The impact of the order book privilege on traders’ behavior and the market process: An experimental study

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Abstract

This study examines an order book insider’s influence in an experimental stock market with heterogeneous information. Participants have the chance to trade either in a market with a monopolistic order book insider or in a market in which nobody has access to the order book. We find that with the same number of orders placed in both markets more transactions occur in the privilege-stock. The order book insider seems to have a coordinating function that helps to aggregate diverse information whereas no significant differences concerning volatility and liquidity occur between the two markets. Only some of the order book insiders are able to outperform the market because of their privilege. © 2000 Elsevier Science B.V. All rights reserved.

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JEL classification: C90; D80; G12

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1. Introduction and related literature

In a stock market organized as a continuous double auction, buy and sell orders are collected in the order book, unless they can be executed immediately. A market participant who has insight into the order book receives information about current trading opportunities and other traders’ preferences. If access to the order book is granted not to all traders but only to one or a group of traders, these are regarded as privileged. For example, the ‘Specialists’ at the New York Stock Exchange (NYSE) as well as the ‘Kursmakler’ at the Frankfurter Wertpapierbörse have monopolistic insight into the order book, they are granted (in addition to other privileges) the order book privilege.

Privileges are usually given for two reasons. First, because of technical constraints, e.g. some information cannot be distributed to all market participants. Second, to give certain traders an incentive to maintain the market. To judge the necessity or the advantages of granting a privilege the trade-off between the profitability of the privilege and the overall market performance has to be taken into account. Thus, granting a privilege is justified if all traders face better trading possibilities than without a privileged trader in the market.

Theoretical literature on market structure issues provides little help to answer the question if and to what extent privileges are profitable, and which market impact goes along with granting privileges. Most studies do not take the order book privilege explicitly into consideration. However, from some models one can draw general conclusions on how the traders’ strategic behavior changes with access to information on the orderflow. Such an approach is introduced by Cohen, Maier, Schwartz and Whitcomb (1981). With an open order book, at least with information on the current bid–ask spread, a trader faces two attractive order placement strategies. A buyer can accept the best existing sell order (market ask) by placing a market order. With a limit order, he or she takes the risk of having no transaction at all in favor of achieving a better price. To specify a limit just above the current market bid is a particularly successful strategy. A theoretical model developed by Conroy and Winkler (1981, 1986) focuses on the effects of the order book-insight on the NYSE specialist’s decision-making situation. Information on the orderflow enables the market maker to assess the potential turnover more accurately (as a consequence of being able to better evaluate the market participants’ preferences). Thus, the specialist’s optimal spread decreases with information on the orderflow. Especially limit orders provide more accurate information on the preferences than market orders. Other theoretical
research addresses the informational content of the orderflow in dual capacity trading. If privileged brokers are allowed to trade on their own account as well as to submit customer orders they may gain relevant information from their customers’ orders. To some extent they are able to identify liquidity trades or informed traders’ orders. In Roël (1990) the brokers provide liquidity directly to identified uninformed traders, whereas in Fishman and Longstaff (1992) they mimic informed traders’ activity. In both frameworks, the brokers profit from their information on customer orders. However, none of these models predict the effects of a privilege in markets where all traders compete in the order book and one trader is privileged regarding access to orderflow information.

Measuring the market impact of privileges empirically is problematic, as there are no two stock markets that differ in solely the order book privilege. Freihube, Kehr, Krahnen and Theissen (forthcoming) circumvent this problem by analyzing the Kursmaklers’ contribution to liquidity at the Frankfurter Wertpapierbörse. Their reference point is a ‘theoretical orderflow’ without any Kursmaklers’ orders. When analyzing the Kursmakler’s activities the authors find that through these c.p. market liquidity is enhanced. Participants trade at more favorable prices. As the Kursmaklers do not only possess the order book privilege but also a courtage privilege, this effect on market performance cannot be isolated and thus cannot be put down solely to the incentives provided by the order book privilege. The authors show that the Kursmakler do not systematically profit because of their privileged access to the orderflow. Their main income comes from the courtage they charge.

Another approach to answer the question how traders respond to an order book privilege is to conduct experiments. The experimental method is particularly suited to analyze matters of market structure, as in an experimental setting it is possible to construct markets that differ in just the variable under investigation (Hey, 1991). This allows to exactly control the variable ‘orderflow information’ for different trader types and to observe their behavior. Numerous experimental studies focus on asymmetric fundamental information concerning the value of assets (see e.g. Plott and Sunder (1982), Schnitzlein (1996), Gerke and Arneth (1997); for a survey see also Sunder (1995)). In these experiments, one or more participants (insiders) receive ex ante better information concerning the value of a stock at the end of a trading period (market exogenous information). In contrast to these studies, the subject matter of this paper is to isolate effects of an information asymmetry which results from the particular institutional design of a stock exchange and is therefore market endogenous.
A previous experimental study on the order book privilege was done by Friedman (1993). The author examines different privileges which are granted to two or three market participants. One of those privileges is the order book privilege. In a continuous auction, all bids and asks are observed by traders with an order book privilege whereas other traders just see the best bid and ask price. In that design the order book insiders do not realize significantly higher profits than the other market participants. The order book privilege does not impair market performance but leads to slightly increased market efficiency. The result might be partly due to the fact that there was always more than one privileged trader in the market and different privileges were present at the same time.

To answer the question how traders’ behavior is affected by an order book privilege and if and what kind of market impact occurs, we designed an experimental computerized double auction market in which information on the orderflow can be controlled for different trader types. The experiments are designed to directly compare markets with and without an order book privilege. In each experiment, two stocks are traded simultaneously. In one market, no one receives information about existing orders; in the other market one trader is granted monopolistic access to the order book. Thus, we can directly compare liquidity and information processing with regard to the two markets. Next to the effects on market efficiency, we focus on isolating the effects of granting an order book privilege on traders’ behavior. The computerized design allows the recording of all actions of an individual trader which enables us to analyze their behavior in interdependence with the situations they face in the different markets. Thus, we can draw conclusions on how traders adapt to the fact that one trader is privileged. With regard to the order book insiders, we examine the incentive effects of the privilege on their behavior and analyze the profitability of the order book privilege.

The paper is organized as follows: Section 2 contains a description of the experimental stock market CAT and the specific design of the experiments discussed here. In Section 3 hypotheses are developed, which are tested in Section 4 (results). Conclusions are drawn in the final section.

2. Experimental design

We developed the experimental stock market CAT (Computerized Asset Trading) to test for interdependencies between the individual decision behavior and the market process and to obtain a better understanding of the
individual behavior in stock markets (see Gerke and Bienert (1999) for the motivation and design of the CAT-System). A brief description of the trading system used in our experiments and the design of these markets follows.

In the CAT-System traders communicate via personal computer with a central stock exchange, which provides the participants with information and records all their actions. All participants receive an initial endowment of stocks and cash. In our experiments, shares of two companies are traded simultaneously. The total number of shares of each stock is 6400. The shares are divided equally among the participants. In addition to the stock endowment the participants receive an initial cash amount. The traders receive 20% of the initial fundamental value (see below) of their stock holdings in a cash account. The traders face the following investment alternatives: They may sell and buy shares of the companies, invest in a fixed term deposit with an interest rate of 10%, or keep money on their cash account without receiving any interest. The participants also have the opportunity to draw credit up to a certain limit which is a percentage of the individual portfolio – the credit rate is 14%. Short sales (negative inventory position of a stock) are permitted.

An experimental session lasts between 11 and 20 trading periods of 8 minutes each. At the end of each period the stocks pay an ex ante uncertain dividend and the interest for fixed term deposits and credit is due. A participant’s asset holding is continuously maintained over the duration of the experiment, that is the inventory at the end of one trading period is carried over to the next period. Before a new trading period starts the participants receive a performance feedback. They can see on their screen by which percentage their portfolio of stocks and cash has increased or decreased. Additionally the market growth – that is the average of all traders’ change in the value of portfolios – is displayed. The shares are evaluated at the latest transaction prices. To avoid a monopolistic position, individual holdings are limited to a maximum of 33% of a particular stock’s market capitalization.

2.1. Stock’s dividends, fundamental value, and private information

The companies’ profits are completely paid as dividend to the stock owner at the end of a period. In our experiments, the dividends change randomly from period to period which implies that the future dividends are uncertain; the company profits follow a random walk. The dividend change from one period to the next is determined by three independent drawings out of a standard distribution with an expected value of zero and a certain standard
deviation. These drawings can be regarded as independent influencing factors on the company’s profit, like a new business opportunity, the (un-)successful introduction of a new product etc.

The sum of all three realizations of the drawings is added to the last period’s dividend and determines the new dividend which is paid out at the end of the trading period. For example: The dividend in the last period was 20 CU. The realizations of the three random drawings are: +1; −2 and +3 (the sum of these three factors is + 2). In this example the dividend paid at the end of the current period will be 22 CU. The realized dividend of period one is the publicly known dividend estimation for the second period and so forth. Both companies start with an estimated profit per share of 20 CU in the first round. From then on the dividends of the two stocks develop independently and randomly.

Some experimental studies use an asymmetric information setting. We chose to implement heterogeneous information rather than insider information to separate the effects of order book- and fundamental information advantages. Similar to Plott and Sunder (1988) or Forsythe and Lundholm (1990), the traders receive private heterogeneous signals about the fundamental value. All private information pooled reveal the perfect information about the realized dividend at the end of a period. Without any information on the value of the three influencing factors, the dividend of the last period is the best estimate for all future profits. However, the traders receive private information on each stock’s dividend at the beginning of a new period. The private information consists of two of the three drawings which determine the realized dividend payment. All three dividend change factors are distributed equally among the traders. That is, each trader receives the sum of two out of three random numbers as private information, so that the uncertainty is reduced to the remaining influencing factor. Therefore, three different ex ante equally valuable information sets are in the market.

For the above-mentioned example this implies: Each trader receives a combination of the drawings (a) +1; (b) −2 and (c) +3 added to the dividend estimation. Three different pieces of private information on the dividend are distributed among the traders: 19 CU (a and b), 24 CU (a and c) and 21 CU (b and c) whereas the realized dividend is 22 CU. The traders are aware that the third part of the complete information – which they do not know – has an expected value of zero. This means that the best estimation for the unknown dividend is the individually received private signal of the future profit per share. Because of the random distribution of the individual signals, the private estimations are ex ante of the same quality.
The present value of all future dividends determines the fundamental value of a stock. Because of the random walk, the best proxy for all future dividends is the current private information on the expected dividend (e.g. 24 CU). So the expected perpetual annuity is 24 CU. The dividend discount model evaluates a stock as the expected (constant) annual dividend divided by the interest rate (0.1). This means that a risk neutral investor would pay 240 CU (‘fundamental value’) for a share with estimated future dividends of 24 CU. At this price, the expected dividend yield is approximately as high as the interest rate on the fixed term deposit.

2.2. Trading shares and transactions

Participants express their willingness to trade shares via limit orders. They specify the amount of shares they want to trade and a price limit. If there is an appropriate counter order, the orders are matched immediately. Otherwise, the order is placed in the order book according to limit and time of input and leads to a transaction when an appropriate counter order is entered into the system. Orders which have not been carried out yet can be canceled by the participants at any time in a trading period. At the end of a trading period, all unexecuted orders are canceled automatically. In the CAT-System, prices exclusively result from transactions. In that respect, prices reflect the participants’ preferences expressed in their limit orders.

2.3. Information requests

All traders have the possibility to request information, such as interest rates or transaction costs, which are constant during the course of the experiment, the dividends paid for the last three periods, the latest transaction prices (price ticker) and the profit estimates of the stocks, which change from period to period. Also individual accounting data can be obtained. All this information is available on request and represents the situation at the particular moment. Other pieces of information like the amount of cash, the current portfolio structure and the latest transaction price of each stock are updated automatically.

2.4. Order book transparency and order book privilege

To isolate effects of the order book privilege on the participants’ behavior and on the market process, the access right to the order book is different for
the two stocks. For one stock the order book is closed for all traders. In the other stock, one trader has access to the order book whereas all other traders receive no information on the order situation at all. Thus, there is one order book insider in each experiment. This privileged trader has the possibility to look at the best five sell and buy orders.

2.5. Incentive scheme

At the beginning of the experiment, the participants invest five German marks. After the final trading period the computer system calculates the traders’ final wealth. The average portfolio value of all participants is the benchmark for the traders payment. After the trading session they receive a higher or lower amount according to their invested money relative to the benchmark. In that way, the incentive for the participants is to perform better than the market and not to maximize the portfolio value.

2.6. Bets and questionnaire

To analyze the aggregation of the heterogeneous information, we use a method based on Grether (1992). After each period participants have to estimate, whether the third parameter of the dividend change – which they do not know – is positive or negative. In other words, they are asked, whether their private signal is higher or lower than the realized company profit. The traders can choose between two different bets: Bet A offers a win of one German marks if the estimate is right and a loss of 1.5 German marks in case the estimate is wrong. On the other hand, bet B pays 0.50 German marks if the participant places a right bet; a wrong bet leads to a loss of 0.5 German marks. If the participants cannot draw conclusions from the market process concerning the company’s realized profits, bet B has an expected value of zero whereas the one of bet B is negative. If a participant estimates the chances of winning the bet to be 60% or higher, a risk neutral person will prefer bet A because of the higher outcome in case the bet is won.

After each experiment, questionnaires were handed out asking the traders without access to the order book, whether they felt disadvantaged and the order book insiders, whether they thought they had an advantage.
The participants – students of the Friedrich-Alexander-Universität of Nürnberg – were handed out written instructions one week before an oral introduction in the CAT-System was given. During that session the participants had the chance to ask and discuss the subject matter of the experiment. Another week later the experiments started. To get familiar with the handling of the computer system, a prior test session was carried out before the first experiment started. All in all, six experimental sessions were carried out. In each experiment nine traders participated, except in one experiment in which eight traders took part. The participants took part twice within about two weeks.

3. Hypotheses

At any time, the non-privileged participants can choose to act in a market with an order book insider (OBI), or in a market where no one has access to the order book. If the non-privileged (NOBI) feel disadvantaged they ought to prefer to trade in a stock that offers the same conditions to all participants. On the other hand it is possible that the OBI enhances liquidity in the privilege-stock, which would be an incentive for the non privileged to engage there as well. Therefore it is unclear which stock the NOBIs will prefer.

Hypothesis 1a: There are no systematic differences in trading activities regarding the two stocks.

Hypothesis 1b: The OBIs make use of their information-advantage and are more engaged in the privilege-stock.

Because of their information advantage with regard to the order situation, the OBIs have the possibility to place their order skillfully, taking into consideration the orders already placed by other participants. The OBIs can either directly accept a counter order or place an order at the top of the order book thus having the best chance to transact at a more favorable price (Cohen et al., 1981).

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1 The instructions for the participants are available at our website http://www.wiso.uni-erlangen.de/WiSo/BWI/BuB/cat.html.
2 As each participant took part in two experiments, the experimenters took care that they traded in differently sampled groups.
Hypothesis 2a: The OBIs deliberately outbid the best order on their side of the market.

Hypothesis 2b: The OBIs more often accept counter orders directly.

Furthermore, we examine whether the OBIs can use the privilege to their advantage. We assume that the OBIs are able to carry out profitable transactions because of the advantages mentioned above. In addition, the participants’ expectations differ due to the heterogeneous information. At least at the beginning of a trading period the private information forms the best estimate for future dividends. The expectations based on that information can be adjusted to new information during the current period. For experimental markets Plott and Sunder (1988), Forsythe and Lundholm (1990) show that prices may converge to an equilibrium under rational expectations. Thus, information on existing orders or transaction prices can influence expectations if those endogenous data reveal information on other participants’ expectations. The insight into the order book might enable the OBIs to draw conclusions on the other participants’ expectations which are based on their personal information. This is a further advantage which should lead to a better performance of the OBIs.

Hypothesis 3: The OBIs profit from their privilege

It is difficult to assess in what way the existence of an order book privilege affects market liquidity and volatility. It can be assumed (see the argumentation concerning hypothesis (1)) that the NOBIs will withdraw from a market with an order book insider to prevent losses to the advantage of the privileged. This would lead to lower liquidity. On the other hand, it is possible that the OBI causes higher liquidity due to an increased activity in the privilege-stock. Pagano and Roëll (1996) find a positive correlation between transparency and liquidity. These contradicting effects could neutralize one another.

Hypothesis 4: The order book privilege does not influence market liquidity and volatility systematically.

When examining the effects of the privilege on the market, it should also be considered how heterogeneous information is reflected in prices, that is, if and in what way informational efficiency is influenced (Fama, 1970, 1991).
The aggregation is successful if participants draw conclusions from market data on other traders’ private information (Grossman & Stiglitz, 1980; Hellwig, 1980). Friedman (1993) found evidence that orderflow access slightly improves informational efficiency. Therefore, we assume the same effect in our experiments.

Hypothesis 5: A better aggregation of heterogeneous information can be observed in the OBI-stock.

4. Experimental results

4.1. Database

For the following analysis six market experiments based on the CAT-system were conducted. To avoid potential familiarization-effects at the beginning and end-effects at the end of the experiments the database contains only data from trading period 2–10. Statistical tests are run to identify effects of the order book privilege on the individual behavior and on the market process. To test whether the samples are from the same population, e.g. to test on mean differences between the groups, the data will be compared using the non-parametric Mann–Whitney-\textit{U}-Test. Therefore data are aggregated per experiment to avoid dependencies within one experiment.

4.2. Effects on the individual behavior

One way of getting an idea of other traders’ expectations concerning the value of a stock is to observe the incoming orders. To benefit from potential advantages of the privilege, the information ‘order book’ has to be recognized by the OBI. As all information has to be requested actively by the traders it is possible to observe the frequency of information requests. From that frequency, conclusion on the importance of that kind of information for each trader type can be drawn. In fact, the order book information seems to be very important to the privileged participants. On average the OBIs update the order book every 20 seconds (26 times in an 8-minute-period). Non-privileged traders can observe information on other investors’ expectations only after a transaction has occurred. The uninformed investors can deduce signals on the part of dividend changes they do not know through the
development of the stock prices if they reveal fundamental information. The information ‘price ticker’ contains the last three transaction prices. The NOBIs request the price ticker 5.2 times per trading period while this information seems to be less important for OBIs (2.5 requests per period). The analysis of the frequency of information requests shows that the OBIs are informed about the current order situation. This is necessary for a possible benefit from their privilege.

Next, we examine if and in what way this affects their trading activities. Therefore we analyze the order activity and the resulting transactions. Table 1 shows that the number of orders placed for each of the stocks hardly differs between the two types of trader. On average, participants with and without order book privilege place six orders per trading period.

Whether privileged traders are in the market or not, NOBIs obviously do not change their order behavior measured by the number of placed orders. The placed orders are distributed equally between the two stocks. Even examining the order behavior of the privileged traders reveals no significant differences in the number of orders placed for both stocks. Obviously, the privilege to see the other traders’ orders does not lead to any more active ordering behavior in that stock.

In contrast to the orders, there are substantial differences in the number of transactions (see Table 2). The comparison of transaction frequencies between the markets reveals that more transactions occur in the stock with a

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Average number of orders per period and trader</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of orders</td>
</tr>
<tr>
<td>NOBI</td>
<td>5.96</td>
</tr>
<tr>
<td>OBI</td>
<td>6.02</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Number of transactions and orders per transaction during a period</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Transactions in the privilege-stock</td>
</tr>
<tr>
<td></td>
<td>Transactions</td>
</tr>
<tr>
<td>NOBI</td>
<td>1.99</td>
</tr>
<tr>
<td>OBI</td>
<td>2.78</td>
</tr>
</tbody>
</table>

Note: Columns of ‘Transactions in the other stock’ are tested against the corresponding columns of ‘Transactions in the privilege-stock’; * significant at the 5% level (two-tailed test).
privileged trader. The OBI trades a lot more shares of the company for which they have access to the order book (Hypothesis 1b). But the presence of an order book insider also leads to more transactions for the NOBI. The number of placed orders and transactions shows that the NOBI do not concentrate their activities on the market without privileges; therefore, Hypothesis 1a cannot be rejected. A possible explanation of that result is that the non-privileged traders do not feel at a disadvantage or the disadvantage is offset by the OBI's positive market impact.

The OBI's turnover concentrates on the privilege-stock, in spite of the fact that the same number of orders for both companies are placed. The analysis of the number of orders placed on average until a transaction is carried out shows that the existence of an OBI leads to a higher transaction quota of all participants. The result that less orders are needed before a transaction occurs can be due to the fact that the OBI quite often accept an existing counter order instead of placing a limit order in the order book or waiting for a more favorable counter order. To clarify this and to examine Hypotheses 2a and 2b, the time of order placement and the order limit is to be examined further.

The OBI gets an overall impression of the whole order situation when seeing the book with the existing orders. Four different market situations can be distinguished and examined in respect to order strategies:

- (A) There is no order on any side,
- (B) There are only orders on the counter side,
- (C) There are only orders on the same market side,
- (D) There are orders on both sides of the market.

Before a trader places an order, situation B and C are identical. The situation can only be distinguished after the OBI's order has been placed. Depending on the market situation there are several strategies to place orders. The OBI are at an advantage compared to the non-privileged if there are orders on the other market side. Here, the OBI can specify their order with regard to price and size in such a way that the desired transaction is carried out on the one hand, and, on the other hand, that the maximum or desired number of shares can be realized. When placing an order, the other participants do neither know if their order will be met at all nor do they know

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3 When several counter orders with different limits exist, the OBI can specify the limit by buying or selling the desired number of shares.
the price. Table 3 presents the shares of the placed orders in situations (A) to (D).

In comparison to the other traders, the OBIs place less orders in situations where the counter side offers no possibility for an immediate transaction (situation A and C). Especially when no order exists – which mostly occurs at the beginning of a period – hardly any orders are submitted. This can be explained as follows: To get an idea of the expectations that vary due to heterogeneous information, privileged traders wait for the first orders placed by other participants. It is also possible that they avoid situations of transaction uncertainty. All in all, OBIs place 92% of their orders in situations where an immediate transaction is possible. In situations where one order exists (B and C) the NOBIs having no idea which side is occupied follow the already existing order. They less often take the counter position. By contrast, when submitting an order the privileged traders decide more often to take the counter position, thus creating a bid–ask spread or triggering a transaction.

In the following we examine the traders’ strategic ordering behavior. Table 4 shows when and to what extent the OBIs outbid the already existing orders

<table>
<thead>
<tr>
<th>Situation</th>
<th>NOBI</th>
<th>OBI in the other stock</th>
<th>OBI in the privilege-stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>(A) No order on any side</td>
<td>4.7</td>
<td>6.5</td>
<td>1.2</td>
</tr>
<tr>
<td>(B) Just order on counter side</td>
<td>12.6</td>
<td>7.8</td>
<td>20.3</td>
</tr>
<tr>
<td>(C) Just order on same side</td>
<td>18.5</td>
<td>27.5</td>
<td>6.4</td>
</tr>
<tr>
<td>(D) Orders on both sides</td>
<td>64.2</td>
<td>58.2</td>
<td>72.1</td>
</tr>
</tbody>
</table>

Table 4
Order placement strategies relative to the existing orders (shares in %)

<table>
<thead>
<tr>
<th></th>
<th>NOBI</th>
<th>OBI in the other stock</th>
<th>OBI in the privilege-stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>(B) Just order on other side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate transaction</td>
<td>49.2</td>
<td>66.7</td>
<td>80.0</td>
</tr>
<tr>
<td>No immediate transaction</td>
<td>50.8</td>
<td>33.3</td>
<td>20.0</td>
</tr>
<tr>
<td>(C) Just orders on same side</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Top of order book</td>
<td>30.8</td>
<td>54.8</td>
<td>36.4</td>
</tr>
<tr>
<td>No outbid</td>
<td>69.2</td>
<td>45.2</td>
<td>63.6</td>
</tr>
<tr>
<td>(D) Orders on both sides</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Immediate transaction</td>
<td>29.7*</td>
<td>24.7**</td>
<td>74.2</td>
</tr>
<tr>
<td>Top of order book</td>
<td>18.6*</td>
<td>15.7</td>
<td>10.4</td>
</tr>
<tr>
<td>No outbid</td>
<td>51.7*</td>
<td>59.6**</td>
<td>15.4</td>
</tr>
</tbody>
</table>

Note: Columns ‘NOBI’ and ‘OBI in the other stock’ are tested against the column of ‘OBI in the privilege-stock’; * significant at the 5% level; ** significant at the 1% level (two-tailed test).
(in Situation C and D) and how often they create an bid–ask spread or accept a counter order (Situation B and D).

In the very rare cases when no counter order exists (C), the OBIs show little interest in outbidding the currently best order on their side of the market. However, if the OBIs place an order in situation B, when only counter orders exist, then they often carry out an immediate transaction by accepting an existing order. In 20% of the cases the OBI provides a bid–ask spread. A similar strategy as in situation B can be observed in situation D (both market sides occupied). Mostly the OBIs accept a counter order. As the theoretical model of Cohen et al. (1981) suggests, the OBIs take their information on other traders’ orders into account; they outbid the best order on their own market side and directly accept counter orders. We can draw the conclusion and state that the OBIs intensively use their order book-insight to purposefully place orders that lead to significantly more transactions which explains the smaller number of orders per transaction. Whether this is also reflected in a higher trading success for the OBIs is the focus of Section 4.3.

4.3. Profitability of the order book privilege

One way of measuring the trading success is to compare the final wealth at the end of the experiment. To exclude effects of different levels of dividends between the experiments, a trader’s final wealth is expressed in relation to the average final wealth in each experiment. The average deviation of non privileged participants’ final wealth is –1.14%. The OBIs’ final wealth exceed that of the NOBIs by 8.5% on average. Due to a high variance within the OBI-group the differences are not significant. Four out of six OBIs did perform very well (rank 2 or 1) whereas in the other two experiments the OBIs finished at the very end of the ranking.

When taking the achieved wealth as criterion of success, several possible interfering factors have to be taken into account. For example, an average or less than average trading success in the other stock or a large non-interest-bearing cash position can neutralize the effect of profitable trading in the OBI-stock. Therefore, we additionally measure the profits made in the privilege-stock with a short-term success criterion to isolate the advantages of order book-insight. We examine whether the privilege enables the OBIs to carry out favorable transactions in the privilege-stock. To do this, the time from a transaction until the end of the following trading period is taken into consideration. To measure the short-term profit we hypothesize that the bought (sold) shares are sold (bought back) at the end of the following period
at the last transaction price. The buyer’s change in wealth is therefore the difference between the transaction price plus the dividend payment minus the sell price at the end of the following trading period. This profit is compared to the hypothetical situation in which the deal would not have been made and instead the money would have been invested in fixed term deposit. The same considerations are valid for sales as the effects on the seller’s asset is tantamount to the effects on the buyer’s asset.

\[ O_B = P_{t+1} + D_t(1 + r) - P_t(1 + rx)(1 + r), \]

where \( O_B \) is the outperformance of buyer (per share), \( P_{t+1} \) the last price at the end of the following period, \( D_t \) the realized dividend at the end of current period, \( r \) the interest rate (0.1), \( P_t \) the transaction price, \( x \) the remaining time of current period in % \((x<1)\) and \( t \) is the end of current period.

Table 5 presents the OBIs’ yield (profit per share/transaction price) in comparison to the NOBIs for selling and buying transactions. The profits of the OBIs are on average higher than the ones of the non-privileged traders. Especially for sale transactions a considerable difference in profits can be seen. Again, the differences are not significant, because of the high standard deviation in the group even though the OBIs perform better on average.

An explanation for the OBIs’ better performance on average could be that they infer from the private information of the individual traders because of order book information. An OBI who is able to correctly assess the private information inherent in the market can take advantage of any occurring under- or overvaluations of the stocks. To find out whether the privileged traders really have this possibility, we use the bets made at the end of each round. After each period we asked the participants to assess, whether their (uncertain) private information over- or underestimated the actual dividend value.

Table 6 presents the relation between won and lost bets made by the participants. The analysis of the bets shows significant differences. The NOBIs are unable to interpret market data as signals related to the dividend value.
paid out at the end of the round. They win only every second bet, the expected result for mere guessing. The OBIs, however, manage a correct estimate more frequently. In spite of this, the OBIs seem to mistrust their assessment, for they more often choose the less risky bet with the lower profit expectation than the other participants. Because of their privilege, the OBIs can, to a certain degree, infer from the heterogeneous information in the market. Whether that leads to more informative prices is analyzed in the following section.

All in all, the OBIs are better off on average and achieve higher transaction profits in the privilege-stock than the other traders do. Despite we can only assume that the OBIs profit from their privilege, because none of the statistical tests show any significance. This confirms the results of Friedman (1993) who also finds on average higher but not systematically higher profits of traders with the order book privilege. There are two possible reasons for the high variance in the performance of the OBIs in our experiments. First, the randomly realized dividends offset in some cases the outperformance because of the privilege. Second, the participants’ individual abilities might play a role.

When analyzing the questionnaires that were distributed after the experiments, we find that the majority of NOBIs felt at a disadvantage (disadvantage: 31 participants, no disadvantage: 14, open: 8). 27 participants said that they would have acted differently had they had order book-insight (no difference: 15, open: 11). Half of the OBIs said that the order book-insight was to their advantage, just one person thought it was no advantage.

4.4. Effects on the market

The design of the two experimental markets is identical in all features except for the order book privilege. Giving a privilege to a certain market participant can be justified, if there are no negative effects on other investors
or if occurring disadvantages are at least compensated by positive effects on the market. This is the case when, e.g. due to their better information about the current order flow situation the OBIs influence the market so that it becomes more efficient.

4.5. Information aggregation

A market is considered informationally efficient if all available information is reflected in the price. In our experiments, the participants receive imperfect information about the stock’s dividend changes at the beginning of a period, but all diverse information pooled contain the dividend realized at the end of the period. As shown in the previous section, the OBIs are able to draw some conclusions on other traders’ private information by observing the orderflow. When seeing the OBIs as traders who are able to gain information on the other participants’ expectations merely from taking into account currently unexecuted orders, then the prices in the market with an OBI should be closer to the fundamental value. If order book-insight is helpful to aggregate different pieces of private information then the adjustment process of the prices to new information should be faster in the privilege-stock than in the other stock. In the following, we examine correlation of the stock price and on the company profit (fundamental value) by means of a linear regression analysis. Our intention is to examine whether the dependency between the realized dividend and the observed prices is stronger in markets with participation of an OBI. Table 7 shows the regression results for the average price of a trading period (minutes 1–8) for the first and the second half a period separately (minutes 1–4 and 5–8).

Factor $a_1$ shows the slope of the regression line. It should be ideally ten when risk neutral investors value a stock by discounting all future dividends.

<p>| Table 7 |
| Regression: price $= a_0 + a_1 \times$ dividend $+ e$ |</p>
<table>
<thead>
<tr>
<th>Minutes</th>
<th>$a_0$</th>
<th>$a_1$</th>
<th>$F$</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOBI-stock</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–8</td>
<td>88.36*</td>
<td>5.83*</td>
<td>94.01*</td>
<td>0.64</td>
</tr>
<tr>
<td>1–4</td>
<td>93.04*</td>
<td>5.57*</td>
<td>57.98*</td>
<td>0.56</td>
</tr>
<tr>
<td>5–8</td>
<td>79.46*</td>
<td>6.16*</td>
<td>83.94*</td>
<td>0.63</td>
</tr>
<tr>
<td>OBI-stock</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–8</td>
<td>49.87*</td>
<td>7.53*</td>
<td>198.06*</td>
<td>0.79</td>
</tr>
<tr>
<td>1–4</td>
<td>56.09*</td>
<td>7.26*</td>
<td>171.36*</td>
<td>0.77</td>
</tr>
<tr>
<td>5–8</td>
<td>42.36*</td>
<td>7.89*</td>
<td>230.05*</td>
<td>0.82</td>
</tr>
</tbody>
</table>

*All coefficients significant ($p < 0.001$).
(Using the dividend discount model to price a stock \( \text{price} = \text{div}/0.1 \) the factor is 10 (see experimental design)). We find that the influence of dividends on prices is stronger in the OBI-stock. The deviation of the observed average prices from the fundamental value is better explained by the regression line in the OBI-stock. Here, the coefficient of determination is 0.79, in the market without an OBI at 0.64. When comparing the price adjustments of the first half of a trading period to those of the second half of the trading period, it becomes evident that even at the beginning of the trading period the correlation in the OBI-stock is stronger than the one in the other stock. The results of the regression analysis suggest that the heterogeneous information is faster and better aggregated by the activities of the OBI. This also becomes obvious by comparing the mispricing of both stocks. We define the mispricing as the deviation of a price from the fundamental value in percent. On average the mispricing in the market with an OBI is 8%. In a market in which no one has access to orderflow information this number is significantly higher (14%).

Both regression analysis and mispricing show that the dividend paid at the end of a trading period is better reflected in the prices of the OBI-stocks than in stocks without privilege. If the NOBIs conclude dividend-related information from the market endogenous data, they should be able to assess whether their individual profit information is below or above the aggregated value. By means of the bets described above, we examine whether the participants can better recognize the correlation between prices and information in a market with an OBI than in one without. The NOBIs’ betting success hardly differs with 48% in markets with as opposed to 49% in markets without the order book privilege. There are also no differences with regard to the participants’ trust in the correctness of their estimate – 74% of the bets are of type B. This means that due to the OBI, the participants do not get better fundamental information than the one they already have. Even though the results from the regression and the mispricing analysis show that the heterogeneous information is better aggregated when an OBI is in the market, the non-privileged traders are not able to draw conclusions from the prices on the pooled information. As shown in Table 6 the OBIs obviously do. Therefore we conclude that the visibility of the orderflow is an important factor to draw conclusions on other traders’ private information.

4.6. Volatility and liquidity

What impact does the order book privilege have on market liquidity? The results with regard to the individual behavior suggest that at least the bid–ask
spread increases because the OBI often accept existing orders. Table 8 shows
the liquidity measure ‘bid–ask spread’ and the average time share in which no
bid–ask spread exists. The transaction quote expresses how many orders on
average are placed before a transaction results. The volatility measure ‘price
difference’ shows the deviation of the highest and the lowest quotation within
one trading period in relation to the average price. The standard deviation of
the prices within a trading period is also calculated in relation to the average
price.

Even though the OBIs often accept a counter order, their presence leads to
an on average smaller bid–ask spread in the privilege-market. The time share
without spread as well is not higher than in the market without a privileged
trader. However, both measures do not differ significantly. That can be ex-
plained as follows: The tendency to directly accept counter orders is at least
compensated for by the tendency to place orders at the top of the order book,
thus reducing the spread. This implies that the participants do not face de-
teriorated trading opportunities taking liquidity into account because of the
OBI’s existence. Likewise, the existing order book privilege has no significant
effect on the price fluctuations. Both volatility measures differ only slightly.
The average difference between highest and lowest price slightly decreases
with an OBI in the market. On the other hand, the standard deviation of the
prices increases due to the OBI.

5. Discussion

In the presented experiments, the participants could trade in both, a stock
with and a stock without participation of an order book insider. If one
participant has order book-insight, the other participants do not automati-
cally deal less in that stock. While the same number of orders in both stocks
are placed, even more transactions in the privilege-stock can be observed.
This can be put down to the order book insider’s strategy to directly accept
orders. According to economic theory, the privileged traders make use of their strategic possibilities which their knowledge of the order flow provides. If there is only one order in the book, the order book insiders systematically submit their order on the counter side, thus creating a bid–ask spread or accepting an existing order. They serve to some extent as a liquidity provider. This explains why non-privileged traders are not trying to avoid the market with a better informed trader. The order book insiders’ strategy does not lead to systematic effects concerning liquidity or volatility. As in Friedman (1993) liquidity is slightly higher in the market with an order book insider.

The privilege to see the orderflow leads to an on average better performance of the order book insiders. Both, their final wealth and the trading performance in their stock is on average higher than those of the other traders but the difference does not show any significance. This result is in accordance with the study of Freihube et al. (forthcoming) who show that the Kursmakler at the Frankfurt stock exchange do not profit systematically because of their order book privilege. In our study in which the order book privilege is isolated, we confirm the experimental results of Friedman (1993). In his combined privilege experiments he also finds no systematic overperformance of the order book insiders.

The analysis of the aggregation of the heterogeneous information reveals differences between a market with and without an order book insider. The bets where the unknown part of the information on the dividends has to be estimated show that the privileged traders are to some extent able to assess the private information of other participants correctly. Regression analysis and the difference between the prices and the fundamental value show that in the privilege-market prices are closer to the fundamental value. The occurring prices reveal the aggregated information better and faster when an order book insider is in the market. Nevertheless, the traders without order book privilege cannot draw conclusions from the observed market data on the realized dividend. Thus, we conclude that knowledge of the orderflow is important for inferring the other traders’ private information. Orders contain more information than just the resulting prices. In our experiments the non-privileged participants profit from the activities of the order book insiders, because they trade at more favorable prices. All in all we state, that in markets where no information on the orderflow is available to traders, granting an order book privilege tends to have positive effects. At least we cannot find systematic negative effects on the market. The disadvantage of the non-privileged participants is obviously offset because of the incentive effects which result from the privilege.
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