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The Anatomy of a Call Market[1]

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This paper provides a detailed analysis of the call auction procedure on the Frankfurt Stock Exchange. We develop a direct measure of execution costs in a call auction that is comparable to the bid–ask spread in a continuous market. We find that transaction costs for small transactions in the call market are lower than the quoted spread in the continuous market, whereas transaction costs for large transactions in the call market are higher than the spread in the continuous market. An analysis of specialist (Makler) participation shows that Maklers provide a valuable service to the market. On average, their compensation is restricted to commission income rather than trading profits. *Journal of Economic Literature* Classification Numbers: G10. © 2001 Academic Press

Key Words: call auctions; transaction costs; bid–ask spread; specialist behavior.

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1. INTRODUCTION

Call market trading bears a close resemblance to the textbook Walrasian tâtonnement process and is frequently considered to be an efficient way of organizing securities trading. The temporal consolidation of order flow may enhance price discovery and reduce the price impact of individual orders. On the other hand, call markets do not offer immediate access to the market and therefore impose waiting costs on investors. This trade-off has been formalized by Garbade and Silber (1979).

Many exchanges rely on call markets to establish opening and closing prices but employ some form of continuous trading mechanism throughout the rest of the trading day.[2] The co-existence of call and continuous markets allows investors to choose between two differently organized markets, raising the question whether execution costs are lower in call or in continuous markets. Although this issue is of obvious importance, the available empirical evidence is ambiguous, perhaps due to the absence of a direct measure of the execution costs in a call market. Previous research has relied on indirect measures of execution costs or estimated implicit spreads from transactions data using the serial covariance estimator developed by Roll (1984).

The present paper develops a direct measure of the execution costs in a call market. The measure is conceptually similar to the bid–ask spread and allows us to compare empirically the execution costs in the call auction to those in the continuous trading session. The data set we use (from the Frankfurt Stock Exchange (FSE)) allows us to study the role of the specialist in price setting. In particular, we look at whether the participation of a specialist in a call market is desirable. Although it may appear obvious that the presence of an intermediary enhances the liquidity of the market, call auctions in electronic markets often dispense with the function of an intermediary.[3] To shed light on the function of the specialist in a call auction we analyze his or her impact on transaction prices and measure the profitability of the trades the specialist makes on his or her own account. Our study thus contributes to the understanding of the economic function of specialists in a call market.

Our paper is related to recent work by Amihud, Mendelson, and Lauterbach (1997). They analyze the gradual transfer of stocks from call market trading to

[2] The New York Stock Exchange, the Paris Bourse, the Frankfurt Stock Exchange, and the London Stock Exchange's electronic trading system SETS establish the opening price in a call auction. In Paris, Frankfurt, and London there is also a closing call auction. Trading around the close has recently attracted a great deal of interest from researchers. Both Cushing and Madhavan (2000) and Hillion and Suominen (1998) empirically analyze trading behavior and return patterns during the last trading minutes of the day. Cushing and Madhavan (2000) explicitly suggest adopting a closing call auction at the NYSE and NASDAQ.

[3] The call auctions for the DAX stocks in the German XETRA system are held without intervention of an intermediary. The same holds true for the call auctions in the SETS system of the London Stock Exchange.

continuous trading on the Tel Aviv Stock Exchange. Using event study methodology, they find that switching to continuous trading is associated with significantly positive abnormal returns. Liquidity (as measured by trading volume and the liquidity ratio) increases after the introduction of continuous trading.[4] Amihud, Mendelson, and Lauterbach (1997) also provide evidence that continuous trading improves the efficiency of the price discovery process. There are two important differences between their work and ours. First, they compare a situation where stocks are traded exclusively in a call market to a situation where they are traded continuously.[5] Second, they do not measure the execution costs in the call auction directly but rely on approximate measures such as trading volume and the liquidity ratio developed by Cooper, Groth, and Avera (1985).[6]

The results of Amihud, Mendelson, and Lauterbach (1997) contrast with the widely held belief that the temporal consolidation of the order flow in the call market leads to reduced transaction costs. To resolve this apparent contradiction we develop a direct measure of the execution costs in a call market. We implement it using a unique data set that comprises information on individual orders submitted to the call auction. In a first step we use the order book information to calculate the market clearing price. We then add a hypothetical market buy order of given size to the order book and recalculate the market clearing price. The change in the market clearing price is interpreted as the price impact of the order. We repeat the procedure for a sell order. The addition of the price impact of a buy and a sell order of equal size results in an estimate of the bid–ask spread in the call market.

Our empirical results document that the transaction costs for small transactions in the call market are lower than the quoted spread in the order book of the continuous market, whereas transaction costs for large transactions in the call market are higher than the spread in the continuous market. Although the latter finding is evidence of insufficient market depth, it does not necessarily imply that the depth in call markets is generally insufficient to accommodate large orders. Our transaction cost measure is based on hypothetical prices calculated from all orders

[4] Brooks and Su (1997) compare execution costs in the NYSE opening call auction and the continuous trading session and conclude that a small liquidity trader can reduce transaction costs by trading in the opening call auction rather than in the continuous market. The method of Brooks and Su (1997) is, however, based on the assumption that an additional order submitted to the call auction would not cause the opening price to change. This is equivalent to assuming that an order submitted to the call auction does not have a price impact. The authors address this problem by rerunning their simulations and adding a one-tick penalty to the opening price whenever the trading volume at the opening is no more than ten round lots. Both the magnitude of the simulated transaction cost and the condition under which it is imposed are, however, ad hoc.

[5] Amihud, Mendelson, and Lauterbach (1997) do, however, analyze pairs of so-called twin stocks (pairs of stocks with identical cash flow rights but differing voting rights) where only one class of shares was transferred to the continuous trading mechanism. They find abnormal returns for both classes of shares. The abnormal return for the class that is being transferred is higher.

[6] Both measures may be inappropriate. First, trading volume in two differently organized markets is not necessarily related to the execution costs, particularly if the trading hours in the markets differ. Second, the suitability of the liquidity ratio as a measure of market liquidity is questionable (see Bernstein, 1987, and Grossman and Miller, 1988).

submitted to the closed order book. This abstracts from the potentially beneficial function of the specialist.

We therefore provide an analysis of the specialist's function and his or her impact on the market outcome. Our data set enables us to identify the trades the specialist makes on his or her own account. We can thus eliminate these trades and determine the price that would have obtained without the specialist's participation. Comparing this resulting series of hypothetical prices to the actual transaction prices, we find that specialist participation reduces return volatility. A further analysis shows that the actual prices are closer than the hypothetical prices to the surrounding prices of the continuous trading session. These results indicate that the specialist provides a valuable service to the market. To assess the cost of this service we calculate the specialist's trading profits and find them to be indistinguishable from zero. His or her compensation thus appears to be restricted to the commission received. These results are consistent with those reported by Madhavan and Panchapagesan (2000). They analyze the NYSE opening auction and find that specialist participation enhances price discovery and reduces return variability. The returns earned on the specialist's transactions are “relatively modest” (Madhavan and Panchapagesan, 2000, p. 655), though significant.

Our results have important implications. A direct measure of execution costs in a call auction is a prerequisite for resolving the trade-off between the reduction in transaction costs through the temporal consolidation of the order flow on the one hand and the reduced accessibility of the market on the other hand. The application of our measure may help to answer the question of whether less liquid stocks should be traded continuously rather than once per day in a call auction.[7] For those cases where investors have the choice between call auctions and continuous trading, our results provide evidence on where execution costs are lower. The findings imply that call market trading is a means of reducing execution costs for small orders. Furthermore, the results on specialist participation indicate that the participation of an intermediary in the auction is beneficial. This has implications for the design of electronic call auctions. Specifically, recent attempts to incorporate intermediaries into electronic call auctions for less liquid stocks, as for example the *Betreuer* in Frankfurt and the *animateur* in Paris, are likely to enhance the liquidity of the market.

The remainder of the paper is organized as follows. Section 2 describes the organization of trading at the Frankfurt Stock Exchange, while Section 3 describes our data set. In Section 4 we analyze the determinants of the market share of the call and continuous market. Section 5 describes our measure of transaction costs in the call auction and compares the transaction costs to those in the continuous auction, while Section 6 is devoted to analyzing the impact of specialist participation. Section 7 concludes the paper.

[7] This is as yet an unresolved issue. Using volume-based measures of liquidity, Kairys, Kruza, and Kumpins (2000) and Kalay, Wei, and Wohl (1999) provide evidence that the liquidity of small firm stocks may be impaired by the switch to a continuous trading system. A direct measurement of the execution costs in the call auction may shed more light on this important issue.

2. THE TRADING MECHANISM

The FSE is by far the largest of the eight German stock exchanges. During our sample period trading starts at 10.30 a.m. with an opening call auction. For this auction as well as for the continuous trading session and the closing call auction at 1.30 p.m. only round lot orders are admissible.[8]

The auction is conducted by the *Amtlicher Kursmakler* (henceforth Makler). His or her position is similar, but not identical, to that of a NYSE specialist. The Makler matches buy and sell orders and sets a price according to the rules issued by the exchange. He or she is allowed but, unlike the NYSE specialist, not obliged to trade on his or her own account.

Several stocks are assigned to each Makler, who has exclusive access to the order book. On the basis of the orders in the book and additional orders communicated verbally on the floor, the Makler announces a tentative price or a tentative spread, known as a *Taxe*. Thereafter, floor traders can revise and submit new orders. The Makler then determines the price that maximizes the trading volume. The exchange rules governing the price setting process, which have been in effect since February 1996, prescribe that in the event of there being no unique market clearing price, the Makler must fix the price which is closest to the preceding transaction price. Deviations from this rule have to be "justifiable."[9] The Makler's scope of discretion regarding which price to choose is thus rather limited. In case there is excess demand or supply the Makler may (but is not obliged to) take the other side of the trade, thereby trading on his or her own account.

The midday call auction (usually called the *Kassamarkt*) is held at noon. Here, odd lot orders are allowed. Therefore, the average order size is smaller than in the opening or closing auction.

Between the call auctions, a continuous trading mechanism called *variabler Handel* is in operation. As in the call auction, the Makler is allowed to trade for his or her own account, but there is no affirmative obligation to do so. Limit orders in his or her book must be filled with priority. The Makler quotes bid and ask prices that may either represent limit orders in his or her book or intended proprietary trades. In practice, the Makler is involved in the majority of the transactions. Freihube *et al.* (1999) report participation rates ranging from 18.4 to 71.4% of the trading volume. The (unweighted) average across stocks is 43.3%. Madhavan and Sofianos (1998, Table 1) report mean participation rates of 27 and 25%, respectively, for the two samples of NYSE stocks they analyze. It becomes clear from this comparison that the Makler is an important market participant.

[8] Fifty or 100 shares (depending on the par value) constitute a round lot. The minimum order size requirement was abolished in 1999. The trading hours were extended in July 1998 and again in 2000. Trading now starts at 9 a.m. and extends until 8 p.m.

[9] "Begründbar" (justifiable) is the phrase used in the exchange rules. An explanation of what is "justifiable" is not given. A regulatory unit at the exchange (Handelsüberwachungsstelle) is responsible for the surveillance.

Investors who trade on the floor must pay a commission (*Courtage*) of 0.04% for stocks included in the DAX index and 0.08% for all other stocks.[10] Thirty percent of this commission goes directly to the Makler to whom the traded stock is assigned. The rest is paid into a pool, which is distributed among the Maklers.

During our sample period the computerized trading system IBIS, *Integriertes Börsenhandels- und Informationssystem* (which, in November 1997, was replaced by XETRA, *Exchange Electronic Trading*) was operated parallel to the floor. The stocks in our sample were all eligible for trading in this system. IBIS was an anonymous electronic open limit order book. No call auctions were conducted in IBIS. Traders were free to act as market makers, i.e., to permanently quote bid and ask prices, but there was no obligation to do so.[11] A transaction occurred whenever a standing bid or ask was accepted. IBIS trading started at 8:30 in the morning, two hours before the floor opened, and extended until 5 p.m. The system remained active during floor trading hours. Maklers were allowed to trade in IBIS.

3. DATA

Our data set was provided by a supervisory unit at the exchange (*Handelsüberwachungsstelle*) and augmented by the handwritten notes of the Maklers. These contain transactions resulting from orders not routed electronically into the order book but communicated verbally on the floor.

The final data set contains the complete order book for each of the three daily call auctions. It also covers all bid and ask quotes and the order book prior to each transaction of the continuous trading session on the floor. Sales and purchases by the Makler are identified. As our analysis focuses on call market trading and as there are no call auctions in IBIS, we restrict most of our analysis to data from the floor of the Frankfurt Stock Exchange. However, to check the robustness of our results we also obtained time-stamped data on transaction prices and volumes in IBIS. Data on bid and ask prices from the electronic trading system are, unfortunately, not available.

The sample consists of 15 stocks and spans the 21 trading days from September 26 through October 25, 1996. The sample selection process is structured such that stocks of differing liquidity are represented.[12] Ten of the sample stocks are part of

[10] Rates for floor brokers (*Freimakler*) are lower. Institutional investors may reduce the commission by transacting through a Freimakler and negotiating the commission with him or her. The rates given in the text are thus upper bounds to the commission actually paid.

[11] Unfortunately, neither data on IBIS bid and ask prices nor transactions data revealing the identity of the traders are available. We are therefore unable to provide information on the degree of market making in IBIS.

[12] The 100 stocks forming the indices DAX (the 30 most liquid stocks) and MDAX (a mid-cap index consisting of 70 stocks) are ranked according to their 1994 DM trading volume. We first select the three stocks with the highest trading volume. We then select four of the stocks ranking 4–10, two of the stocks ranking 11–20, four of the stocks ranking 21–50, and three of the stocks ranking 51–100.

TABLE I
Stocks in the Sample

Quintile	Firms	Market capitalization (Dec. 1996, million DM): Total	Market capitalization (Dec. 1996, million DM): Free	FSE trading volume 9/26–10/25, 1996 (million DM)	Percentage of total trading volume in the call auctions: Open	Noon	Close	Total
I	Daimler Deutsche Bank Siemens	43,549.7	35,218.0	638.14	11.3	4.90	6.16	22.36
II	Mannesmann Bayer Volkswagen	30,359.7	27,828.7	498.17	10.5	6.63	7.20	24.33
III	Dresdner Bank Viag BMW	19,525.0	9,466.7	274.77	9.54	8.36	10.34	28.13
IV	Karstadt FAG Kugelf. Continental	2,756.3	1,689.3	81.08	12.37	9.59	12.14	34.10
V	Heidelbg. Zem. VEW Dt. Babcock	4,181.0	883.0	22.24	16.89	17.48	13.72	48.09
Average		20,074.3	15,017.1	302.88	12.12	9.37	9.91	31.40

Note. Figures on market capitalization are taken from the Fact Book 1996 issued by Deutsche Börse AG. The free float is the part of the equity not closely held. Figures on equity holdings used to calculate the free float are taken from Hoppenstedt Aktienführer and double-checked against other sources. Stocks are sorted into quintiles by trading volume. Quintile I contains the stocks with the highest volume. The stocks belonging to each quintile are listed in the second column.

the DAX index, which comprises the 30 most liquid German stocks. The remaining five sample stocks are contained in the MDAX, a mid-cap index comprising 70 stocks. Average prices remain relatively stable during the sample period, and both realized and expected volatility are low.[13]

Table I provides summary statistics for the sample. The table reveals considerable variation with respect to market capitalization and trading volume across stocks. The average stock in the largest quintile has more than 10 times the market capitalization and nearly 30 times the trading volume of the average stock in the smallest quintile. A comparison of the total capital and the free float (defined as the fraction of the equity that is not closely held) reveals that there are large differences in the fraction of the capital held by long-term shareholders.

Stocks from these groups are selected randomly. One stock is discarded from the data set. The Makler handling this stock retired and the data on proprietary trades is, therefore, unavailable. Our final data set thus consists of 15 stocks.

[13] Expected volatility is measured using the VDAX (DAX volatility index) which is calculated on the basis of implied volatilities from index option prices. The average VDAX values for September and October 1996 were 11.29 and 10.95%, respectively, as compared to yearly averages of 14.6, 12.5, and 23.4% in 1995, 1996, and 1997.

4. TRADING VOLUME IN THE CALL AND CONTINUOUS MARKETS

The co-existence of call auctions and continuous trading sessions offers market participants the opportunity to choose between two different trading mechanisms. Both Admati and Pfleiderer (1988) and Spiegel and Subrahmanyam (1995) show that liquidity traders who enjoy a certain degree of latitude in the timing of their trades have an incentive to pool their trades. In Spiegel and Subrahmanyam (1995) this incentive results from the desire to optimally share inventory risk in the absence of asymmetric information. In Admati and Pfleiderer (1988) liquidity traders pool their trades to protect themselves against losses to informed traders. A call auction may serve as a focal point for this endogenous temporal consolidation of the order flow (Pagano and Röell, 1990, 1992).

It is often hypothesized that call markets are especially suited to low-volume stocks (see, for example, Stoll, 1985). This is supported by empirical evidence indicating that adverse information is a more severe problem for less liquid stocks (Easley *et al.*, 1996, and studies analyzing the components of the spread, e.g., Stoll, 1989, George *et al.*, 1991). These arguments lead to the hypothesis that the fraction of the trading volume in call markets is negatively related to total trading volume and market capitalization.

Table I reports the trading volume for the three call auctions as a percentage of the total trading volume on the Frankfurt Stock Exchange. Relating these figures to the total trading volume, also shown in the table, yields striking results. The percentage of the call market trading volume is strongly negatively correlated to the total trading volume. The correlation coefficients are −0.54 for the opening call auction, −0.75 for the noon auction, −0.68 for the closing auction, and −0.81 for the aggregated call market volume.[14] Each coefficient is significantly different from zero at better than the 5% level (two-tailed test). These results are consistent with those reported by Stoll and Whaley (1990), Lehman and Modest (1994), and Schmidt *et al.* (1995) and lend strong support to the hypothesis that the advantages of call market trading are more pronounced for less liquid stocks.

We proceed by asking whether there are systematic differences between the orders that are submitted to the call auctions and those submitted to the continuous trading session. Traders face a trade-off between immediate order execution in the continuous market and the likelihood of lower transaction costs in the call auctions. An analysis of the average transaction size may shed light on the question of whether this leads to a self-selection "bias." Table II reports the average size of limit orders that were executed in the three call auctions and the continuous auction.[15]

[14] The results for the noon auction and for the total call auction volume may be biased by the fact that odd lot orders can only transact in the noon auction. This potential bias is not present in the figures given for the opening and closing auctions. Each order submitted to one of these auctions was also eligible for the continuous trading sessions. Relating the trading volume in the call markets to the total trading volume including the trading volume in IBIS yields very similar results.

[15] Similar calculations for market orders cannot be performed because our data set does not contain information on the number of market orders. It only contains the total number of shares offered and sought by these market orders.

TABLE II
Order Size

Volume quintile	Call auctions Open	Noon	Close	Continuous trading session
I	45,829.87	8,431.83	350,733.33	99,196.13
II	92,960.67	8,953.90	259,118.33	163,316.67
III	89,071.27	18,424.00	315,133.33	157,850.00
IV	32,303.80	18,668.20	100,215.17	67,727.77
V	34,576.10	16,259.00	40,599.83	40,483.33
Average	58,948.34	14,147.39	213,160.00	105,714.78

Note. The table gives the median size (in DM order volume) of executed limit orders in the call auctions and the continuous trading sessions. We report medians because the distribution of order sizes is heavily skewed. Stocks are sorted into quintiles by trading volume. Quintile I contains the stocks with the highest volume.

The figures show that, as expected, the average order size is much lower in the noon auction. The table also reveals that the average size of executed orders in the continuous trading session is higher than the order size in the opening auction but lower than the order size in the closing auction.

The closing auction is special not only with respect to order size. The number of executed limit orders in the closing auction is low despite a considerable trading volume. Even for the most liquid stocks it frequently happens that no limit order is executed in the closing auction. This suggests that the closing auction is used to match market orders at a price set by the Makler. The high average order size is consistent with market participants desiring to close positions at the end of the trading session. This is evidence of inventory control similar to that predicted by Brock and Kleidon (1992) and documented empirically by Chan *et al.* (1995).

5. THE COST OF TRANSACTING IN CALL AND CONTINUOUS MARKETS

In the call market the temporal consolidation of the order flow and the simultaneous execution of multiple transactions at a single price may be associated with lower transaction costs. There are two arguments in support of this view. First, the call market protects limit order traders from being "picked off" because their orders are executed at the market clearing price rather than at the specified price limit. Second, potential insider profits (and thus losses incurred by uninformed traders) are smaller in a call market than in a continuous market because there is only one transaction at a single market clearing price and insiders are, therefore, not able to price discriminate.[16] Both arguments imply that there is less need for

[16] This argument is the basic intuition behind the model of Kyle (1985). There, insider profits in the continuous auction are twice as large as those in the single auction.

limit order traders to adjust their price limits to account for the adverse selection problem. This, in turn, implies that transaction costs are lower in the call market.

Measuring Transaction Costs in the Call Market

An empirical comparison of the execution costs in call and continuous markets requires the existence of a valid measure of execution costs. In a continuous market these costs can readily be measured by the bid–ask spread. Assuming that the spread midpoint is the best available estimate of the asset's value from the perspective of an uninformed investor, the spread measures the difference between this value estimate and the transaction price and is, therefore, a valid measure of the execution cost.

In a call market no explicit bid–ask spread exists. It is, however, possible to construct a measure that is directly comparable to the bid–ask spread.[17] We again take the point of view of an uninformed investor and assume that the market clearing price resulting without his or her order is the best estimate of the asset value available to him or her. If the investor submits an order this may cause the market clearing price to change. The difference between the market clearing price with and without his or her order is a valid measure of the price impact of his or her order and, therefore, of the execution cost.

Since our data contain information on all orders submitted to the call auction we can measure the price impact of an individual order. We proceed as follows. We eliminate the position taken by the Makler since the Makler decides on his or her participation in the trade after having observed the orders submitted by other traders. Elimination of the Makler enables us to consider only those orders that have been submitted without knowledge of the order book.[18]

Our next step is to calculate the market clearing price using the order book information. The market clearing price is defined as the price that maximizes the trading volume in shares. If there is no single market clearing price, we choose the price in the middle of the interval of market clearing prices.[19]

In order to measure the price impact of an additional order, we recalculate the market clearing price after adding, first, a market buy and, second, a market sell order to the order book. Our estimate of the bid–ask spread in the call market is

[17] Madhavan (1996) proposes a conceptually equivalent measure in the context of a theoretical model.

[18] When analyzing the orders that have actually been submitted to the market while eliminating the position taken by the Makler, we are implicitly assuming that the order flow would have been the same if the Makler had not been present. We believe that this is not a critical assumption for several reasons. First, the actions of the Makler are largely unobservable. Second, prior to this paper there has been no empirical investigation of his or her role. There was thus only very limited, if any, information about the extent of Makler participation. Third, the exchange rules put into effect in February 1996 leave the Makler only very little latitude. Taken together, these arguments imply that investors cannot easily condition their orders on anticipated Makler behavior. Therefore, the shift in strategy by limit order traders in the absence of the Makler is unlikely to be an important factor.

[19] Alternatively, we use the price which is closest to the previous transaction price. This alternative price setting rule leads to very similar results.

simply the sum of the price impact of a buy order and a sell order of equal size. We calculate the measure separately for the opening, noon, and closing auctions. This distinction is useful given the different average order sizes documented in Table II.

In order to address the issue of market depth we choose two different order sizes: (1) a small order size equal to one round lot and (2) a large order size equaling the average size of limit orders executed in the call auctions for the stock in question, rounded to the next round lot. The cross-sectional average of the DM volume associated with one round lot is DM 15,500 (approximately US $10,000), whereas the corresponding cross-sectional average for the larger order size is slightly more than DM 200,000 (US $130,000).

The results on execution costs in the call market are presented in Table III. The average cost for a small transaction is 0.332% for the opening auction, 0.15% for the noon auction, and 0.162% for the closing auction. Higher transaction costs at the opening auction indicate that a given order imbalance has a larger price impact. Our result is thus consistent with the finding by Amihud and Mendelson (1987) and others that the volatility of open-to-open returns is larger than the volatility of close-to-close returns.

Transaction costs for large transactions are much higher. This is, of course, not surprising. What is surprising, however, is the magnitude of the increase. The average execution costs for large transactions are 2.369, 1.596, and 1.423% for the

TABLE III
Transaction Costs in the Call and Continuous Markets

	Transaction costs in the call market (%)								Bid–ask spread in the continuous market (%)		
	Open		Noon		Close		Average			Effective	
Quintile	Small	Large	Small	Large	Small	Large	Small	Large	Book	Small	Large
I	0.005	0.367	0.018	0.386	0.018	0.342	0.014	0.365	0.263	0.051	0.064
II	0.093	0.955	0.092	0.579	0.046	0.430	0.077	0.655	0.391	0.078	0.116
III	0.256	2.100	0.091	1.212	0.082	1.202	0.143	1.505	0.407	0.104	0.119
IV	0.330	2.174	0.117	1.070	0.059	0.839	0.169	1.361	0.519	0.258	0.341
V	0.974	6.250	0.432	4.731	0.605	4.303	0.670	5.095	1.647	0.842	0.865
Average	0.332	2.369	0.150	1.596	0.162	1.423	0.215	1.796	0.645	0.266	0.301

Note. Transaction costs in the call market are measured as follows. We use all customer orders submitted to the auction. We then add an additional market buy order and calculate the hypothetical market clearing price. Analogously, we add a market sell order to the book and calculate the resulting price. The difference between these prices is our spread measure. We choose two different order sizes, one round lot (small) and the average size of executed limit orders for the stock in question (large). Transaction costs in the continuous market are measured by the book spread and the effective bid-ask spread. The book spread is defined as the quoted spread calculated from the orders in the order book. This measure is comparable to the transaction cost measure for the call market because it is calculated on the basis of customer orders only. The effective spread is the average spread for the transaction volume quintile that corresponds to the order size used to calculate the transaction costs in the call market. Stocks are sorted into quintiles by trading volume. Quintile I contains the stocks with the highest volume.

opening, noon, and closing auctions, respectively. They are thus approximately seven to ten times as high as those for small transactions.[20] This is evidence of insufficient market depth, particularly at the opening auction.

Transaction costs decrease almost monotonically across trading volume quintiles. The correlation between the average transaction cost in the call auction and the log of the total trading volume is −0.76 for the small transaction size and −0.62 for the large transaction size.

Comparison of Transaction Costs

The figures in Table III allow a direct comparison of transaction costs in the call market to those in the continuous auction. We use two measures of transaction costs for the continuous trading session. The first is the *book spread,* defined as the spread calculated from the orders in the order book.[21] It is comparable to the transaction cost measure for the call market because it is calculated on the basis of customer orders only. The *effective spread,* which measures the cost ultimately borne by the investors, is lower than the book spread for two reasons. First, the spread quoted by the Makler is usually inside the book spread, reflecting his or her willingness to trade for his or her own account. Second, more than 45% of the transactions occur at prices inside the quoted spread (Freihube *et al.*, 1999).

Since the effective spread is increasing in the transaction volume, we have to control for order size when comparing the effective spread to the transaction cost measure in the call auction.[22] We proceed as follows. We sort the transactions in the continuous trading session into quintiles according to the transaction volume. Next, we calculate average effective spreads for each quintile. We compare the spread for the smallest quintile to the transaction cost for small transactions in the call market (as defined above). The transaction costs for large orders in the call market are contrasted with the average effective spread for the corresponding order size quintile.[23]

[20] Bear in mind that our transaction cost measure abstracts from potential benefits of the Makler's own trading activities. It is therefore likely to overstate the actual transaction costs paid by investors at the Frankfurt Stock Exchange.

[21] Our data set contains the order book immediately before a transaction occurs. If the transaction is triggered by a limit order, the spread in the order book is zero or negative because the limit order that triggered the transaction is already contained in our data set. We eliminated these observations. The book spread reported in Table III is thus calculated as the average quoted spread in the order book where an observation is recorded prior to each transaction triggered by a market buy or sell order.

[22] There is no positive relation between the book spread and the depth at the best bid and ask price in the book; these two variables are, if anything, negatively correlated. Therefore, we do not adopt a similar procedure for the book spread.

[23] Thus, if the average size of executed limit orders in the call market for Deutsche Bank is 3,500 shares we determine the quintile that contains this order size and compare the effective spread for this quintile to the transaction cost in the call market. Note that the qualitative results are insensitive to the procedure used to control for order size. The share volume used to calculate transaction costs for large transactions in the call market never falls in the largest size quintile. In spite of this, the transaction cost measure for large transactions in the call market is higher than the effective spread in the largest order size quintile for all sample stocks.

The bid–ask spread for the small transaction size in the call market is significantly lower (t value 2.76, z value from a Mann-Whitney u-test 2.99, both tests based on results for individual stocks) than the book spread in the continuous auction. However, for large transactions the spread in the call market is significantly larger than the spread in the continuous auction (t value 1.92, z value 2.55). These results imply that small orders, but not large orders, may obtain better execution in the call market.

If alternatively the effective spread is used as a measure of transaction costs in the continuous market, the spread for the small transaction size in the call market is, on average, still smaller than the effective spread for small orders, but the difference is not significant (t value 0.45, z value 0.95). For large orders, the spread in the call market is significantly larger than the effective spread in the continuous market (t value 2.54, z value 3.69). Note, however, that the effective spread already incorporates any reduction in transaction costs brought about by the activity of the Makler, whereas the transaction cost measure for the call market does not.

Determinants of Transaction Costs

The results shown in Table I document that the market share of the call market is higher for less liquid stocks. This suggests that the differences in execution costs between call and continuous markets (as documented in Table III) are related to measures of liquidity like trading volume or firm size.

This pattern would be consistent with theoretical considerations. As outlined previously, the characteristics of call market trading may lead to a reduction of the adverse selection costs. Given the evidence that the degree of informational asymmetry is higher for low-volume stocks (e.g., Easley *et al.*, 1996), it is thus plausible that the relative advantage of call market trading is higher for less liquid stocks. The hypothesis that call market trading is relatively better suited than a continuous trading mechanism for small firms' stock implies that the relation between execution costs and firm size is flatter in the call market. To test this hypothesis we estimate the following regression:

$$
\begin{aligned}
s_{i,j} &= \alpha + \beta_1 D_j + \beta_2 TO_i + \beta_3 D_j TO_i + \beta_4 \operatorname{Log}(Cap_i) \\
&\quad + \beta_5 D_j \operatorname{Log}(Cap_i) + \beta_6 Std_i + \varepsilon_{i,j}. \qquad (1)
\end{aligned}
$$

$s_{i,j}$ is the bid–ask spread of stock i in market j, where $j = 0$ for the call market and $j = 1$ for the continuous auction. We compare the spread measure for the call market to the book spread in the continuous auction because both measures abstract from the participation of the Makler. In the call market we use the spread calculated for the small transaction size. D_j is a dummy variable taking on the value 1 when the observation is taken from the continuous auction. The log of the market capitalization, $\operatorname{Log}(Cap_i)$, the turnover ratio TO_i, defined as the ratio of trading volume to market capitalization,[24] and two interaction terms are included as explanatory variables. We include the standard deviation of close-to-close returns, Std_i, to control for the impact of return volatility on execution costs.[25] The results are (heteroscedasticity-consistent t-values in parentheses, adjusted $R^2 = 0.82$):

$$\begin{aligned} s_{i,j} = {} & \underset{(1.03)}{1.355} + \underset{(2.50)}{5.330} D_j - \underset{(5.69)}{0.012} TO_i - \underset{(0.90)}{0.006} D_j TO_i - \underset{(1.23)}{0.061} \operatorname{Log}(Cap_i) \\ & - \underset{(2.44)}{0.206} D_j \operatorname{Log}(Cap_i) + \underset{(3.89)}{0.505} Std_i. \end{aligned}$$

The positive coefficient β_1 captures the observation, already documented in Table III, that the book spreads for small trades in the continuous auction are higher than the transaction costs for these trades in the call market. Transaction costs decline with both market capitalization and turnover and increase with return volatility. Both interaction terms are negative although only β_5 is individually significantly different from zero. An F test rejects the null hypothesis that the coefficients on the interaction terms are jointly zero. This indicates that the inverse relationship between market capitalization and transaction costs is less pronounced in the call market. Consequently, transaction costs are relatively low for smaller firms and relatively high for larger firms, resulting in a flatter relationship between the spread and its stock-specific determinants. This is consistent with the widely held belief that call market trading is especially suited to less liquid stocks.

6. THE IMPACT OF THE AUCTIONEER

Call auctions conducted on the floor, such as those at the New York and Frankfurt Stock Exchanges, rely on an auctioneer with a certain degree of price-setting latitude. The auctioneer—the specialist in New York and the Makler in Frankfurt—has an informational advantage because he or she decides on his or her participation in a trade after having seen the order book.

According to one view, the auctioneer may stabilize prices and thus decrease volatility. Furthermore, he or she may accommodate excess demand or supply by trading for his or her own account and thus contribute to the liquidity of the market. On the other hand, the Makler may exploit his or her informational advantage and price setting latitude and earn profits at the expense of other traders (Stoll and Whaley, 1990, Brock and Kleidon, 1992). Our data set enables us to address these questions empirically.

[24] We use the turnover ratio instead of the trading volume because the latter is strongly positively correlated with the market capitalization whereas the turnover ratio is not.

[25] We also estimate the model including the price level as an additional explanatory variable. The coefficient is, however, not significantly different from zero. We further estimate a model where we allow the coefficient on the standard deviation to be different for the call market and the continuous market but can not reject the hypothesis that the coefficients are equal.

TABLE IV
Makler Participation

	Makler participation rate					
	Open		Noon		Close	
Quintile	Mean	Median	Mean	Median	Mean	Median
I	0.138	0.096	0.233	0.176	0.220	0.184
II	0.242	0.224	0.224	0.218	0.279	0.258
III	0.238	0.191	0.238	0.217	0.378	0.329
IV	0.126	0.050	0.181	0.158	0.149	0.103
V	0.274	0.185	0.263	0.189	0.345	0.279
Average	0.204	0.149	0.228	0.191	0.274	0.230

Note. The participation rate is the position taken by the Makler in the call auction expressed as a fraction of the total trading volume in the call auctions. Stocks are sorted into quintiles by trading volume. Quintile I contains the stocks with the highest volume.

Participation Rates

We first analyze the extent of Makler participation. For each stock and each auction type we calculate the Makler participation rate as the position taken by the Makler expressed as a percentage of the total trading volume. Table IV reveals that Makler participation is important, accounting for approximately 20% of the trading volume. There seems to be no distinct pattern in the cross-sectional variation, indicating that the high average participation rates are not driven by high values for illiquid stocks.[26]

Participation rates tend to be higher in the closing auction. Together with the results shown in Table II this implies that the Makler takes considerable fractions of the large orders matched in the closing auction in his or her own book. This may be a reflection of his or her inventory management because he or she may offset a position accumulated over the trading day in the closing auction. In fact, we found that the position the Makler takes in the closing auction leads to a reduction of his or her inventory in 58.6% of the cases. This proportion is significantly different from 50% (z value 2.81).

Makler Participation and Return Volatility

The high participation rates documented in Table IV raise questions about the specific price setting rules used by the Maklers that we will now address. The Makler may use his or her informational advantage and his or her price setting latitude either to make profitable trades or to stabilize prices. In the first case one would expect Makler trades to be profitable on average and to increase return volatility. This is the view taken in Stoll and Whaley (1990). In the second case, the Makler should, on average, not earn profits on his or her trades and his or her participation should result in lower return volatility.

[26] The sample stocks are handled by different Maklers. This may explain some of the variation. Our sample is too small to explicitly control for the person of the Makler.

TABLE V
Makler Trades and Return Volatility

Quintile	Average variance ratios: Open-to-open	Noon-to-noon	Close-to-close	All auctions
I	2.034	1.755	1.786	4.202
II	5.082	2.402	4.137	13.684
III	2.206	1.898	2.637	6.481
IV	2.090	1.613	1.530	2.538
V	2.566	2.218	2.227	3.737
Average	2.796	1.977	2.463	6.128

Note. The table shows the ratio of the variance of hypothetical and actual returns. Actual returns are 24-hour returns calculated from opening, noon, and closing auction prices and a return series calculated from all auction prices. Hypothetical prices are those prices that would have obtained without Makler participation. Stocks are sorted into quintiles by trading volume. Quintile I contains the stocks with the highest volume.

We first address the issue of return volatility. The actual transaction prices are determined after inclusion of the Makler trades. The hypothetical price series that we calculated in order to measure the transaction costs exclude the Makler trades. Therefore, comparing the volatility of the corresponding return series allows us to disentangle the impact of the Makler trades.[27] For each sample stock we calculate four return series, using both the actual and the hypothetical transaction price series. We calculate three 24-hour return series from opening, noon, and closing auction prices. We also calculate a return series including all call auction prices. We then relate the variance of the hypothetical return series which would have obtained without Makler participation to the variance of the actual return series. The higher the resulting variance ratio, the more the actual price improves (in the sense of reducing return volatility) on the hypothetical price.

The variance ratios shown in Table V are uniformly larger than one. Thus, Makler participation tends to decrease return volatility. This is consistent with the results Madhavan and Panchapagesan (2000) report for the NYSE.[28]

[27] In some cases the deviation between actual and hypothetical price is very large. This may happen when only limit orders with “unrealistic” (e.g., outdated) limits are in the book. We use a 5% filter to correct these values: whenever the deviation between actual and hypothetical price is more than 5% we replace the hypothetical price with the actual price. This results in replacing 20 hypothetical prices. The filter has a function similar to that of price change limits used on many exchanges.

[28] Madhavan and Panchapagesan (2000) use a different methodology. They use actual and hypothetical opening prices from the NYSE. They then define a benchmark price (the midquote at 3 p.m.) and calculate the difference between the log of the (actual and hypothetical) call auction price and the benchmark price. The variance of this price differential for the hypothetical call auction prices is, on average, more than eight times the variance of the price differential for the actual call auction prices. Thus, the actual call auction price which is set by the specialist is a much more accurate estimate of the benchmark price than the hypothetical price calculated from the order book. Our results reported in Table VI are comparable to those of Madhavan and Panchapagesan (2000). There we also use prices and midquotes from the continuous trading session as a benchmark.

TABLE VI
Deviation between Call Auction Prices and Continuous Auction Prices

	Mean absolute deviation			
Quintile	After open	Before noon	After noon	Before close
I	8.171	11.167	7.107	8.444
II	10.316	14.052	12.473	11.476
III	4.896	6.533	10.294	7.551
IV	2.464	2.739	2.442	2.604
V	2.443	2.277	1.857	2.860
Average	5.658	7.354	6.835	6.587

Note. The table shows the ratios of the mean absolute deviation between hypothetical call market prices and the price of the continuous trading session immediately before or after the call auction (nominator) and the mean absolute deviation between actual call market prices and the (same) prices of the continuous trading session (denominator). The second line indicates which call auction (open, noon or close) is analyzed and whether call auction prices are compared to preceding ("before") or subsequent ("after") continuous auction prices. Stocks are sorted into quintiles by trading volume. Quintile I contains the stocks with the highest volume.

The results on return volatility can be combined with the participation rates shown in Table IV. If the trades the Makler makes on his or her own account were destabilizing, we would expect the variance ratio to be negatively correlated to the participation rate. We find, however, that for the opening transaction the variance ratio is positively correlated to the mean participation rate (correlation 0.61). No relation is found for the noon auction (correlation 0.04) and the closing auction (0.05). These results support the conclusion that the Maklers do not use their price setting latitude in a way that increases volatility.

So far we have analyzed the impact of Makler participation on return volatility solely in the context of the call auction prices. An alternative is to compare the actual and hypothetical call market prices with the prices of the surrounding continuous trading sessions. For each stock we calculate the average absolute deviation between the call market prices and the continuous auction prices immediately prior to and immediately after the call auction. This is done separately for the hypothetical and the actual call auction prices. Table VI reports the ratios of these mean absolute deviations. A ratio larger than one indicates that the actual transaction price is closer to the prices in the continuous auction and, in this sense, improves on the hypothetical price. Since the prices of the continuous trading session are affected by bid–ask bounce, we repeat the calculation using the midquotes in effect before and after the call auction. The results are similar to those obtained using transaction prices.

The ratios are uniformly larger than one, indicating that the call auction prices actually set by the Makler are closer to the prices of the continuous auction than the hypothetical call auction prices that would have resulted without Makler participation. The correlation between the ratios and the participation rates shown in Table IV is positive but not significantly different from zero. This indicates that higher participation rates do not lead to larger deviations between call market and continuous trading session prices. This supports the hypothesis that Makler participation does not increase return volatility.

Taken together, our results imply that the actual prices deviate considerably from the hypothetical prices calculated on the basis of the orders in the book. This suggests that the Maklers do make use of their price setting latitude to set prices that are closer to the prices of the continuous trading session. Together with the observation that the actual return series exhibit lower volatility, this indicates that the Maklers stabilize prices. The large participation rates and the significant impact of Makler participation on return volatility are, however, at odds with the statement made above that the price setting rules issued by the exchange leave the Maklers only limited price setting latitude. A detailed analysis of the prices set by the Maklers reveals that they often set prices that are not inside the interval of market clearing prices determined by the orders in their book. The results in Tables V and VI indicate that they tend rather to set a price which is more in line with the market conditions as revealed, for example, by the prices in the continuous auction. Frequently there is large excess demand or supply at these prices. In these cases the Maklers have to accommodate the order imbalance which contributes to the high participation ratios we observe. We stress that, prior to the present study, this aspect of the price setting behavior was not publicly known.

Profitability of Makler Trades

The final question we address is the profitability of the Makler trades in the call auctions. Assuming zero initial inventory, we use the Makler trades to calculate the position at the end of the sample period. Shares are valued at the closing price of October 25. It should be noted that the imputed inventory will not equal the Makler's actual inventory because we only include transactions made in the call auctions. This is sufficient since we are only interested in the profitability of these transactions.[29] When calculating the trading profits we assume that the Makler follows a zero net investment strategy. According to this strategy, long positions are financed by credit, whereas the proceeds of short positions in stocks are invested in a deposit account. We assume a 5% interest rate.[30]

We use two measures of trading profits. The first is simply the unadjusted profit or loss associated with the zero net investment strategy just described. This measure neglects the fact that the position held by the Makler is not riskless. To adjust for risk we determine the average share holding of the Makler (which may be a long or a short position). We then calculate the profit of a zero net investment portfolio consisting of these average share holdings and an offsetting position in the riskless

[29] We also calculate Makler profits including the transactions made in the continuous trading session. The results are similar to those reported here. We therefore conclude that the Maklers do not use the call auctions to lay off inventory accumulated through profitable trading in the continuous trading session.

[30] The results are not sensitive to the choice of the interest rate.

TABLE VII
Profitability of Makler Trades

Quintile	Unadjusted	Risk-adjusted
I	−2,166.01	−48,429.53
II	−73,757.48	−63,606.07
III	−9,702.27	−20,784.81
IV	12,278.46	10,689.15
V	36,542.21	8,390.74
Average	−7,361.02	−22,748.1
(t value)	(0.38)	(1.88)

Note. The table shows the profits associated with the Makler transactions in the call auctions. Stocks are sorted into quintiles by trading volume. Quintile I contains the stocks with the highest volume. The t-values in the last row are calculated on the basis of the individual values.

asset. The profit or loss associated with holding this portfolio is used as a benchmark against which to gauge the Makler's profits. The benchmark portfolio has the same average risk as the Makler's portfolio and takes into account the realized stock return. The difference between the actual trading profits and the profit associated with the benchmark portfolio is our risk-adjusted measure of profitability.

The results are shown in Table VII. They indicate that the transactions the Maklers make for their own accounts are, on average, not profitable. The average profit is DM $-7,361$ which is not significantly different from zero. The risk-adjusted profits are even lower. The average is DM $-22,748$ which is significantly different from zero at the 10% level.

The result is not caused by a general stock market trend during the sample period. Only three of the stocks have a (positive or negative) cumulative return of more than 3% over the 21 trading days. We therefore interpret our results as indicating that, on average over all stocks, the Maklers do not earn profits on their trades in the call auctions. They may not even receive compensation for the inventory risk they assume. It thus appears that the commissions paid by the investors (which are not included in our calculation) are the Maklers' main source of income.

The figures in Table VII suggest that the profitability of the Makler trades is related to the total trading volume of the stocks. This is corroborated by a stock-level analysis. We find that the profitability of the Makler trades is negatively correlated to the total trading volume. The correlation is -0.35 for the unadjusted and -0.63 for the risk-adjusted profits. The latter value is significantly different from zero at the 5% level. This indicates that gross trading profits are higher, the less liquid the stock is. There are two possible explanations for this result. Competition from the computerized trading system IBIS may limit the ability of the Makler to extract rents from trading liquid stocks.[31] Alternatively, the

[31] The market share of the computerized trading system IBIS is positively correlated to the total trading volume (see Theissen (2001)). Therefore, competition between floor and screen trading may be more intense for more liquid stocks.

higher profits for less liquid stocks may be a compensation for higher inventory risk.

7. CONCLUSION

This paper provides a detailed analysis of the call auction procedure on the Frankfurt Stock Exchange. Our data set contains information about individual orders for a sample of 15 stocks. We analyze the market share of the call market, the transaction costs in the call market, the impact of auctioneer participation on prices and return volatility, and the profitability of the trades the Maklers make for their own accounts.

We find that the market share of the call market is negatively correlated to market capitalization and trading volume. This is consistent with theoretical arguments implying that call market trading is especially suited to low-volume stocks.

Unlike previous studies, our data set makes it possible to develop and implement a method which directly measures the execution costs of orders submitted to a call auction. This measure is based on the price impact of an additional order. Using the order book information, we first calculate the market clearing price. We then add a market buy or sell order to the book and recalculate the market clearing price. We calculate a bid–ask spread by adding the price impact of a buy order and a sell order of equal size. When the additional orders are small, transaction costs in the call market are lower than the spread in the order book of the continuous market and are of the same order of magnitude as the effective spread in the continuous trading session. If larger additional orders are considered, transaction costs in the call market increase dramatically. This is evidence of insufficient market depth.

These results do not, however, imply that call markets generally suffer from insufficient depth. Our transaction cost measure is based on hypothetical prices calculated from all orders submitted to the closed order book. This method abstracts from the potentially beneficial function of the Makler. The participation of an intermediary such as the Makler may be desirable because he or she may accommodate order imbalances, increase the liquidity of the market, and stabilize prices. On the other hand, the latitude the Makler enjoys in price setting gives him or her an incentive to manipulate prices. This may increase return volatility.

Our data set allows us to identify the trades the Maklers make for their own accounts. We can thus eliminate these trades and determine a price that would have obtained without their participation. Comparing this hypothetical price series to the actual transaction prices we find that Makler participation tends to reduce return volatility. A further analysis shows that the actual prices are much closer to the surrounding prices of the continuous trading session than the hypothetical prices that would have resulted without Makler participation. We calculate the profits associated with the positions taken by the Makler and find that, on average, the Maklers do not earn profits on the positions they take. These results suggest that Makler participation is beneficial. Therefore, recent attempts to introduce intermediaries in the electronic call auctions in the French NSC system and the German XETRA system (see Demarchi and Foucault, 1998, for details) may well be a step in the right direction.

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