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Market Transparency
and Call Markets

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Abstract:

This paper reports the results of 16 experimental asset markets that explore the effects of trade transparency on the price formation process and its results using a more realistic design than related studies. The open orderbook does not improve informational efficiency and does not result in higher liquidity (lower transaction costs). An increase in information intensity leads to both higher trading volume and higher volatility in both orderbook treatments. The comparison shows that they only differ in price volatility which is higher with an open orderbook. The market results mentioned above are confirmed by analyses on the individual level.

JEL Classification: D44, G12, G14

Key words: Market Microstructure, Experimental Asset Markets, Orderbook Transparency, Individual Behavior in Call Markets

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This paper reports the results of 16 experimental asset markets that explore the effects of trade transparency on the price formation process and its results using a more realistic design than related studies. The open orderbook does not improve informational efficiency and does not result in higher liquidity (lower transaction costs). An increase in information intensity leads to both higher trading volume and higher volatility in both orderbook treatments. The comparison shows that they only differ in price volatility which is higher with an open orderbook. The market results mentioned above are confirmed by analyses on the individual level.

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During the last decade there has been a growing interest in issues of market microstructure. Among the still unresolved problems of an optimal design of stock exchanges is the relation between market efficiency and the amount of information about the trading process. There are two features of market transparency which are usually distinguished: trade disclosure (ex post transparency) and quote disclosure (ex ante transparency).

In a competitive market with homogeneously informed, rational traders different transparency rules do not affect market outcomes. But with heterogeneous information it is possible for informed traders to extract rents from trading with uninformed market makers in non-transparent markets. When there is quote transparency in a continuous market strategic trading occurs in the form of submitting orders as late as possible. A simple mechanism of distorting this behavior is the time priority rule. Pagano/Röell (1996) show that with higher transparency market makers are better able to distinguish between informed and liquidity traders. This additional knowledge that can be extracted from the orderflow improves the liquidity of the dealership market. Theoretical considerations show that there is a trade-off between liquidity and transparency while information efficiency should improve when more trading information is available.

Another important distinction has to be drawn between large trades (block trades) and ordinary trades. In an dealership market liquidity may decline when large trades or quotes have to be published immediately since the market maker runs the risk of taking unbalanced positions. Transparency may therefore be restricted to enhance liquidity. But with restricted transparency informational efficiency may also decline.

While theoretical and empirical research concentrates on quote disclosure there are also a few studies examining ex post transparency. The only empirical study on this issue is concerned

with the speed of block trade disclosure at the London Stock Exchange (Gemmill 1996). Using the methodology of event studies, there is no effect of the time span for the publication of large trades and the market spread. Therefore, a delay in publication does not improve liquidity in a dealer market. There are also two experimental studies considering trade transparency. Bloomfield/O'Hara (1998a) find that in dealership markets trade disclosure increases informational efficiency and reduces liquidity since market makers face a decreased incentive to compete in a transparent market. Interestingly, there is almost no effect of quote disclosure on either allocational efficiency, informational efficiency, and bid-ask spreads. In a companion study (Bloomfield/O'Hara 1998b) spreads widen with higher transparency requirements for market makers which is in accordance with theoretical models. The experiment by Flood/Huisman/Koedijk/Mahieu/Röell (1997) also focuses on trade transparency in a dealership market. The nine market makers in their markets trade against two computerized dealers. In this quote-driven market under a high degree of trade transparency informational efficiency increases but spreads also widen. Furthermore, there is no distinguished effect on price volatility. The same results are achieved in a related experiment (Flood/Huisman/Koedijk/van Dijk/van Leeuwen 1998) also pertaining to a dealership market.

Our study contributes to the research cited above in testing the effects of trade transparency in a call market. To our knowledge, there is no other study published so far that addresses the problem of trade information in a call market. The experimental markets we use provide insights into the (aggregated) market level as a standard issue in the analyses of experimental asset markets and into the individual level of the market participants which is hardly examined in the related literature.

The goal of the paper is to compare two different types of market transparency concerning their implications for the informational efficiency of an asset market. The dependence of the results on two degrees of information intensity, i.e. the frequency and volume of information arrival, is investigated, too.

The basic trading mechanism we used is a call market where a clearinghouse matches buy and sell orders once a trading period. After the orders are collected a computer aggregates them and fixes the market clearing price so that the transaction volume is maximized (see below for details). Differing from other experimental asset markets our design reveals a more realistic¹ market atmosphere because of

- infinitely-lived assets instead of an execution (liquidation) of holdings at the end of each trading period combined with a reinitialization or restart at the beginning of the next period (i.e. in fact a repetition of one period);
- the trading of six different assets instead of a single risky asset;
- the information structure with ratios derived from financial statements of real but anonymous companies instead of abstract information like expected value and standard deviation of earnings (or other moments from a known probability distribution).

The paper is organized as follows. Section A describes the experimental design and procedures pertaining to market environments, market institutions, information structure and subjects. In section B we develop a set of testable hypotheses that motivate the data analysis. Section C presents and discusses the results from 16 experimental sessions, including the data, the statistical tests, and a description of the performance measures. In section D we describe and test some data on individual trader behavior. The final section E concludes the paper.

A Experimental Design and Procedures

Market Environments

The experimental market consists of 12 time sequences called „trading periods“, each lasting at most 10 minutes. The market participants (the experimental subjects) are typically 10 undergraduate students of three German universities who buy and sell six different assets called „stocks“ for cash under various market treatments described below. At the (unannounced) end of an experimental session the participants are paid the profits they earn², ranging from DM -1.14 to DM 20.55³ in a typical market experiment.

Because the necessity and the impact of performance related payment on intrinsic and extrinsic motivation is still an unresolved problem in the literature (see Grether/Plott 1979, Binswanger 1981, Kachelmeier/Shehata 1992, for instance) we conduct experiments with and without payment for the same treatment and with comparable subjects. The price series and the results presented in this paper do not differ significantly between the 5 paid and the 4 unpaid sessions of treatment A (see below), tested with nonparametric statistics (cf. tables 0.1 through 0.4 in the appendix).

Like a work of art asset units (called „shares“) in our experiments do not have a true value. They are redeemed at the end of the experiment by their market prices. Hence, a stock's value is represented by the subjective perceptions of the fundamental data. The ratios are the basis for subjective valuations and consequently serve as proxies for the stocks' values. This feature

¹ An issue pointed out by Kahneman 1991 and Neumann/Politzer 1992, for instance. A minor drawback of a more realistic design is that not all traditional measures of market efficiency can be applied in our design.

² Divided by a factor of 5 000.

³ Negative profits have to be paid.

of our design reflects the short term view of the stock market as a beauty contest. Nevertheless, the determination of market prices is not totally arbitrary since the financial ratios are the basis for an unambiguous assessment of a firm's profitability. There is a clear trading strategy for each stock that could be derived from the information set (see the section on individual behavior for details). Although a subject's earnings do not depend on her correct assessment of company performance the recognition of fundamental information is (in the absence of coordination between subjects) the only way to infer what the other traders might be doing.

The six different stocks are infinitely-lived assets of real but anonymous companies, i.e. the information set described below is derived from real data. The endowments of the subjects are not reinitialized at the beginning of each period like in many other studies (cf. Theissen 1996 and the literature surveyed there).

Market Institutions

All institutional settings examined in the experiment are computerized in principle. Only the submission and the collection of orders (by the experimenter) is organized manually. This computer assisted design allows us to perform different trading institutions and market transparency treatments comparable to institutional characteristics of real asset markets. The design does not neglect reputational and psychological effects cut by anonymous screen trading. While many experimental markets use completely computerized environments because of economic efficiency in data collection and analyses, the impact of computerization is a treatment variable that has to be controlled.

In every period subjects can submit limit or market orders in each stock. The simultaneous submission of a limited buy and sell order for the same stock was possible, too. However, mul-

multiple orders were not feasible. Due to the collection of orders by the experimenter and the anonymity of traders there was no information extractable from the order submission process.

As stated above, we investigate the relative performance of a clearinghouse institution under two treatments of market transparency. In a call auction market participants start each trading period with their information set consisting of the former end-of-period prices and the new information on the listed companies. During the trading period (max. 10 minutes) participants submit buy and/or sell orders and deliver them to the auctioneer at the personal computer who enters the orders. The orders are not executed immediately but stored until the end of the period. At the end of the clearing period the bids and asks are aggregated, and the market is cleared at the price that maximizes transaction volume (in shares). Figure 2 shows an example of the price determination process.

Please insert Figure 2 around here

The market is cleared at the price at which the supply (revealed by the asks) equals the demand (revealed by the bids), and all higher bids and lower asks are filled at this market price. Thus, the call institution provides a uniform price to all market participants.⁴

As discussed above, an important attribute of a trading institution is the market transparency, i.e. the ability of market subjects to observe price-relevant information in the trading process (cf. O'Hara 1995). Information in this sense means the knowledge about the current and past

⁴ If this results in two prices or a range of prices the price nearest to the last end-of-period price is chosen, and the price trend is considered, too. If the clearing price does not clear the market completely in one trading period, rationing with the following rules takes place: Sell (buy) orders with lower (higher) price limits are filled with priority. If limits are equal they are rationed to the same proportion. In contrast, Friedman 1993a used a strict price-time priority that is orders are filled on the first come first served rule.

prices and volumes, the orderflow, and the identities and motivations of market participants (cf. Madhavan 1996).

While the disclosure of the current and past prices is a routine in most experimental markets the information about the orderflow is investigated only in a few studies experimentally (see Friedman 1993b). To examine the effects of the disclosure of orderflow information we use two different treatments A and B:

Treatment A

The market participants only receive the current clearing prices for the six stocks in each period completed by some additional information used in real stock markets like „market cleared“, „only buyers“, „only sellers“, „buyers over“, „sellers over“ etc. The orderbook is closed and no (continuously updated) „indicated prices“ (cf. Friedman 1993a, 417), i.e. prices the market would clear at if no further orders are received, are provided.

Treatment B

Additional to the information disclosure in treatment A the subjects get transparency about all buy and sell orders which were collected by the batch institution (auctioneer's orderbook, see Figure 2 above) to determine the past market clearing prices. The public orderflow contains the aggregated volume (in shares) of each limit price (bid or ask) on both sides of the market. Aggregated market orders were disseminated the same way. The identities of the market participants are not revealed (sealed-bid auction). It is important to note that the public orderbook is available to all subjects after the clearing process so that they can observe the price formation process ex post.

Under treatment A we conducted a series of 9 experimental sessions, treatment B was repeated seven times. The transparency mode was the only treatment variable. All other institutional characteristics of the experimental market were held constant, thereby insuring a maximum of comparability between the two treatments.

Information Structure

In both treatments A and B market participants are provided with information about a company's financial statement. For each of the six stocks subjects get four financial ratios concerning the profitability and the long-term debt-paying ability. The ratios were derived from a neural network which analyzed about 12 000 German companies for solvency or insolvency. We use four of in all 14 ratios which are selected by the neural network as best indicators for success or failure of a firm. The four ratios are:

$$XR = \frac{\text{(Operating) Cash Flow}_5}{\text{Total Assets}}$$

This measure of rentability can be interpreted as an indicator of future earnings potential.

Therefore, positive changes in XR indicate an increase in asset values and should result in price increases.

$$XF = \frac{\text{(Operating) Cash Flow}}{\text{Total Debt (Liabilities) - Received Payments on acc.}}^6$$

The cash flow ratio shows a company's ability to pay back its liabilities out of its cash flow. Again, an increasing XF-ratio points to a positive development of a stock and should cause market prices to rise.

⁵ Cash Flow = Operating Result (Income) + Normal Depreciation; Total Assets = Balance Sheet Total

$$XE = \frac{\text{Shareholders' Equity} - \text{Intangible Assets}}{\text{Corrected Total Assets}}^7$$

XE contains information about the capital structure of a company. Due to a reduction of leverage risk increasing values of XE have to be interpreted positively and should lead to increasing market prices.

$$XV = \frac{\text{Short Term Debt}}{\text{Total Assets}}^8$$

A second ratio relating to the capital structure is the short term debt ratio XV. This is the only ratio which has to be interpreted in the way that positive changes in XV indicate a decrease in a company's value and should result in decreasing market prices.

Our subjects knew how to interpret the ratios correctly by detailed written and verbal instruction. Further, they had information about the distribution of the four ratios derived from the whole sample of 12 000 companies analyzed in the neural network (average and range of ratios' values). Thus, subjects have knowledge about each company's development (increase or decrease of ratios' values) and about the relative performance of the six firms (ratios's change in relation to the mean of the distribution).⁹ Although it is not possible (due to the lack of a theoretical model) to assess the value corresponding to a specific combination of financial ratios, expectations about the direction of the change in value can be formed unequivocally.

⁶ Cash Flow = Operating Result (Income) + Normal Depreciation

⁷ Corrected Total Assets = Balance Sheet Total - Intangible Assets - Cash - Real Estates

⁸ Short-Term Debt = (Residual) Max. Time to Maturity 1 Year

⁹ The special output of the neural network, the total score, ranged from 0 indicating insolvency to 1 showing solvency, enables us to create two different types of insiders: market insiders who use a superior methodology for their analyses of companies' information set (total score), and company insiders who get the ratios one period earlier; the experimental analysis of the latter treatment is published in an additional paper.

Therefore, the financial ratios allow subjects to rank the stocks in each period. This is demonstrated in more detail in section D (see below).

At the beginning of the first trading period and every second period market participants receive new ratios, i.e. subjects can trade on new fundamental information in the first, the third and so on period (see Figure 3).

Please insert Figure 3 around here

Finally, subjects are informed about the current clearing price (see above) and the fulfillment of their orders in every clearing period. The deposit holding, the cash volume, and the total wealth valued by the current clearing prices are provided, too.

All of the above information pertaining to market environments, market institutions, trading rules and stocks is contained in detailed experimental instructions that every market participant received a week before start. All main issues are discussed at the beginning of the market experiments, too.

Subjects, Endowments, and Procedures

Subjects were full-time undergraduate students in the department of finance, Bamberg University, in the department of audit and tax, Münster University, and half-time undergraduates in the department of finance and banking, Hagen University.¹⁰ A total of 165 subjects participated

¹⁰ Treatment A (treatment B) was conducted three (four) times at Bamberg, five (zero) times at Münster, and one (three) times at Hagen. There was no difference in trading behavior between the three locations.

in the experimental sessions (treatment A: 9 sessions with 91 subjects; treatment B: 7 sessions with 74 subjects). Each subject took part in only one session.

About one week before each experimental session, subjects received written instructions¹¹ that were read aloud at the beginning of each session, too. After clarifying questions were answered, market participants were given a questionnaire to elicit cognitive variables like locus of control, illusion of control, risk attitudes, self perception of competence, cognitive styles, knowledge in business administration, finance and in general issues.

Then working material (paper, calculator, order sheets) and the starting set of information (current clearing price from the real stock market, financial ratios from the current financial statements) were handed out. After final questions were answered, twelve trading periods were conducted.

After each trading period market participants were provided with the market clearing prices, a sheet with their deposit holding for each stock, cash volume and wealth status, and in treatment B the orderflow information. Each experimental session lasted approximately 2.5 hours. After the completion of the 12th period, each subject filled out a post experimental questionnaire relating to main issues of the session like the perceived and handled importance of the ratios, and the ability to cope with the experimental situation. Subjects earnings were calculated by taking the sum of cash and portfolio holdings¹² subtracting total initial wealth. The increase or decrease in experimental wealth during the course of the experiment was converted

¹¹ Written instructions are available from the authors on request.

¹² The value of stock holdings was calculated using the market prices of one of the last three trading periods (determined randomly).

to real payments by dividing with the factor 5000. Finally, earnings were paid privately in cash or bank transfer.¹³

Due to the renunciation of a normative price one may speculate that our participants could decide to play against the experimenter. This is possible by disregarding financial ratios and driving stock prices up to maximize their earnings. However, this behavior does not occur. Although in each session some subjects realized that they could maximize their payments by setting high limits the price determination mechanism prevents a realization of these orders. In addition, the provision of financial incentives does not change neither subjects' behavior nor market outcomes. If subjects are not paid for their participation the main motivation is to maximize earnings relative to the other market participants. To be the most successful trader in an experimental session it is necessary to anticipate other traders' strategies. The most useful way to do this is to concentrate on the financial ratios.

Subjects were initially endowed with DM 50 000 cash and 20 shares of each stock. Participants had a credit limit of 10% of the initial cash endowment, and they could sell short assets with the restriction to buy back one period later. Short positions and credits were double negatively weighted at the end of the experiment.

B Relative Performance of Market Treatments - Hypotheses

Informational Efficiency

Concerning the three topics of market microstructure literature (see above) a main issue is the improvement of the informational efficiency of asset markets. Informational efficiency has several different meanings in the empirical and experimental capital market research (cf. Fama 1970, 1991, Tobin 1984; see the experimental studies recently surveyed by Sunder 1995).

¹³ Only in treatment A sessions with paid experiments.

If one follows the differentiating concept introduced by Tobin (1984) information-arbitrage efficiency and fundamental-valuation efficiency may be distinguished. The first means that a market is efficient „if it is on average impossible to gain from trading on the basis of generally available public information“ (Tobin 1984, 2). This implies the independence of price changes from generally available information. The latter is defined as following: „a market in a financial asset is efficient if its valuations reflect accurately the future payments to which the asset gives title“ (Tobin 1984, 2), that is there is a rigid relation between current price and future dividends on average.

Fama’s concept combines both aspects. Informational efficiency is identical to valuation efficiency in the sense that an asset’s current price is the best proxy for the discounted future payments.

Following Tobin in this study our design allows to test for informational efficiency but not for the valuation efficiency because of the absence of an asset’s (normative) fundamental value. A conclusive concept for the incorporation of financial ratios into the true rational expectations asset value has not been developed yet neither by theorists nor by practitioners.

Hypothesis 1 Building on results from previous call market studies (cf. Schwartz 1993) it is hypothesized that a call market is more informationally efficient if the transparency is higher because more information is available for all market participants.

Though we concentrate on ex post orderbook transparency subjects who are provided with this kind of information learn something about others’ expectation formation processes in the past

and may use this knowledge in the future. Therefore, forecasts of reactions of other market participants should be more accurate and prices should be more informationally efficient.

Operational efficiency

Another market performance concept focuses on the internal or operational efficiency of an asset market. One can investigate how much an experimental or real asset market differs from the idea of a perfect market without frictions, i.e. the orderflow of the market participants reflects their transaction plans. Therefore, it is necessary that order submissions, order monitoring and order revisions are costless and without temporal delays for all market participants (cf. Schreiber/Schwartz 1985, Friend 1972, Bienert 1996).

Obviously the operational efficiency plays an important role for informational efficiency because spatially or temporally fragmented knowledge about the assets' values can only be reflected in the transaction or clearing prices if this information is revealed in the orders. Thus, operational efficiency is a necessary condition for an informationally efficient market. The most important aspect of operational efficiency is liquidity. Liquidity generally describes the possibility that orders are filled without time delay and price impact. According to this definition, liquidity may be broken down into the four aspects

- immediacy,
- depth,
- width, and
- resiliency.

Apart from explicit transaction costs (e.g. brokerage commissions) implicit costs or costs of immediacy of an asset market are the dominant issue in theoretical and empirical market micro-

structure studies. While the time dimension (immediacy) is out of focus in a call market analysis because of the batch institution (discrete time) the cost dimension is worth studying.

Although a liquidity measure comprising all four dimensions of liquidity has not been developed yet, there are two convincing proxies commonly accepted in the literature (cf. Hasbrouck 1993, Huang/Stoll 1996, Schmidt/Iversen 1992, Copeland/Friedman 1991, Friedman 1993b): market depth and trading volume. Market depth means the willingness to transact on each side of a market, volume is a proxy for liquidity as a whole as order volume is considered to be higher in more liquid markets. Since high liquidity means low deviations of transaction prices from the equilibrium price, investors are more willing to trade in liquid markets.

Hypothesis 2a Considering theoretical results (cf. Schwartz 1993) we hypothesize that more transparency (treatment B) causes **deeper** markets because transparency lowers the uncertainty about the behavior of other market participants.

Hypothesis 2b Considering theoretical results (cf. Schwartz 1993) we hypothesize that more transparency (treatment B) causes **more liquid** markets because transparency lowers the uncertainty about the behavior of other market participants.

Orderbook Transparency

A topic in the present discussion about the reshaping of (real) equity markets is the availability of orderflow information in full electronic or electronically assisted trading mechanisms (cf. Schwartz 1993, Schmidt/Iversen 1992). Orderbook transparency features in call markets can be examined as follows (cf. Friedman 1993a).

A first variant contains „blind“ traders who submit their orders to the auctioneer (clearinghouse) but they have no knowledge of what orders other traders are submitting. The only information is the market clearing price. Another possibility is that traders are continuously informed about the price at which the market would clear if no further orders are received by the batch institution (information about the „indicated price“, Friedman 1993a, 417). A third variant gives subjects a summary description of the whole orderbook in addition to the clearing price (ex-post transparency), and a fourth variant opens the orderbook in the widest sense and gives the summary description continuously updated, and before the market clearing price is determined (ex-ante transparency).

The first variant is like our treatment A and the third possibility is equivalent to the B treatment. Generally the insight into the (limit) orderbook enables market participants to infer trends of the market. If the orderbook signals many buy but few sell orders (see Figure 2) this may indicate a price increase, for instance.

With regard to the information intensity issue and the availability of orderflow information one can argue that in trading periods with low information intensity (see below) trading volume is low (cf. Franke/Hess 1997). Besides the clearing price information at the end of the period the orderflow information may be an important determinant for subjects' decisions. By contrast, the open orderbook is less useful in trading periods with new information arrival (companies' ratios).

Hypothesis 3a The orderbook disclosure increases the **trading volume** especially in periods with low information intensity.

Hypothesis 3b In addition we expect that the **volatility** of clearing prices in the two orderbook treatments differs because the orderflow information leads to an adjustment process in every second period, i.e. subjects infer information from „order behavior“ of all market participants.

Due to the lack of a theoretical model it is not possible to judge the directional change of volatility. The increased (endogenous) information about the orderflow could lead to trading strategies resulting in higher volatility (cf. Franke/Hess 1997). On the other hand, enhanced information supply may allow traders to build more rational expectations which results in less disagreement on the value of a stock. Consequently, volatility is reduced compared to a situation without information about other's transactions.

Information Intensity

Another view of market performance concentrates on the market behavior regarding the intensity of information arrival. Usually it is argued that the arrival of new information at an asset market causes market participants to revise their expectations and consequently their portfolios via orders in the market. Franke and Hess complemented (1995, 11): „Hence trade volume increases, and at the same time, price volatility increases because the revision in expectations leads to a revision of equilibrium prices. As the price does not instantaneously jump to its new equilibrium price, it takes some time for the market participants to find out the new equilibrium price by trial and error. In this time period, volatility is higher than normal.“

Concerning the information intensity issue our experimental information structure can be divided in trading periods with and without new information arrival (financial ratios, see above).

Hypothesis 4a In trading periods with new ratios, i.e. in the periods with higher information intensity, **trading volume** as a proxy for the time pattern of information arrival is higher than in the other.

Hypothesis 4b In trading periods with new ratios, i.e. in the periods with higher information intensity, **price volatility** is higher than in the other.

C Results

Informational Efficiency

The results of a typical trading period are shown in Figure 2 for two of the six stocks. The orderbook reveals that the asks ranked from DM 300 to DM 725 (see column 1) and the bids from DM 250 to DM 600 (see column 3). The intended supply (demand) is summed up in column 4 (5). Column 6 indicates the potential turnover and column 7 states the resulting excess demand or supply, i.e. the order volume which is not fulfilled at the relevant clearing price. The maximization of the total trading volume determines the clearing price of stock B which has to be fixed at DM 550.

The results for stock F in Figure 2 display the case of price ranges mentioned above. If there is more than one clearing price complying with the maximum-volume rule the price with the lowest excess demand is chosen.

Informational efficiency in Tobin's sense as a performance criterion cannot be measured directly. Therefore, we look at the relation between the information set given to the subjects and the clearing prices. This is identical with the question whether the signs of the financial ratios' changes are reflected in the price changes of the stocks. To prove the connection between both changes we regressed the logarithmic price changes on the ratios' changes:

$$\ln PC_t = \alpha + \sum \beta_i FRC_{t,i} + \varepsilon_t$$

where $\ln PC_t$ denotes the logarithmic price change of a stock from t-1 to t, $FRC_{t,i}$ denotes the change of the four financial ratios ($i=1,2,3,4$), and ε_t denotes the error term.

Because of similarities of some ratios (see above) the regression on the total set of ratios violates the basic assumptions of regression analysis (multicollinearity). Due to the lack of a theoretical concept for the incorporation of financial statement's ratios into a rational expectations asset value we use subjects' answers in a post-experimental questionnaire as a proxy of ratios' importance within the valuation process. On the scale from 1 (no importance) to 6 (great importance) the market participants ranked the XR profitability ratio as the most important ratio (see Table A in the Appendix).¹⁴

Therefore, we limit our regressions to this ratio on the aggregated level. The regression results are shown in Table 1a. We run a regression for each stock based on the data of all treatment A sessions (upper half of Table 1a) and of all B sessions (lower half).¹⁵

Please insert Table 1a around here

The data in Table 1a indicate significant results for treatment A (positive correlation between XR changes and price changes) and for the first three stocks. The explanation of the price changes by XR ratio changes is quite good. The B treatment does not show any significant

¹⁴ In addition the consistency is checked by requesting the subjects to rank order the four ratios. The results are quite similar (about 80% of the subjects assigned the highest rank to XR).

¹⁵ The results of stock F under treatment A are not reported because they violate the a-priori expectations of a positive β .

results. This seems to be an effect of the orderflow information which we have to consider in the transparency discussion below.

Regarding hypothesis 1, we cannot maintain that our type of orderbook transparency increases informational efficiency. In contrast, the reported results exhibit a decrease in the positive correlation between XR changes and price changes. Testing in the latter direction with the same data, Table 1b presents the results.

Please insert Table 1b around here

Three in five stocks (A, B, C) show significantly lower R^2 in the B treatment than in the A sessions. Thus, the data reveal a tendency towards a decreasing informational efficiency with increasing orderbook transparency.

Our data support the experimental results by Friedman (1993a) who stated that the (ex-ante) public display of the orderbook lowers the informational efficiency of a call market.¹⁶

Operational Efficiency

Market Depth

Analogous to customary empirical analyses of continuous trading mechanisms and dealership markets we define our performance measure for market depth as the difference between the best rejected (extramarginal) bid and ask prices (cf. Friedman 1993b). Friedman (1993a, 423) pointed out that the application of the spread concept to call markets provides an implicit

¹⁶ Friedman used an orderflow information mode with continuous updates of the summary description of the orderbook instead of the ex-post type in our study. The informational efficiency is traditionally measured by the deviation from rational expectations price.

measure of transaction costs as discussed above. In contrast to Schwartz' (1993, 183) assertion that „the bid-ask spread does not exist in call market trading“ because of the fact that all transactions are executed at a uniform price we agree with Friedman's interpretation that the call-market spread represents the difference in transaction price for a new buy order as opposed to a new sell order.¹⁷ Higher values of spread correspond to lower operational efficiency (market depth).

The average relative spread values (bid-ask spread in a stock divided by its market clearing price) for the six stocks in the 9 treatment A sessions and in the 7 B sessions are presented in Table 2. As shown there, the spread differs significantly between both treatments.

Please insert Table 2 around here

The data indicate that in markets with (ex-post) orderflow information the efficiency decreases. Hypothesis 2a is not confirmed. These results are quite similar to those by Friedman (1993a) who reported a significantly lower efficiency (higher spread) in treatments with (ex-ante) public orderflow. Again one possible explanation for this market behavior is that traders informed about the orderbook used the current market information more intensively than the companies' information because they tried to gain from trading on other subjects' expectations revealed in the orderflow.

Liquidity

¹⁷ This spread seems quite similar to the market spread in dealer markets (Schwartz 1993, 146-147) if one assumes that every call market participant can act indirectly as a dealer on his own, i.e. each participant is allowed to submit orders both with bids and asks (like in our experiment, as long as the ask is higher than the bid).

Trading volume is usually considered to be a good proxy for liquidity (cf. Theissen 1996). Volume is measured in each trading period as the number of shares traded, i. e. we use net volume and avoid double counting of trades. Table 3 presents the average trading volume (in shares) for each stock and the whole market both for treatment A and B.

Please insert Table 3 around here

The data indicate no significant difference in trading volume for the market environment with more transparency. Therefore, hypothesis 2b is not confirmed for the liquidity measure. This evidence is more definite than the results of Friedman (1993a). In his study the effect of enhanced (ex ante, see above) orderflow information is not clear-cut. In one of his treatments volume increases and in the second one volume decreases.

Information Intensity

In both treatments A and B the arrival of the new financial ratios is at the beginning of every trading period with an odd number. In treatment B the (ex-post) open orderbook provides additional information.

Table 4 reports data for the average trading volume in each stock and for the whole market for all 16 experimental sessions (treatment A and B). The first data column presents the average volume for the periods with new ratios, the second column shows the average volume for the periods without new ratios.

Please insert Table 4 around here

As expected both the parametric and the nonparametric statistics indicate a significantly higher trading volume in trading periods with high information intensity compared to those without ratios' change. Hypothesis 4a is supported by our results, i. e. trading volume is higher in periods with new information about financial ratios.

Table 5 presents the average variance of price changes for both trading periods with and without arrival of new information for each stock and the whole market.

Please insert Table 5 around here

In the upper third of the Table data from all 16 sessions are shown. The middle third represents the data from treatment A and the lower third reports the B sessions. The data indicate that after new information arrived the volatility in the whole market is higher as expected but this is not true for all stocks.

If one compares the treatments A and B it would appear that the market participants are „diverted“ from companies' data by the orderflow information in treatment B. Therefore, only subjects in treatment A showed the expected transaction behavior under high information intensity.

From the results of the 16 experimental markets, especially the A treatment, we can draw the conclusion that hypothesis 4b is supported by our results.

Our data support the results of the Franke and Hess study (1995) which analyzes information intensity within a real context (floor trading versus anonymous electronic trading). The authors

have shown that trading volume and price volatility are positively correlated with new information arrival, too. Note, that not the fact of information arrival and its impact on volatility is of interest here but the quality of the additional information.

Complementing the results concerning the information intensity issue we finally raise the question whether the increased information supply leads to higher trading volume and price volatility. As shown in Table 5, in trading periods with high information intensity the orderbook disclosure does not have a significant impact on market behavior. In contrast, we now investigate every second trading period comparing the experimental sessions from treatments A and B. Table 6 presents the data.

Please insert Table 6 around here

In the upper half of the table we report the comparison between the price volatility of both treatments when new information arrives. The volatility in the B sessions is significantly higher only for the whole market and for some stocks. On the other hand, the lower half of Table 6 reveals that volatility is higher for almost all stocks and the whole market under low information intensity conditions. is dominant.

With respect to the results reported in Table 6 hypothesis 3b is supported by our results. A similar analysis with our second measure, the volume, shows no significant differences (thus, the data are not reported here). Therefore, hypothesis 3a has to be rejected.

As stated above an obvious explanation for subjects' behavior is that the (ex-post) orderbook disclosure initiates an adjustment process in the trading periods following the periods with new information arrival. Market participants hope to infer information about subjects' valuation processes regarding the ratios' changes from public orderflow and adjust their price expectations on a small volume base. The open orderbook seems to be helpful to form expectations about the expectations of others.

D Individual Behavior - Hypotheses and Results

In addition to the market results, we analyzed the effects of orderbook transparency on individual behavior. In our experimental context, individual behavior is defined as market participants' transactions and their portfolio structure.

Before the details are explored, a closer look at the characteristics of the six stocks is necessary to get an insight into what subjects are able to perceive and what may be the basis of their decisions. To get an idea of how a market participant will judge the attractiveness and the risk of each stock, it is useful to look at the financial ratios and to compute different measures of risk. These measures are more relevant from a theoretical point of view since it is doubtful that subjects really tried to compute any of these statistical measures. This problem is sharpened by the fact that they received the information successively and therefore would have to update these measures each trading period. But still, it may be possible that they intuitively act as if they conducted statistical calculations.

Since there is no formal theory relating the ratios to absolute price levels of the stocks we assume that subjects infer relative attractiveness of a stock by comparing the ratios for each company with the mean of the sample of about 12 000 companies. Subjects know the mean of each of the financial ratios of this sample from the instructions. From this point of view one can assess the reference dependent value of each company and rank the stocks accordingly (see also Table B in the appendix):

- Stock A has a clearly positive trend for each of the four ratios which are well above the mean.

- The figures for stock B have to be interpreted negatively in all periods and lie fairly below the mean.
- Stock C shows a negative development in the first three periods, improves clearly in the last three periods, but the ratios values are (with the exception of XV) always worse than the mean of all companies.
- The ratios for stock D have to be judged negatively during the first four periods and improve in the last two rounds. The values are just above the mean.
- Stock E has a rather ambiguous trend that is rather stable in the first three periods, gets worse in period 4 and improves in the last two periods, the ratios performing just above the mean.
- Stock F shows a decrease of the ratios in the first four periods and an increase in the last two periods.

All the ratios lie far above the mean for every period. Roughly speaking in terms of attractiveness, a ranking of the stocks reveals that stock F and A are the most attractive, the less attractive stocks D and E follow, C is rated considerably lower than these and B is by far the least attractive stock. It has to be noted here that attractiveness also depends on the price level of a stock. Still, we do not consider differing prices here for two reasons. First, subjects were told at the beginning that the first market prices have to be considered as a fair market value for a given set of ratios. There is no private information about potential over- or underpricing and subjects have no reason (and did not express any concerns about mispricing) to suspect otherwise. Second, during the course of the experiment there is no measure determining a proper price change for a given change in financial ratios. Only the direction of a price move can be justified on theoretical grounds.

The following table shows a standardized index for the differences of the individual ratios to the mean averaged over the four ratios. A value of 1 indicates that this stock scores best on all four ratios compared to the other five stocks. In every single period from period 1 on the relative attractiveness can be judged unanimously resulting in the ranking:

$F > A > D > E > C > B$.

Index	Stock A	Stock B	Stock C	Stock D	Stock E	Stock F
Period 0	0,2311	0,0426	0,287	0,432	0,201	1,0
Period 1	0,4121	0,0692	0,195	0,408	0,369	1,0
Period 3	0,4839	0,0149	0,264	0,455	0,405	1,0
Period 5	0,6249	0,0	0,281	0,471	0,439	0,98
Period 7	0,7513	0,0	0,404	0,537	0,41	0,99
Period 9	0,8665	0,0	0,397	0,582	0,419	1,0
Period 11	0,7887	0,0	0,336	0,603	0,401	0,98

Although attractiveness is less relevant for trading activity compared to divergence of opinion the analysis of individual transactions clearly reveals that subjects concentrate on the most attractive stocks. Presumably, trading occurs because of different expectations about future trends of the ratios and as a result of different risk attitudes.

There are two potential data pools in our experimental design to compute risk measures, the financial ratios and the market clearing prices that result during the experiment. It seems more likely that market participants react to the variability of the financial ratios which are already

comparable to each other. On the contrary, price variability is much harder to assess for subjects and requires more cognitive efforts.

The analysis of the variation of the financial ratios shows that - no matter if one applies the standard deviation or the mean absolute deviation from the mean of the ratios - stock F is by far the riskiest, A and B show still a comparatively high risk, E bears intermediate risk, and C and D are the less risky.

Though price volatility is different in each experiment, the overall pattern is that the volatility of stocks A and C is relatively high, stocks B and D show intermediate risk levels, E is still less risky and clearly F has the lowest risk measured by the coefficient of variation of prices (we used absolute price changes instead of relative price changes because we do not think that subjects apply relative change rates systematically).

Depending on what people might regard as the appropriate data and risk measures different stocks are attractive for subjects, but A and B should in every case be regarded as risky whereas E and D are in between. The assessment of C and F depends on the data one uses.

Transaction behavior

Descriptive analysis

We first look at the distribution of individual orders. Theoretically, trading activity should be highest in stocks for which individuals' opinions about the future development diverge (Harris/Raviv 1993). If the future course of a stock is equivocal subjects are likely to come to different expectations about the price trend and (*ceteris paribus*) more traders revise their portfolio structures compared to a stock whose future development seems relatively clear.

Following this reasoning we expected the highest number of active traders in stocks C and E since for these stocks the trend is not stable during the experiment. Instead, non-parametric test for the mean reveal that the number of active traders is equally high in stocks A and F. It is significantly ($\alpha < 0.05$ if not stated otherwise) higher than the number of active traders in stocks E which is in turn higher than that in C. Stocks D and B significantly get even less attention. Though subjects did not get all the data we used to compare the six stocks in attractiveness and risk at once (but subsequently over the course of the experiment), it seems that they learned quickly to respond to the fundamental values and concentrated on the more attractive ones.

The ranking of the stocks changes only slightly when the transaction volume (limit price in deutschmarks times number of shares) is taken into account. The average transaction volume of an order (in deutschmarks) shows the sequence F, E, A, B, D and C. Though the order volume remains stable during the experiment, the number of active traders is significantly higher in the first half of the experiment. Another exception is stock C which is significantly traded more often in later trading periods.

There are slightly more buy (3179) than sell orders (2816), about 80% of all orders submitted are limit orders with no difference on the buy and sell side. Buy orders cluster at the beginning of the experiment (about 55-60%), sell orders dominate in the last three trading periods (significant at the 5% level). The proportion of limit to market orders rises from an average of 77% in the first four trading periods to 84% in average in trading periods 9 to 12 (significant at the 5% level), which indicates that market participants learn to avoid the risk of large price movements that may result in a thin market. These results are not significantly influenced by the transparency of the orderbook.

We also tested for the possibility that traders' behavior differed between the three universities where the experiments were conducted. But as we already expected due to similar education there was no significant difference in all the measures we applied to analyze individual behavior. Furthermore, the behavior of the unpaid subjects does not differ from the behavior of the group of subjects that was paid for participation.

Transparency of the orderbook and transaction behavior

Hypotheses on the effect of orderbook transparency on individual behavior cannot be directly deduced from market microstructure models since subjects receive the orderbook after the price formation process took place. At this time, the additional information does not entirely reduce transaction risk in the same period (the uncertainty if an order is settled and at which price). But it allows to get information about the expectations of market participants. This knowledge of the (ex-post) public orderflow can be used to react more appropriately to others' trading strategies and to gauge future market values in the following period (reconsider the notion of financial markets as beauty contests). The additional information could also trigger subjects to trade more actively. Since the number of participants and the number of active traders both differ slightly between the experiments, the average order volume per active trader is a suitable measure. This leads to hypothesis 5:

Hypothesis 5 The average order volume (in shares) per active trader is higher with an open orderbook.

The hypothesis is not confirmed for all stocks. This supports our prior results for the market level (see hypothesis 2b). The order volume is not higher when market participants are pro-

vided with orderbook transparency. Table 7 demonstrates that for most of the stocks the data show the tendency that more information does not lead to a higher volume.

Please insert Table 7 around here

Another effect of the increased transparency focuses on the limits (the prices of bids and asks), concretely on the influence of orderbook transparency on price limits. If subjects use the information about other participants' orders and price limits to improve their judgment about others' expectations, the difference between clearing price and bid or ask price should be smaller. A related measure that may be used to test this conjecture is the difference between subjects' (sellers') willingness to accept and their (buyers') willingness to pay (WTA-WTP-Disparity). So we get hypothesis 6:

Hypothesis 6 The average difference in percent between limit prices and the last market clearing price is smaller when subjects are provided with orderbook transparency.

In the case of rejected limit orders a comparison of the deviations over the six stocks shows that hypothesis 6 is not confirmed. The deviations show the tendency of higher deviations with enhanced orderbook information both for buy and sell orders (see Table 8). Of course, this result corresponds to the statement that market spreads are not lower when market participants have access to orderflow information (see hypothesis 2a).

Please insert Table 8 around here

These results are confirmed considering only the orders which are filled, though for buy orders the difference is not significant. These results keep true if one takes single stocks to test the hypothesis. Again, the orderbook transparency does not decrease the difference between limit prices and the market clearing price, instead, the deviations in buy limits are higher for all six stocks. The results for the sell limits show the same tendency.

A possible explanation for this phenomenon is that the information about other traders' orders leads subjects to disregard fundamental information and to focus on the amount others' are willing to pay or accept. They therefore successively place lower buy orders and higher sell order because they have seen that other market participants have been more „greedy“ and they also try to get a bigger share of the cake.

Portfolio structures

Descriptive analysis

Although subjects are not enabled to calculate an optimal risk adjusted portfolio with the data provided in the sessions, some interesting features can be stated on a more descriptive level.

The analysis of subjects' portfolio structures on an aggregate level only makes sense with regard to the distribution of portfolio changes in time since we had a closed market and therefore the average number of shares of each stock in a portfolio is always 20 (except for small rounding errors resulting from the repartition of stocks when the two market sides do not match exactly). If one uses classes for the deposit holdings of assets (<10 ; $10 \leq 20$; $20 \leq 25$; $25 \leq 30$; $30 \leq 40$; $40 \leq 50$; >50 shares) it is apparent that most of the restructuring of the given portfolio structure of 20 shares of each stock takes place during the first half of the experiment. The final distribution of stocks among traders is realized already at the end of trading

period 6. Only about a third of our subjects still hold all six companies in the last trading period, about 40% have 4 or 5 different stocks in their portfolio, approx. 15% own shares of 3 companies, and about 12% only hold shares from one or two companies or only cash. Although individuals' trading behavior is different in the first and the second half of the experiment there is no significant difference in the measures we used to analyze the aggregated (market) level. Therefore, we presented only the results averaged over the 12 periods.

Though these results are based on aggregate holdings the analysis of individual holdings confirms our conclusion. Taking the absolute value of average changes in portfolio structure for every trader for all six stocks this measure is significantly (at the 1% level) higher in the first half (20) than in the second (15). This means that individuals change their portfolio structure significantly more in trading periods 1 to 6. This result holds in general also for the single stocks (only the holdings of stock E are changed insignificantly more often in the second half).

This result is compatible to subjects' transaction behavior in the respect that the number of active traders is significantly higher in the first half of the sessions compared to the second. On the other hand, there are no significant differences for average trading volume in deutschmarks and in number of shares traded. This means that active traders do not increase their order volume towards the end.

Finally, one may conclude from the results that subjects are more often engaged in trading activities that only aim at short-term profits and not at long-term increases in the value of stocks. If the subjectively optimal portfolio is already accomplished in the first half of the experiment but trading volume does not decrease in the second half, short-term trading activities should be more common towards the end. If one uses changes in cash balance as an indirect measure of

trading activities this hypothesis is confirmed by significantly higher changes in cash balances in the second half (0.9350) compared to the first (0.4075). This difference is significant at the 5% level.

Transparency of the orderbook and portfolio structures

The information about the orderbook increases the complexity of the experimental situation. As the literature on decision heuristics demonstrates, an increase in information available leads to decision strategies that are trying to reduce the growing complexity. In our experiment the orderflow information should result in a behavior that reduces situational complexity. While the direct implication of this decision strategy is a decreased trading activity for each trader a rather indirect simplifying decision strategy is the reduction of different stocks in one's portfolio. This allows the traders concentrate their attention to only a portion of total stocks available. We therefore postulate the following hypotheses:

Hypothesis 7a Orderbook transparency causes traders to submit less orders per period.

Hypothesis 7b Orderbook transparency results in a lower average number of different stocks per period in each trader's portfolio.

The examination of the average number of orders shows that there is no significant difference between the two treatments, the number of orders only being slightly higher with the closed orderbook. Hypothesis 7a has to be clearly rejected.

As shown by the data in Table 9, the additional information seems to lead subjects to concentrate on a smaller number of different stocks. This result is confirmed by the fact that for all

stocks but stock F the frequency of traders with an average number of less than 10 shares is significantly higher in the open orderbook treatment.

Please insert Table 9 around here

Furthermore, subjects in the closed orderbook treatment concentrate significantly more on stock C and neglect E and F. The number of changes in portfolio structure is higher with the closed orderbook (18.4) than with the open orderbook (16.1) but the results are not significant. Insignificance also characterizes the higher average percentage of changes in cash in the open orderbook treatment (0.7141 versus 0.6084) as a measure of trading activities. Overall, hypothesis 7b cannot be rejected.

The result that hypothesis 7a is rejected while 7b is confirmed seems puzzling at first sight. However, the seemingly contradiction can perhaps be resolved by the interpretation that traders try to reduce the number of stocks in their portfolios in with an open orderbook but they are not able to successfully carry out this strategy. The closed orderbook allows subjects to reduce their holdings, instead, and the frequency for the submission of orders does not change when there are less stocks to be observed.

In sum, the results concerning individual behavior under the (ex-post) orderflow information suggest that the public orderbook influences the portfolio structure and forces the tendency for a more sophisticated stock selection („stock picking“).

E Summary and Conclusion

The present study of 16 experimental stock markets finds important differences between various microstructure settings of a call market. Overall, one of the most impressive results is that orderflow information does not increase market efficiency generally. This is complemented by

the observation that in developing price expectations market participants have the tendency to infer more information from the clearing price and the public orderflow than from the companies' ratios in later trading periods.

Comparing the operational efficiency of call markets with and without public orderflow there is evidence that enhanced orderflow information leads to lower efficiency, i.e. an open orderbook lowers market depth and liquidity. These results are supported by other experimental studies (cf. Friedman 1993a).

We can show, on the one hand, that new information arrival or high information intensity causes higher volatility and trading volume as expected considering the more recent literature in finance. On the other hand, market participants react to the access to public orderflow in low information intensity periods, and a higher volatility results. It is obvious that subjects use the orderflow information to adjust their price expectations from the high information intensity periods in the following trading period and hope to gain from „insights“ in other participants' order behavior.

Additional analyses of individual behavior support the results for the market level and yield further insights into the trading process. Market participants show the ability to interpret the financial ratios and concentrate on attractive stocks. Contrary to our hypothesis, the orderflow information does not lead subjects to trade more actively. Subjects show the tendency to use the (ex-post) public orderbook to trade on the bid or ask of the market spread in the following trading period.

With regard to market participants' deposit holdings the supply of additional orderflow information results in the concentration on less stocks in order to reduce situational complexity. Furthermore, restructuring processes to adapt initial endowments to one's preferences take place mostly during the first half of our experiments.

Finally, the study demonstrates that a laboratory asset market does not have to lack realistic features. The results show that it is possible to compare market performance and participants' behavior in different market settings which refrain from traditional approaches. The findings have to be confirmed and considered in companion analyses which focus on the competition of trading mechanisms (call versus continuous trading versus dealer markets) under various treatments. With respect to this and future policy recommendations it is necessary to test for validation especially in the sense that a closer look has to be taken at the question how the number of traders affects laboratory call market performance and public orderbook impact.

Appendix

Please insert Table A around here

Please insert Table B around here

Instructions to Participants

(original instructions in German)

1 Introduction

In our experimental stock market, you will trade shares of a number of securities (stocks). You submit your buy and sell orders directly to the stock exchange. There are no transaction costs (deposits charge, commissions etc.) and tax effects are neglected.

Initially, you are endowed with fictitious 50.000 DM. You can invest this amount fully or partly in stocks of six real but anonymized companies. Cash holdings as a risk free investment will not earn any interest. Additionally, you are endowed with 20 stocks of each company at the beginning of the experiment.

The names of the stocks (companies) are fictitious because no participant should have advantages by previous knowledge about the involved companies. In reality they are listed on German stock markets. The stocks of the six different companies have similar characteristics (common stocks with a par value of 50 DM). For reasons of simplicity, a company's profits

will not be paid out to its owners but fully accumulated. Therefore, profits will be reflected in the information about each company you are provided with (see below).

The experiment will end after approximately 1.5 hours. To avoid manipulations, not the final trading period will be chosen to assess final wealth but one of the three last trading periods will be selected at random.

2 Information available to every investor

One important feature of the investment situation in the experiment is that you will not receive the usual publicly available information like news in the media, balance sheets or similar. Instead, you are provided with information that is already compressed (ratios). These ratios should ease (compared to the information given in reality) the assessment of each of the six companies.

The ratios stem from a neural network, which analyzed the financial statements of 11.500 listed and not-listed companies (non-financial institutions only). The ratios, which will be explained in the following, give hints on the future success or failure of a company.

You will be provided with information about the six companies at the beginning of each trading period. This information represents the best estimator of the future development of a company. It predicts correctly the success or the failure of a company with a probability of approximately 90%. At the beginning of the first trading period you will be provided with the last end-of-period market price of each stock and the most recent value of the ratios (past data).

All ratios are adjusted in a way that they can be compared to the ratios of all other companies. The way the ratios are constructed also eliminates manipulations of balance sheets (window dressing etc.). In addition, you are provided with the mean and the range of every ratio from the original data pool of 11.500 companies; successful (not successful) companies are characterized by a better (worse) value than the given mean.

You are provided with the following information (ratios) each trading period:

Profitability: Ratio XR

- The measure of profitability will be given by the relation between (operating) cash flow and total assets. The cash flow is calculated by adjusting the earnings for depreciation. It represents the real amount of cash of a company (difference between deposits and payments).
- The ratio XR can be interpreted as an adjusted profitability of the whole company. *Increasing values of XR indicate a rather successful, decreasing values a rather not successful future development of the company.*
- With respect to the 11.500 companies, XR ranges from -15% to +65% in each period, the mean is 15%. Successful companies show a $XR > 15\%$, less successful ones a $XR < 15\%$.

Financial strength: Ratio XF

- The cash flow as an indicator of financial strength, i.e. the ability to use cash without raising additional equity or debt capital, is related to the level of debt capital of a company. This ratio is also called „internal“ financial strength, since external financing is excluded.
- The ratio XF shows a company's ability to pay back its liabilities out of its cash flow, if all funds were employed. If, for example, $XF = 100\%$, then the internal financial strength exactly equals its liabilities, i.e. the company could pay back its liabilities at once. Of course, this need not to be reasonable due to profitability reasons. *An increasing XF ratio indicates a rather successful, a decreasing a less successful future development of the company.*
- With respect to the 11.500 companies, XF ranges from -20% to +155% in each period, the mean is 33%. Successful companies show a $XF > 33\%$, less successful ones a $XF <$

33%.

Capital structure: Ratio XE

- This information about capital structure is confined to a relation of an adjusted shareholders' equity and a corrected total assets value.
- Hence, the ratio XE represents a modified shareholders' equity quota. Analyses using the neural network show that a tendency towards increasing XE values indicates a rather successful future development of the company (because of the decreasing leverage risk).
- With respect to the 11.500 companies, XE ranges from -20% to +150% in each period, the mean is 40. Successful companies show a $XE > 40\%$, less successful ones a $XE < 40$ (Mind that if $XE > 100\%$, it is important to consider that the denominator, i.e. total assets, has been reduced!)

Indebtedness: Ratio XV

- In addition to XE, XV provides you with information concerning capital structure in terms of indebtedness with short term debt capital. This short term debt capital (up to one year) is related to the total assets of a company.
- The ratio XV represents a kind of short term debt ratio. The experiences of the expert's neural network show that a tendency towards decreasing XV values indicates a rather successful future development of the company, while less successful companies rather show a (significant) increase in their short term debt.
- With respect to the 11.500 companies, XV ranges from 0% and 100% in each period, the mean is 65%. Successful companies show a $XV < 65\%$, less successful ones a $XV > 65\%$.

3 Purchase and sale of stocks (placing orders)

In every trading period you have the opportunity to submit buy and sell orders. At the beginning of the experiment you will receive order forms in which you have to fill in your buy and sell requests. The orders are collected by the experimenter.

A single market clearing price of each stock is computed by considering the buy and sell orders of all participants. The price formation process is set up by the experimenter so that the market is cleared at the price that maximizes transaction volume. The market price of each stock is solely based on the orders that you and the other participants of the experiment of your group have submitted (approximately 10 participants in each group).

In addition to the requested number of stocks you can also state the requested buying or selling price on the order form. If you state a price, the order is called a limit order, if you only state the number of stocks, the order is called a market order:

Market orders will be cleared at the market price and always executed, if there are enough corresponding orders on the other side of the market. One is buying „cheapest“ (at the most favourable market price) and selling „best“ (at the highest market price). If there are not enough corresponding orders to execute all unlimited orders, then every order is only partially executed, i.e. only a certain part of the originally requested number of stocks is traded. If such a repartition becomes necessary, you will be informed about how many stocks of your order were actually traded. You will get this information at the same time when the market clearing price is announced.

If you submit a **limit buy order**, you do not only state the number of requested stocks but also the price up to which you are willing to buy. If the market price is *equally high or lower*, then your order will be executed at market price, i.e. you will receive the requested number of each stock, if there are enough corresponding orders on the other side of the market. If this is not the case, an allotment with the following procedure will take place: at first, the buy orders with the highest buy limit will be executed. If the limits are equal, only parts of each order can be executed. You are informed about the number of shares of your order that was executed. Occasionally your order may not be executed at all.

If the *market price* is *above* your *price limit*, then your buy order will not be executed and you will receive no stocks.

If you submit a **limit sell order**, you do not only state the number of requested stocks but also the price at which you are willing to sell. If the market price is assessed *equally high* or higher, then your order will be executed at market price, i.e. you will deliver the requested number of each stock, if there are enough corresponding orders on the other side of the market. If this is not the case, an repartition with the following procedure will take place: at first, all sell orders will be executed that have the lowest sell limit. If the limits are equal, only parts of each order can be executed. You are informed about the number of shares of your order that was executed. Occasionally your order may not be executed at all. If the market price is *below* your *price limit*, then your *sell order* will not be executed and you will keep your stocks.

The following abbreviations indicate whether or not a repartition was necessary:

- bG (bB): „bezahlt Geld (Brief)“, i.e. that limit orders were not completely executed at the market clearing price (example: „100bG“ means that buy orders which had a limit of 100 (equal to the clearing price), could only be executed with a lower than requested number of stocks. Buy orders with a higher limit or unlimited buy orders were executed. „100bB“ means that sell orders which had a limit of 100 (equal to the clearing price), could only be executed with a lower than requested number of stocks. Sell orders with a lower limit or unlimited sell orders were executed.
- repG (repB): „repartiert Geld (Brief)“, i.e. that at the market price even buy (sell) orders with a limit equal to the market price or higher (lower) could only be executed by allotment or not executed at all.

In the cases where there was no stock trading at all, you will receive the announcement:

- „G (Geld)“ or „B (Brief)“, respectively. This price represents the highest bid and the lowest ask, respectively. There were no sell or buy orders, respectively, for this stock.

Your cash position, which is initially 50.000 DM and which can be increased by sales of stocks and decreased by purchases, should not be negative. It will be tolerated that you may costlessly exceed it up to 10% of your initial cash endowment, but you have to pay back the deficits in the next trading period. Something similar holds true for short selling of stocks: these are allowed but you have to even it out in the second but next period. At the end of the experiment your cash deficits and the outstanding stock positions will be double-weighted (negatively). The valuation of your achievements in the experiment is not necessarily based on the market prices of the last trading period (the period will be chosen randomly). Therefore, even in the last period you should decide as if afterwards purchases and sales would still be possible.

4 Incentives

The additional wealth that you gain throughout the experiment will not only determine your rank within the group but will also have real financial consequences. Your profits will be converted to real payments by dividing it through the factor 5000. But you have to pay for your losses in the same way.

5 Concluding remarks

In accordance with reality, there are no „wrong“ or „true“ decisions. Invest your money and make your investment decisions in a way that you feel confident with them based on the given information.

References

- Amihud, Yakov and Haim Mendelson, 1985, An Integrated Computerized Trading System, in: Yakov Amihud et al., eds., Market Making and the Changing Structure of the Securities Industry, Toronto, Lexington, 217-235
- Amihud, Yakov and Haim Mendelson, 1987, Trading Mechanisms and Stock Returns, *Journal of Finance*, 42, 533-555.
- Bagwell, Laurie S., 1991, Shareholder Heterogeneity, *American Economic Review*, 81, 218-221.
- Bienert, Horst, 1996, *Der Marktprozeß an Aktienbörsen*, (Gabler, Wiesbaden).
- Binswanger, Hans P., 1981, Attitudes Towards Risk, *Economic Journal*, 91, 867-890.
- Bloomfield, Robert and Maureen O'Hara, 1998a, Market Transparency: Who Wins and Who Loses?, Working Paper Johnson Graduate School of Management.
- Bloomfield, Robert and Maureen O'Hara, 1998b, Can Transparent Markets Survive? Revised Working Paper, Johnson Graduate School of Management.
- Camerer, Colin, 1992, The Rationality of Prices and Volume in Experimental Markets, *Organizational Behavior and Human Decision Processes*, 51, 237-272.
- Cohen, Kalman J. et al., 1986, *The Microstructure of Securities Markets* (Prentice-Hall, Englewood Cliffs).
- Copeland, Thomas E. and Daniel Friedman, 1991, Partial Revelation of Information in Experimental Asset Markets, *Journal of Finance*, 46, 265-294.
- Copeland, Thomas E. and Daniel Friedman, 1992, The Market Value of Information: Some Experimental Results, *Journal of Business*, 65, 241-266.
- Fama, Eugene F., 1991, Efficient Capital Markets II, *Journal of Finance*, 46, 1575-1617.
- Fama, Eugene F., 1970, Efficient Capital Markets, *Journal of Finance*, 25, 383-417.

- Flood, Mark, Ronald Huisman, Kees G. Koedijk, Ronald J. Mahieu, and Ailsa A. Röell, 1997, Post-Trade Transparency in Multiple Dealer Financial Markets, Working Paper Maastricht University.
- Flood, Mark, Ronald Huisman, Kees G. Koedijk, Mathijs A. van Dijk, and Irma W. van Leeuwen, 1998, The More You See, the Less You Get: Price-Competing Insiders under Different Trading Mechanisms, Working Paper Maastricht University.
- Forsythe, Robert, Thomas R. Palfrey, and Charles R. Plott, 1982, Asset Valuation in an Experimental Market, *Econometrica*, 50, 537-567.
- Franke, Günter and Dieter Hess, 1995, Anonymous Electronic Trading Versus Floor Trading, Working Paper, University of Konstanz.
- Franke, Günter, 1991, Inside Information in Bank Lending and the European Insider Directive, in: Klaus J. Hopt, ed., *European Insider Dealing* (London) S..
- Friedman, Daniel, 1993a, How Trading Institutions Affect Financial Market Performance: Some Laboratory Evidence, *Economic Inquiry*, 31, 410-435.
- Friedman, Daniel, 1993b, Privileged Traders and Asset Market Efficiency: A Laboratory Study, *Journal of Financial and Quantitative Analysis*, 28, 515-534.
- Friedman, Daniel, Glenn W. Harrison, and Jon W. Salmon, 1984, Informational Efficiency of Experimental Markets, *Journal of Political Economy*, 92, 349-408.
- Friedman, Daniel and Joseph Ostroy, 1995, Competitiveness in Auction Markets: An Experimental and Theoretical Investigation, *Economic Journal*, 105, 22-53.
- Friedman, Daniel and Shyam Sunder, 1994, *Experimental Methods: A Primer for Economists* (Cambridge University Press, Cambridge).
- Friend, Irwin, 1972, The Economic Consequences of the Stock Market, *American Economic Review*, 62, 212-219.

- Gemmill, Gordon, 1996, Transparency and Liquidity: A Study of Block Trades on the London Stock Exchange under Different Publication Rules, *The Journal of Finance*, 51, 1765-1790.
- Gerke, Wolfgang, Horst Bienert, and Uwe Schroeder-Wildberg, 1995, Orderbuchtransparenz bei homogenem Informationsangebot, *Kredit und Kapital*, 28, 227-269.
- Grether, David M. and Charles R. Plott, 1979, Economic Theory of Choice and the Preference Reversal Phenomenon, *American Economic Review*, 69, 623-638.
- Hasbrouck, Joel, 1993, Assessing the Quality of a Security Market, *Review of Financial Studies*, 6, 192-212.
- Huang, Roger D. and Hans R. Stoll, 1996, Dealer Versus Auction Markets: A Paired Comparison of Execution Costs on NASDAQ and the NYSE, *Journal of Financial Economics*, 41, 313-357.
- Kachelmeier, Steven J. and Mohamed Shehata, 1992, Examining Risk Preferences Under High Monetary Incentives, *American Economic Review*, 82, 1120-1141.
- Kahneman, Daniel, 1991, Judgment and Decision Making: A Personal View, *Psychological Science*, 2, 142-145.
- King, Martin and Ailsa Röell, 1988, Insider Trading, *Economic Policy*, 8, 165-193.
- Madhavan, Anand, 1996, Security Prices and Market Transparency, *Journal of Financial Intermediation*, 5, 255-283.
- Neumann, Peter J. and Peter E. Politser, 1992, Risk and Optimality, in: Frank Yates, ed., *Risk-Taking Behavior* (Wiley, Chichester) 27-47.
- Nöth, Markus and Martin Weber, 1996, Insider Detection in Experimental Asset Markets, Working Paper, University of Mannheim, August.
- O'Hara, Maureen, 1995, *Market Microstructure Theory* (Basil Blackwell, Cambridge).

- Pagano, Marco and Ailsa Röell, 1990a, Trading Systems in European Stock Exchanges: Current Performance and Policy Problems, *Economic Policy*, 10, 65-115.
- Pagano, Marco and Ailsa Röell, 1990b, Auction Markets, Dealership Markets and Execution Risk, CEPR Working Paper No. 8, London.
- Pagano, Marco and Ailsa Röell, 1996, Transparency and Liquidity: A Comparison of Auction and Dealer Markets with Informed Trading, *Journal of Finance*, 61, 579-611.
- Röell, Ailsa, 1992, Comparing the Performance of Stock Exchange Trading Systems, in: J. Fingleton and D. Schoemaker, eds., *The Internationalisation of Capital Markets and the Regulatory Response* (Graham and Trotman, London) 167-172.
- Schmidt, Hartmut and Peter Iversen, 1992, Automating German Trading: Bid-Ask Spreads on Competing Systems, *Journal of Financial Services Research*, 6, 373-397.
- Schnitzlein, Charles R., 1996, Call and Continuous Trading Mechanisms Under Asymmetric Information: An Experimental Investigation, *Journal of Finance*, 51, 613-636.
- Schreiber, Paul S. and Robert A. Schwartz, 1985, Efficient Price Discovery in a Securities Market, in: Amihud, Yakov, Thomas S. Y. Ho and Robert A. Schwartz, eds., *Market Making and the Changing Structure of the Securities Industries* (Lexington, Toronto) 19-39.
- Schwartz, Robert A., 1993, *Reshaping the Equity Markets* (Business one Irwin, Homewood).
- Smith, Vernon L. et al., 1982, Competitive Market Institutions, *American Economic Review*, 72, 58-77.
- Stoll, Hans R., 1992, Principles of Trading Market Structure, *Journal of Financial Services Research*, 6, 75-107.
- Sunder, Shyam, 1995, Experimental Asset Markets: A Survey, in: John H. Kagel and Alvin E. Roth, eds., *The Handbook of Experimental Economics*, (University Press, Princeton) 445-500.

- Theissen, Erik, 1996, Market Structure and the Aggregation of Information: An Experimental Investigation, Working Paper, University of Frankfurt.
- Tobin, James, 1984, On the Efficiency of the Financial System, *Lloyds Bank Review*, 152, 1-15.
- Van Boening, Mark V. et al., 1993, Price Bubbles and Crashes in Experimental Call Markets, *Economics Letters*, 41, 179-185.
- Williams, Arlington W., 1980, Computerized Double-Auction Markets: Some Initial experimental Results, *Journal of Business*, 53, 235-258.

Table 0.1

Average Logarithmic Returns in Treatment C and D (with/without financial incentives)

T-tests for the comparison of means are performed. The following hypotheses are tested:

$$H_0: R_{TC} = R_{TD}$$

$$H_1: R_{TC} \neq R_{TD}$$

The t-statistic shows that H_0 cannot be rejected, because the average returns in treatment C are not significantly different from those in treatment D. So hypothesis 1 is maintained.

<i>Returns</i>	<i>Treatment C</i>	<i>Treatment D</i>	<i>t-stat</i>
Stock A	.066	.04	-.88
Stock B	-.02	-.02	.13
Stock C	.05	0	-1.67*
Stock D	.03	.02	-.62
Stock E	.02	.03	.29
Stock F	0	.02	1.44
All stocks	.02	.01	-.85

Notes: * (**) (***) indicates that there is a difference in the average returns between treatment C and D which is significant to the 10% (5%) (1%) level.

If there is no quotation in a stock at time t then the quotation in t-1 is used for calculating the return.

R_{TC} denotes the average return in treatment C, R_{TD} denotes the average return in treatment D.

Table 0.2

Average Trading Volume under Treatment C and D (with/without financial incentives)

T-tests for the comparison of means are performed. The following hypotheses are tested:

$$H_0: TV_{TC} = TV_{TD}$$

$$H_1: TV_{TC} \neq TV_{TD}$$

The t-statistic shows that H_0 cannot be rejected, because trading volume in treatment C is not significantly different from trading volume in treatment D. So hypothesis 2 is maintained.

<i>Trading Volume</i>	<i>Treatment C</i>	<i>Treatment D</i>	<i>t-stat</i>
Stock A	16.20	23.76	1.60
Stock B	17.02	22.89	1.28
Stock C	20.04	31.54	1.66
Stock D	16.78	21.81	1.11
Stock E	16.98	21.50	.71
Stock F	12.18	12.73.	.27
All stocks	76.25	82.79	.60

Notes: * (**) (***) indicates that there is a difference in the average trading volume between treatment C and D which is significant to the 10% (5%) (1%) level.

If there is no trading volume in a stock in a period then this is treated as a missing value.

TV_{TC} denotes the average trading volume in treatment C, TV_{TD} denotes the average trading volume in treatment D.

Table 0.3

Comparison of Volatility between Treatment C and Treatment D (with/without financial incentives)

Moses tests are performed to detect (significant) differences in dispersions between treatment C and treatment D. The Moses test is chosen instead of a parametric F-test for testing differences in variances because it cannot be assumed that the sample values are normally distributed. The following hypotheses are tested:

$H_0: \text{Span}_{TC} = \text{Span}_{TD}$

$H_1: \text{Span}_{TC} \neq \text{Span}_{TD}$

The data in the last column of this table indicate that there are significant differences between treatment C and treatment D for share A and share C and for the whole market. In these cases hypothesis 3 is not maintained.

	<i>Treatment C</i>	<i>Treatment D</i>	<i>1-tailed Probability (Moses test)</i>	<i>1-tailed Probability without Outliers (Moses test)</i>
Stock A	.0235	.0152	.45	.04**
Stock B	.0340	.0285	.63	.35
Stock C	.0347	.0091	.01***	.03**
Stock D	.0131	.0064	.31	.35
Stock E	.0158	.0042	.13	.35
Stock F	.0083	.0027	.63	.11
All stocks	.0222	.1768	.63	.00***

Notes: * (**) (***) indicates that there are differences which are significant to the 10% (5%) (1%) level.

In the Moses test without outliers 2.5% of the data are removed from each end as outliers from the sample.

Span_{TC} denotes the span of the sample values in treatment C, Span_{TD} denotes the span of the values in treatment D.

The term volatility is used as synonym for variance.

Table 0.4
Orderflow Information and Average Relative Spreads - Aggregated Over All Stocks

A t-test for the comparison of means is performed. The following hypotheses are tested:

H_0 : $\text{Spread}_{TC} = \text{Spread}_{TD}$

H_1 : $\text{Spread}_{TC} \neq \text{Spread}_{TD}$

The spread values and the t-statistic shown in this table indicate that the spreads are equal for both treatments. As a result hypothesis 4 is maintained.

	<i>Treatment C</i>	<i>Treatment D</i>	<i>t-stat</i>
Average Relative Spreads	.1069	.1241	-1.04

Notes: Both in treatment C and D approximately 2.5% of the data are removed from each end as outliers.

Spread_{TC} denotes the average relative spread in treatment C, Spread_{TD} denotes the average relative spread in treatment D.

Table 1a
Determinants of Price Changes: Regression Results

The table presents results of the regression $\ln(p_t) - \ln(p_{t-1}) = \alpha + \beta (\Delta XR) + \varepsilon_t$. p_t stands for the price of the respective stock in period t , ΔXR for the change of the financial ratio XR from period $t-1$ to period t and ε_t for an error term in period t with an expected value of 0 and a variance of σ^2 .

	<i>Stock A</i>	<i>Stock B</i>	<i>Stock C</i>	<i>Stock D</i>	<i>Stock E</i>	<i>Stock F^a</i>
<i>Treatment A:</i>						
Coefficient:						
Constant	.031*	-.013	.031*	.033*	.018	
(t-stat)	(2.507)	(-.790)	(2.098)	(3.157)	(1.688)	
ΔXR	2.123*	1.112*	3.350*	.837*	.578*	
(t-stat)	(4.704)	(5.494)	(5.733)	(2.137)	(3.235)	
R ²	.181	.232	.247	.044	.095	
<i>Treatment B:</i>						
Coefficient:						
Constant	.084*	-.025	.087*	.070*	.034	.029
(t-stat)	(3.361)	(-1.011)	(3.694)	(2.702)	(1.721)	(1.573)
ΔXR	1.689	.223	1.426	1.615	.557	.131
(t-stat)	(1.859)	(.726)	(1.533)	(1.660)	(1.713)	(.659)
R ²	.042	.007	.029	.034	.037	.006

Notes: ^a The results of stock F in treatment A are not listed because the a-priori expectation of a positive coefficient β is violated.
A * indicates that the coefficient is significantly different from zero at the 5% level.

Table 1b
The Correlation between Price Changes and Changes of Financial Ratios: Test Results

R^2 determined by the regression described in Table 1a served as the basis for our analysis if price changes can be explained better by the financial ratio changes in an open orderbook than in a closed orderbook scenario. For reasons of simplification we used the square root of R^2 , which is just the Pearson correlation coefficient between price changes and changes of the financial ratio XR and a good estimator for the linear dependence of these variables. For the procedure the correlation coefficients of treatment A and treatment B were converted into values z_A and z_B , respectively, according to the Fisher transformation. The test statistic

$$T = \frac{z_A - z_B}{\sqrt{1/(n_A - 3) + 1/(n_B - 3)}} \text{ is approximately normally distributed (} n_A \text{ is the number of observations in treatment A, } n_A = 102, n_B$$

the number of observations in treatment B, $n_B = 80$).

According to hypothesis 1 we tested $H_0: \rho_A \geq \rho_B$ against $H_1: \rho_A < \rho_B$, ρ standing for the correlation in the population. The test statistics show no significantly negative values. The reverse seems to be true, so we cannot maintain the hypothesis that a call market is more informationally efficient if transparency is higher.

	<i>Stock A</i>	<i>Stock B</i>	<i>Stock C</i>	<i>Stock D</i>	<i>Stock E</i>	<i>Stock F</i>
<i>Treatment A:</i>						
R^2	.181	.232	.247	.044	.095	.005
R	.426	.482	.497	.209	.308	.069
<i>Treatment B:</i>						
R^2	.042	.007	.029	.034	.037	.006
R	.206	.082	.171	.185	.192	.074
Test statistics	1.617	2.914	2.455	.166	.817	-.037

Table 2
Orderflow Information and Average Relative Spreads - Aggregated Over All Stocks

A t-test for the comparison of means is performed. The following hypotheses are tested:

$H_0: \text{Spread}_{TB} \geq \text{Spread}_{TA}$

$H_1: \text{Spread}_{TB} < \text{Spread}_{TA}$

In contrast to our assumption, the spread values and the t-statistic shown in this table indicate that the spreads are higher in case of an open orderbook treatment B. As a result hypothesis 2a is not confirmed.

	<i>Treatment A</i>	<i>Treatment B</i>	<i>t-stat</i>
Average Relative Spreads	.1166	.1935	-4.24

Notes: Both in treatment A and B 2.5% of the data are removed from each end as outliers.

Spread_{TA} denotes the average relative spread in treatment A, Spread_{TB} denotes the average relative spread in treatment B.

Table 3
Average Trading Volume under Treatment A and B

T-tests for the comparison of means are performed. The following hypotheses are tested:

$$H_0: TV_{TB} \leq TV_{TA}$$

$$H_1: TV_{TB} > TV_{TA}$$

The t-statistic shows that H_0 cannot be rejected, because trading volume in treatment B is not significantly higher than in treatment A (except for stock B and F). A look on the data confirms this result, i.e. in 2 cases the trading volume in treatment A is even higher, in the other cases there is only a small difference. So hypothesis 2b is not confirmed.

<i>Trading Volume</i>	<i>Treatment A</i>	<i>Treatment B</i>	<i>t-stat</i>
Stock A	12.33	11.75	.26
Stock B	13.07	14.28	-.44
Stock C	17.44	15.21	.68
Stock D	12.96	12.93	.01
Stock E	13.30	13.43	-.05
Stock F	9.83	11.18	-.81
All stocks	78.94	78.76	.02

Notes: * (**) (***) indicates that there is a difference in the average trading volume between treatment A and B which is significant to the 10% (5%) (1%) level.

If there is no trading volume in a stock in a period then this is treated as a missing value.

TV_{TA} denotes the average trading volume in treatment A, TV_{TB} denotes the average trading volume in treatment B.

Table 4
Trading Volume in Dependence on Information Intensity

T-tests for the comparison of means are performed. The following hypotheses are tested:

$$H_0: TV_{NOR} \geq TV_{NR}$$

$$H_1: TV_{NOR} < TV_{NR}$$

The t-statistic shows that H_0 can be rejected for stocks B, C, D, E, F and for all stocks. In these cases the trading volume is significantly higher for periods with new ratios and hypothesis 4a is supported by our results. Looking at the data one can see that the trading volume is always higher in periods with new ratios (except for stock A). In addition the z-statistics of a Mann-Whitney test are calculated that support our findings.

<i>Trading Volume</i>	<i>Periods without New Ratios</i>	<i>Periods with New Ratios</i>	<i>t-stat</i>	<i>z-stat</i>
Stock A	12.79	11.36	.64	-.69
Stock B	9.82	17.37	-2.88***	-2.22**
Stock C	12.86	20.07	-2.23**	-2.29**
Stock D	8.36	17.53	-3.81***	-3.57***
Stock E	8.66	18.05	-3.51***	-3.60***
Stock F	8.52	12.33	-2.39***	-1.92**
All stocks	61.01	96.71	-4.62***	-4.11***

Notes: * (**) (***) indicates that there is a difference in the average trading volume between periods with new financial ratios and periods without which is significant to the 10% (5%) (1%) level.

If there is no trading volume in a stock in a period then this is treated as a missing value.

TV_{NR} denotes the average trading volume in periods with new ratios, TV_{NOR} denotes the average trading volume in periods without new ratios.

Table 5
Volatility in Dependence on Information Intensity

Moses tests are performed to detect (significant) differences in dispersion between periods with and without new financial ratios. The Moses test is chosen instead of a parametric F-test for testing differences in variances because it cannot be assumed that the sample values are normally distributed. The following hypotheses are tested:

H_0 : $\text{Span}_{\text{NOR}} = \text{Span}_{\text{NR}}$

H_1 : $\text{Span}_{\text{NOR}} \neq \text{Span}_{\text{NR}}$

The statistics show that the two test samples differs significantly under A&B and single A treatment for all stocks. Especially the data in treatment A indicate that the volatility in periods with new ratios is significantly higher than in the other periods. Looking at all the data one can see that the volatility is higher for 17 in 21 cases in periods with new ratios than in the other periods. This supports hypothesis 4b partially.

<i>Volatility of...</i>	<i>Periods without New Ratios</i>	<i>Periods with New Ratios</i>	<i>1-tailed Probability (Moses test)</i>	<i>1-tailed Probability without Outliers (Moses test)</i>
Treatment A&B:				
Stock A	.0163	.0403	.1055	.5000
Stock B	.0309	.0481	.7514	.2480
Stock C	.0333	.0389	.1840	.5000
Stock D	.0241	.0341	.7514	.0978*
Stock E	.0211	.0205	.7542	.7027
Stock F	.0147	.0160	.7514	.3218
All stocks	.0243	.0347	.3128	.0044***
Treatment A:				
Stock A	.0077	.0277	.0155**	.0036***
Stock B	.0185	.0474	.1023	.0065***
Stock C	.0170	.0409	.0298**	.0335**
Stock D	.0105	.0123	.7525	.0116**
Stock E	.0065	.0191	.1023	.2771
Stock F	.0105	.0045	1.0000	.5000
All stocks	.0119	.0260	.1082	.0010***
Treatment B:				
Stock A	.0245	.0636	.1794	.7593
Stock B	.0459	.0489	1.0000	.5000
Stock C	.0528	.0359	.5000	.6315
Stock D	.0420	.0579	.0144**	.2729
Stock E	.0406	.0214	1.0000	.9452
Stock F	.0189	.0309	.1004	.2729
All stocks	.0400	.0450	.3133	.7432

Notes: * (**) (***) indicates that there are differences which are significant to the 10% (5%) (1%) level.

In the Moses test without outliers 2.5% of the data are removed from each end as outliers from the sample.

Span_{NR} denotes the span of the sample values in periods with new ratios, Span_{NOR} denotes the span of the values in periods without new ratios.

The term volatility is used as a synonym for variance.

Table 6

Comparison of Volatility between Treatment A and Treatment B in Dependence on Information Intensity

Moses tests are performed to detect (significant) differences in dispersions between treatment A and treatment B both in periods with and without new financial ratios. The Moses test is chosen instead of a parametric F-test for testing differences in variances because it cannot be assumed that the sample values are normally distributed. The following hypotheses are tested:

H_0 : $\text{Span}_{\text{TB}} = \text{Span}_{\text{TA}}$

H_1 : $\text{Span}_{\text{TB}} \neq \text{Span}_{\text{TA}}$

Generally the data in the table show that the volatility in treatment B is always higher than in treatment A (except for 1 case). The data indicate that especially in the periods without new ratios the volatility in treatment B (open orderbook) is much higher than in treatment A (closed orderbook) which supports hypothesis 3b.

	<i>Treatment A</i>	<i>Treatment B</i>	<i>1-tailed Probability (Moses test)</i>	<i>1-tailed Probability without Outliers (Moses test)</i>
Periods with New Ratios:				
Stock A	.0277	.0636	.2227	.2216
Stock B	.0474	.0489	1.0000	.3311
Stock C	.0409	.0359	1.0000	.7727
Stock D	.0123	.0579	.0010***	.0036***
Stock E	.0191	.0214	.2227	.0852*
Stock F	.0045	.0309	.0561*	.0493**
All stocks	.0260	.0450	.1199	.0020***
Periods without New Ratios:				
Stock A	.0077	.0245	.0121**	.0145***
Stock B	.0185	.0459	.2227	.1408
Stock C	.0170	.0528	.0121**	.0273**
Stock D	.0105	.0420	.0121**	.0036***
Stock E	.0065	.0406	.0000***	.0014***
Stock F	.0105	.0189	.0265**	.0074***
All stocks	.0119	.0400	.0302**	.0000***

Notes: * (**) (***) indicates that there are differences which are significant to the 10% (5%) (1%) level.

In the Moses test without outliers 2.5% of the data are removed from each end as outliers from the sample.

Span_{TA} denotes the span of the sample values in treatment A, Span_{TB} denotes the span of the values in treatment B.

The term volatility is used as synonym for variance.

Table 7
Average Order Volume and Order Book Transparency

Since the number of active traders in a stock is not constant, the order volume in a stock (in shares) is divided by the number of active traders in that stock in every period (standardization). Subsequently, order volume is averaged over the periods. The resulting coefficients are compared with a t-statistic to prove if there are any differences in means. The following hypotheses are tested:

$H_0: \text{ORDVOL}_{TB} \leq \text{ORDVOL}_{TA}$

$H_1: \text{ORDVOL}_{TB} > \text{ORDVOL}_{TA}$

The t-statistic shows that H_0 cannot be rejected. Therefore, the average order volume is not higher with the open orderbook and hypothesis 5 is not confirmed. Instead, the order volume shows the tendency to be higher in treatment A.

	<i>All Stocks</i>	<i>Stock A</i>	<i>Stock B</i>	<i>Stock C</i>	<i>Stock D</i>	<i>Stock E</i>	<i>Stock F</i>
Treatment A	252.95	25.67	76.12	60.98	41.30	40.56	8.32
Treatment B	66.44	14.41	12.09	13.45	9.56	9.74	7.17
(t-stat)	(1.96)	(1.17)	(1.88)	(2.03)	(1.85)	(1.79)	(.86)

Note: ORDVOL_{TA} denotes the order volume (in shares) per active trader in treatment A, ORDVOL_{TB} applies to the same measure for treatment B.

Table 8

Differences between Market Clearing Price and Rejected Bid or Ask Prices in Dependence of the Orderbook Transparency

Deviations in percent of rejected limit order prices from market clearing prices in the same period are computed. These deviations are averaged over the trading periods and compared separately for the supply and the demand side. The differences in mean are tested with the t-statistic. The following hypotheses are tested:

$$H_0: \text{DIFFBID}_{\text{TB}} \geq \text{DIFFBID}_{\text{TA}} \quad \text{and} \quad H_0: \text{DIFFASK}_{\text{TB}} \geq \text{DIFFASK}_{\text{TA}}$$

$$H_1: \text{DIFFBID}_{\text{TB}} < \text{DIFFBID}_{\text{TA}} \quad \quad \quad H_1: \text{DIFFASK}_{\text{TB}} < \text{DIFFASK}_{\text{TA}}$$

The t-statistic shows that H_0 cannot be rejected for both buy and sell orders. Therefore, the average deviation of bid and ask price limits is not smaller when subjects have access to the orderbook. Hypothesis 6a is not confirmed. Instead, the deviations show the tendency to be smaller in treatment A.

	<i>All stocks</i>	<i>Stock A</i>	<i>Stock B</i>	<i>Stock C</i>	<i>Stock D</i>	<i>Stock E</i>	<i>Stock F</i>
Buy Orders							
Treatment A	.1835	.1356	.1731	.1599	.1214	.1065	.0927
Treatment B	.3769	.2539	.2691	.3037	.2261	.2230	.1591
(t-stat)	(8.22)	(5.78)	(3.27)	(6.24)	(4.68)	(5.77)	(3.77)
Sell Orders							
Treatment A	.2461	.1519	.2212	.2686	.1710	.1922	.1150
Treatment B	.3340	.481	.2838	.1972	.3058	.2594	.2021
(t-stat)	(2.69)	(2.58)	(1.34)	(-1.53)	(2.62)	(1.61)	(2.48)

Note: $\text{DIFFBID}_{\text{TA}}$ ($\text{DIFFBID}_{\text{TB}}$) denotes the average deviation (in percent) of buy orders from the market clearing price in treatment A (B), $\text{DIFFASK}_{\text{TA}}$ ($\text{DIFFASK}_{\text{TB}}$) denotes the average deviation in percent of sell orders from the market clearing price in treatment A (B).

Table 9
Numer of Different Stocks in Traders' Portfolios and Deposit Holdings

The number of different stocks is averaged over the periods. A t-test for the difference in mean number of stocks in subjects' portfolios is conducted for the following hypotheses:

$H_0: NOC_{TB} \geq NOC_{TA}$

$H_1: NOC_{TB} < NOC_{TA}$

The t-statistic shows that H_0 has to be rejected. The number of different stocks in participants' portfolios is smaller when market participants have to handle the additional information about the orderbook. Hypothesis 7 is supported by our results.

The lower part of Table 10 shows the distribution of deposit holdings of each stock in both treatments. Although we did not conduct statistical tests it can be easily seen that the frequencies for portfolios with less than 10 shares of a company are higher for treatment B.

Average Number of Stocks

Treatment A 4.9806

Treatment B 4.6786

(t-stat) (4.89**)

Stock Treatment	A		B		C		D		E		F	
	A	B	A	B	A	B	A	B	A	B	A	B
Frequencies of Deosit Holdings (classified)												
less than 10 shares	21.0	27.2	28.2	36.4	31.8	41.9	23.7	29.9	23.7	28.1	20.5	17.5
10 to 20 shares	17.5	15.1	19.0	10.6	16.4	13.3	15.9	11.9	20.1	11.2	19.2	18.8
20 to 25 shares	28.0	22.1	24.8	26.4	21.8	26.2	32.7	29.6	24.6	23.0	28.5	26.2
25 to 30 shares	7.6	3.8	4.6	2.4	4.7	1.8	4.1	3.8	7.3	3.7	10.4	10.8
30 to 40 shares	9.5	9.3	8.2	7.8	8.5	3.2	9.3	11.3	7.7	16.0	15.5	18.9
40 to 50 shares	7.6	9.6	5.4	5.0	4.7	1.8	5.9	5.3	7.9	10.0	4.6	6.0
more than 50 shares	8.7	12.9	9.8	11.3	12.1	11.7	8.4	8.2	8.5	8.1	1.3	1.8

Notes: ** denotes that the t-statistic is significant at the 5% level.

NOC_{TA} (NOC_{TB}) denotes the number of different stocks in the portfolios for subjects in treatment A (B).

Figure 1
From Traditional to Microstructure Paradigm

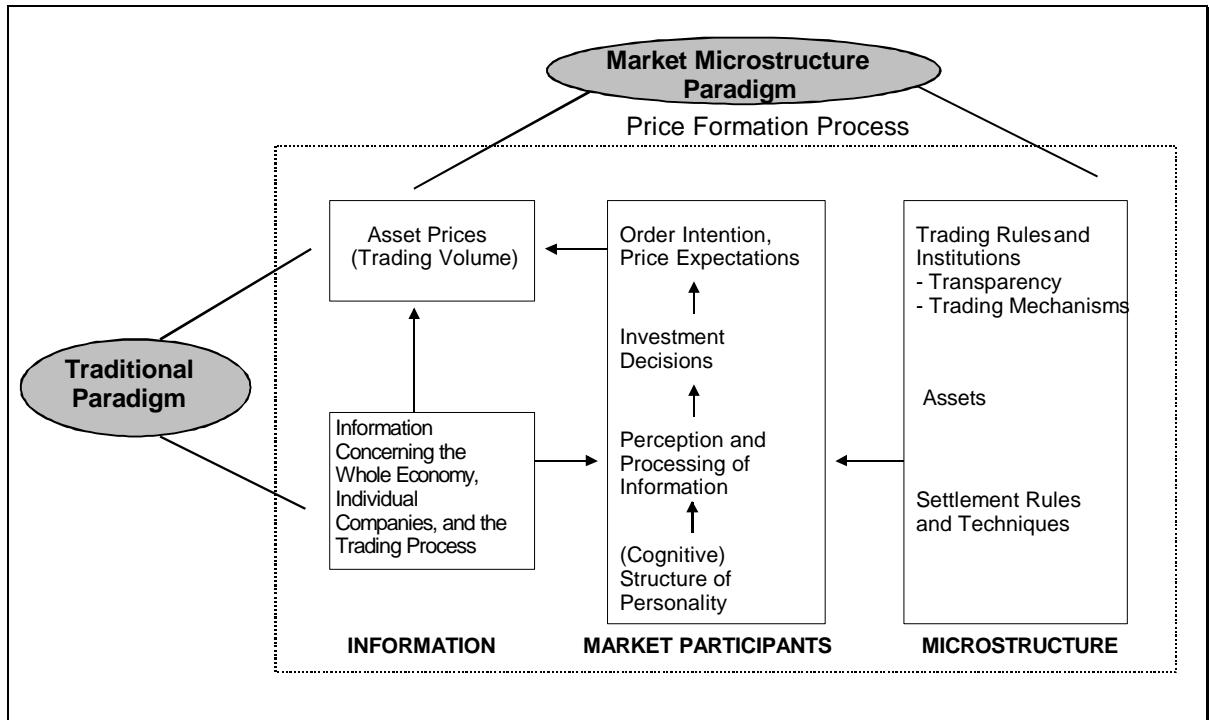


Figure 2
Price Formation Process - Orderbook

Stock B			Volume			
Orderflow		Bid	Intended Supply	Intended Demand	Potential Turnover	Excess Demand/Supply
Ask	Price					
	250	10	0	75	0	75
10	300		10	65	10	55
5	450		15	65	15	50
15	550	50	30	65	30	35
	600	15	30	15	15	15
5	650		35	0	0	35
10	725		45	0	0	45

Stock F			Volume			
Orderflow		Bid	Intended Supply	Intended Demand	Potential Turnover	Excess Demand/Supply
Ask	Price					
5	1700		5	60	5	55
	1800	25	5	60	5	55
8	1950		13	35	13	22
	1990	10	13	35	13	22
	2000	20	13	25	13	12
15	2100		28	5	5	23
	2250	5	28	5	5	23
20	2450		48	0	0	48

In the example for stock F, the market clearing price is 2000 and the transaction volume is 13 shares. At this price the sellers which were willing to sell 5 shares at 1700 and 8 shares at 1950 both sell for 2000. At the same price the buyer with the highest bid (2250) gets 5 shares and the remaining 8 shares are distributed with an equal proportion to the buyers that were willing to pay 2000. Therefore, each of these subjects gets 0.4 (8/20) shares times the number of shares the trader wanted to buy in the first place (rounded to the next lower integer). Note that each list entry may represent more than one trader. For a description for stock B see the results session below.

The following supply-demand graph illustrates the matching of the two market sides at a price of 2000.

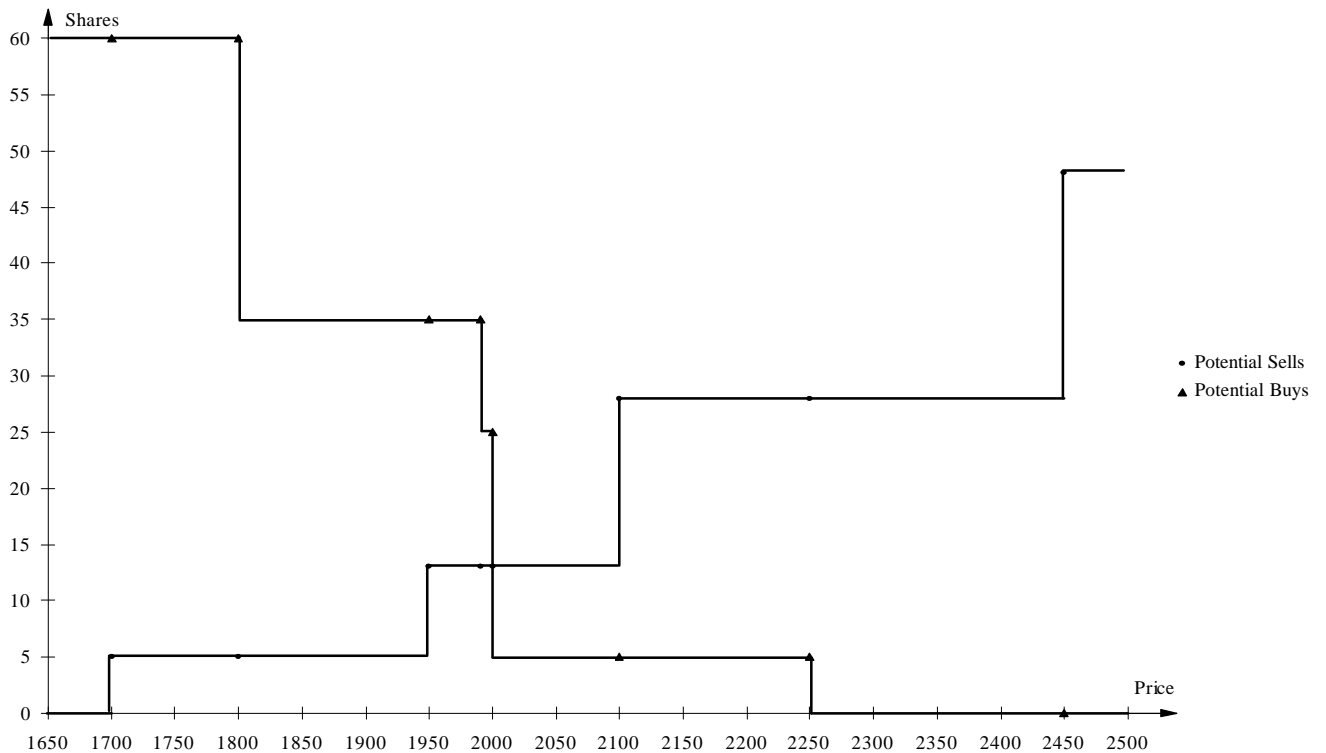


Figure 3
New Information Arrival and Trading Periods in an Experimental Session

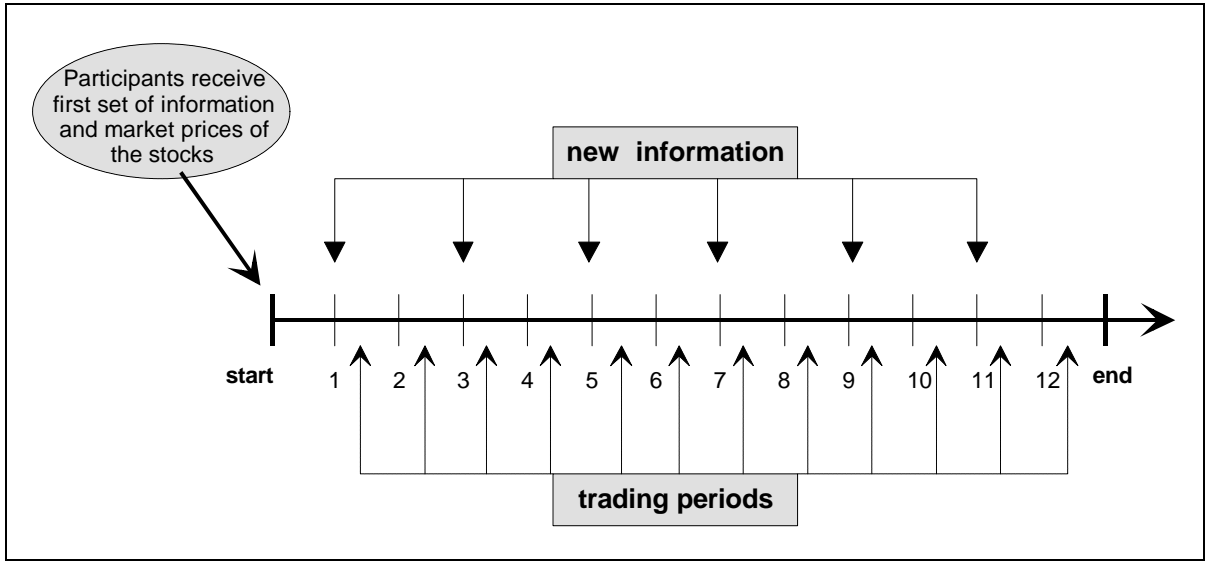


Table A
Financial Ratios' Importance Perceived by Market Participants

54.7% (53) of all subjects (117) negate the statement that the four ratios are equally important for their decisions. Subjects' consistency for the ascription of ranks and the statement about the importance was assessed using Kendall correlation coefficients. The coefficients are 0.4388, 0.5098, 0.4055 and 0.4743 for XR, XF, XE, and XV, respectively. These values are significant at the 1% level.

<i>Ratio ...</i>		<i>XR</i>	<i>XF</i>	<i>XE</i>	<i>XV</i>
Rank ascribed by x% of subjects					
	Rank 1	78.5	8.1	14.1	3.2
	Rank 2	12.3	45.2	28.1	15.9
	Rank 3	4.6	32.3	29.7	33.3
	Rank 4	4.6	14.5	28.1	47.6
% of subjects stating the ratio is ...	very important*	58.1	29.1	25.6	32.5
	mean important**	35.9	58.9	54.7	44.4
	not important***	6.0	12.0	19.7	23.1

Note: The subjective importance of the ratios was elicited using a 6-point scale. * denotes values of 5 and 6 and represents high importance, ** denotes values of 3 and 4 thereby meaning intermediate importance, *** means that the ratio was not considered important.

Table B
Financial Ratios' Trends and Difference to the Sample's Mean

The first part of Table B shows the ratios to subjects provided with every second period. At the beginning they get the information for period 0 and period 1 simultaneously. In the second part we display the deviation of ratios from the mean of 12 000 companies To get an idea of how subjects might have perceived the ratios. These values are standardized in a way that positive numbers have a positive meaning. Negative numbers have to be interpreted negatively. The last part of the table shows the standard deviations as risk measures for the financial ratios.

	Stock A				Stock B				Stock C				Stock D				Stock E				Stock F			
Initial Prices	291				415				211				303				528				1 809			
Financial Ratios	XR	XF	XE	XV	XR	XF	XE	XV	XR	XF	XE	XV	XR	XF	XE	XV	XR	XF	XE	XV	XR	XF	XE	XV
Period 0	0.15	0.22	0.43	0.39	0.04	0.07	0.42	0.49	0.08	0.12	0.38	0.28	0.20	0.34	0.53	0.27	0.05	0.07	0.27	0.31	0.53	1.87	1.15	0.26
Period 1	0.21	0.37	0.55	0.38	0.07	0.11	0.37	0.50	0.04	0.06	0.29	0.27	0.16	0.26	0.52	0.28	0.23	0.30	0.24	0.37	0.26	1.30	1.54	0.19
Period 3	0.23	0.43	0.59	0.36	-0.05	-0.07	0.29	0.49	0.03	0.04	0.23	0.29	0.15	0.25	0.50	0.28	0.25	0.34	0.24	0.35	0.33	1.39	1.24	0.23
Period 5	0.25	0.57	0.82	0.29	-0.20	-0.25	0.15	0.55	-0.01	-0.01	0.17	0.34	0.12	0.19	0.47	0.26	0.25	0.33	0.25	0.42	0.22	1.29	2.38	0.16
Period 7	0.26	0.62	0.81	0.26	-0.26	-0.29	0.02	0.60	0.04	0.05	0.16	0.33	0.10	0.16	0.48	0.27	0.16	0.20	0.20	0.46	0.24	1.06	1.83	0.22
Period 9	0.30	0.66	0.99	0.27	-0.09	-0.10	0.14	0.58	0.08	0.10	0.23	0.30	0.17	0.28	0.53	0.28	0.18	0.24	0.24	0.39	0.31	1.07	1.15	0.27
Period 11	0.25	0.61	0.99	0.29	-0.09	-0.10	0.14	0.58	0.08	0.11	0.30	0.38	0.19	0.33	0.55	0.26	0.17	0.23	0.27	0.38	0.36	1.17	1.05	0.29

Difference to Mean	Stock A				Stock B				Stock C				Stock D				Stock E				Stock F			
	XR	XF	XE	XV	XR	XF	XE	XV	XR	XF	XE	XV	XR	XF	XE	XV	XR	XF	XE	XV	XR	XF	XE	XV
Period 0	0.00	-0.11	0.03	0.26	-0.11	-0.26	0.02	0.16	-0.07	-0.21	-0.02	0.37	0.05	0.01	0.13	0.38	-0.10	-0.26	-0.13	0.34	0.38	1.54	0.75	0.39
Period 1	0.06	0.04	0.15	0.27	-0.08	-0.22	-0.03	0.15	-0.11	-0.27	-0.11	0.38	0.01	-0.07	0.12	0.37	0.08	-0.03	-0.16	0.28	0.11	0.97	1.14	0.46
Period 3	0.08	0.10	0.19	0.29	-0.20	-0.40	-0.11	0.16	-0.12	-0.29	-0.17	0.36	0.00	-0.08	0.10	0.37	0.10	0.01	-0.16	0.30	0.18	1.06	0.84	0.42
Period 5	0.10	0.24	0.42	0.36	-0.35	-0.58	-0.25	0.10	-0.16	-0.34	-0.23	0.31	-0.03	-0.14	0.07	0.39	0.10	0.00	-0.15	0.23	0.07	0.96	1.98	0.49
Period 7	0.11	0.29	0.41	0.39	-0.41	-0.62	-0.38	0.05	-0.11	-0.28	-0.24	0.32	-0.05	-0.17	0.08	0.38	0.01	-0.13	-0.20	0.19	0.09	0.73	1.43	0.43
Period 9	0.15	0.33	0.59	0.38	-0.24	-0.43	-0.26	0.07	-0.07	-0.23	-0.17	0.35	0.02	-0.05	0.13	0.37	0.03	-0.09	-0.16	0.26	0.16	0.74	0.75	0.38
Period 11	0.10	0.28	0.59	0.36	-0.24	-0.43	-0.26	0.07	-0.07	-0.22	-0.10	0.27	0.04	0.00	0.15	0.39	0.02	-0.10	-0.13	0.27	0.21	0.84	0.65	0.36

Standard Deviation of the Ratios	Stock A	Stock B	Stock C	Stock D	Stock E	Stock F
XR	0.04	0.11	0.03	0.03	0.06	0.10
XF	0.15	0.14	0.05	0.06	0.09	0.25
XE	0.21	0.13	0.07	0.03	0.02	0.45
XV	0.05	0.04	0.03	0.01	0.05	0.04

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