (that is $(P - R)_{low} \neq 0$) the rate for day-to-day money adjusts almost completely to the observed disequilibrium, whereas in the reverse case (that is $(P - R)_{high} \neq 0$) no significant adjustment takes place. This result supports Hypothesis 1 of an asymmetric adjustment process due to the applied auction rule. Apparently, until the fall of 1988, the information content of a relatively high REPO rate was extremely small. Therefore, the empirical results seem to support the Bundesbank's decision to change the auction rule.

The Reaction of the Money Market to a U.S.-Style Auction

Table 3 shows the estimated asymmetric adjustment process in case of a discriminatory U.S.-style auction, that is, since the fall of 1988. Although the asymmetry is less dramatic, the difference between the two adjustment parameters is still significant.[15]

In accordance to Hypothesis 2, the reaction of the money market rate is stronger whenever the REPO rate is relatively high. This implies that in case of a U.S.-style auction, the information content of a high REPO rate exceeds the information content of a low one.

14. Neither lagged differences of the considered time series nor other potential variables, for example, the share of successful bidders B, showed to be significant.

15. Due to a t-statistic of 1.75, the test against the one-sided alternative predicted by theory leads to a rejection of symmetry at the 5 percent level.

TABLE 3

THE ADJUSTMENT PROCESS OF THE MONEY MARKET RATE IN CASE OF A DISCRIMINATORY AUCTION

$$\Delta R = \underset{(3.57)}{0.06} - \underset{(2.37)}{0.05\ B} + \underset{(8.69)}{0.28\ (P-R)_{low}} + \underset{(5.30)}{0.42\ (P-R)_{high}}$$

$$OBS = 165 \quad R^2 = 0.42 \quad DW = 1.85$$

NOTES: B denotes the share of successful bidders. For further explanations see Table 2.

Furthermore, the estimates demonstrate the increasing importance of REPOs in refinancing, because a high proportion of successful bidders, B, now apparently leads to a significant relief of the money market and decreasing interest rates.

3. CONCLUSIONS

The Bundesbank currently considers REPO auctions as its most important instrument to fine-tune the money market. Therefore, an adequate type of auction requires a reliable link between the outcome of the auction and the money market. In order to enforce this link, the Bundesbank changed the auction rule from a Dutch auction to a discriminatory auction. Neither the Bundesbank nor the publications mentioning this change question the correctness of this decision (see, for example, Deutsche Bundesbank 1994a, p. 41).

By contrast, the pricing rule of the U.S. Treasury bill auction is still under discussion. An early debate centered around the issue of which auction rule maximizes the seller's revenue [see Scott and Wolf (1979) and the literature reviewed therein]. A more recent debate was triggered in the aftermath of the so-called Salomon Squeeze by the claim that discriminatory auctions are susceptible to illegal bidding practices.[16] In view of this claim, the Treasury has recently considered switching exactly into the reverse direction, that is, from the discriminatory to the Dutch auction.

This study has demonstrated that the Bundesbank's change of the pricing rule led to consequences implied by auction theoretical results. It has been shown that in the previously used Dutch auction, the information content of a relatively high REPO rate was poor, which explains why the influence of the Bundesbank on the money market was particularly weak in this case. We then showed that in case of a discriminatory auction, the opposite is true. Although the less dramatic asymmetry in the reaction pattern of money market rates indicates an improvement of the auction mechanism, the skepticism toward the Bundesbank's decision, stirred by the theoretical analysis of bidding behavior, is also confirmed.

Since the asymmetry pattern has been reversed, in abandoning the Dutch auction the Bundesbank seems to have thrown the baby out with the bath water. Auction theoretical results suggest that a removal of the bidding restrictions, for example, a

16. For a detailed assessment of the Salomon Squeeze and some recommended policy changes see, for example, the *Joint Report on the Government Securities Market* (1992).

finer price grid, which would have made rationing less important, might have solved the Bundesbank's problems more effectively.

APPENDIX: DATA DESCRIPTION

The daily money market rates are collected from the *Handelsblatt*, which correspond to a great extent to those of other German financial papers. All other data are taken from the *Monthly Reports of the Deutsche Bundesbank*. The considered auction data refers to interest rate tenders for securities repurchase agreements with the usual maturity. In December 1992 the Bundesbank reduced this maturity from about one month to two weeks.[17] The investigation starts in summer 1980 and ends in December 1993. In this period, seventy-nine Dutch auctions and 181 U.S.-style auctions were performed. In order to avoid possible distortions, we remove six observations from the sample, since from February 1981 to May 1982 Lombard credit was not available to banks.[18] I excluded data of the first twelve discriminatory auctions, taking into account that bidders had to get used to the new pricing rule. Thus, the sample period for this pricing rule starts in February 1989.

At the end of the month the Bundesbank often refrains from supporting the rate for day-to-day money. Due to this fact the interest rates observed on 30 April 1989, on 31 January 1990, and on 31 March 1993 have to be considered as outliers. Furthermore, on 2 November 1990, the Bundesbank increased the Lombard rate exactly on the day a new REPO rate was announced. It is noteworthy that the asymmetry results of this study would have been even stronger if these four observations had been included.

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17. In order to capture this change the rates for day-to-day money were adjusted according to compound interest. However, this adjustment had no relevance for the presented results.

18. Until the mid-eighties in particular, the Lombard credit played an important role as a source of refinancing (see, for example, Deutsche Bundesbank 1985).

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