

# Time and the Price Impact of a Trade:

## A Structural Approach

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### Abstract

This paper revisits the role of time in measuring the informational content of trades. Using a VAR methodology and NYSE data, Dufour and Engle (2000) showed that duration between trades carry informational content with respect to the price impact of a trade. This paper draws on their work, but addresses this issue within the framework of a structural model. Specifically, we extend Madhavan/Richardson/Roomans' microstructure model to account for time varying trade intensities. We estimate the model on a cross section of stocks traded on one of the largest European stock markets, and also for the NYSE traded Dow Jones stocks. Our results provide contrasting evidence regarding the informational content of time. Although we also find that "time matters" in that the informational content of a trade increases with the duration since the last trade, the informational content is quite different. While Dufour and Engle's results provided evidence for the hypothesis that "no trade means no information", which is in line with Easley/O'Hara's (1992) microstructure model, our results suggest that in an automated order book market with no dedicated market makers the impact of time on the price impact of trades is more in accord with the predictions from the Admati/Pfleiderer (1988) model.

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# 1 Introduction

The availability of financial market transaction level data spurred the interest of both academia and practice in quantitative assessments of market quality, implicit transaction costs, and the importance of informational asymmetry in the trading process. In that context a growing econometric literature studies the role of time, especially the time between trade events, with respect to information processing (most prominently Engle and Russell (1998) and Engle (2000)). In a recent paper Dufour and Engle (2000) have shown that the informational content of a trade is negatively affected by longer durations. This finding supports the key prediction of Easley and O'Hara's (1992) microstructure model that longer no-trade intervals indicate periods of no news. On the other hand, the classic structural microstructure models put forth by Glosten and Harris (1988), Huang and Stoll (1997) and Madhavan, Richardson, and Roomans (1997) (MRR) completely ignore the information contained in the sequence of trade durations. Although these models - which are basically structural models to measure the impact of trades on the fundamental asset value - are estimated on these irregularly spaced data, the informational content of trade durations is not accounted for.

This paper revisits the role of time in measuring the informational content of trade. The methodological novelty of the paper is that we use an extended version of Madhanvan Richardson and Roomans' (1997) structural model instead of a purely statistical methodology (like Dufour and Engle's (2000) VAR approach). The second novelty is that we use a cross section of stocks traded on one of the large European Stock markets (the Xetra system) as well as more recent transaction data for NYSE traded Dow Jones stocks. Using the Xetra data has two main advantages. First, we can provide evidence on the time issue for an automated auction market with open order book, a trading protocol that gains increasing worldwide popularity. Second, the data quality is excellent. Most importantly, trade misclassifications do not occur since any trade in the automated auction system can be either classified as buyer or seller initiated.<sup>1</sup>

Classical microstructure theory has ignored the role of time in the trading process. The timing of trades was either considered to be exogenous as in Glosten and Milgrom (1985) or played no role at all like in Kyle (1985) as trades were batched together. In contrast, Diamond

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<sup>1</sup>See Boehmer, Grammig, and Theissen (2006) for an analysis of the consequences of trade misclassification for microstructure models.

and Verrecchia (1987) argue that long intervals of trade inactivity are evidence for bad news in the case of short sale constraints. Viewing the spread as a measure of asymmetric information this would imply a wider spread in long no-trade intervals. On the other hand, in absence of such restraints, Easley and O'Hara (1992) have pointed out that long no-trade intervals simply indicate that there is no new information. This would in turn imply a narrower spread since the probability that the next trade is information based is lower.

Dufour and Engle (2000) use an extended version of the Hasbrouck (1991) vector autoregressive (VAR) model to quantify and test whether the arrival time of transactions matters for determining the information content of a trade. They estimate the model on a cross section of stocks using the familiar 1991 TORQ data. The Dufour and Engle study made a strong case for the "no trade means no information hypothesis" derived from Easley and O'Hara (1992). Recent evidence challenge this conclusion. A contradicting effect was lately found by Beltran, Grammig, and Menkveld (2005) who report a positive relation between trade informativeness and trade duration for the German stock exchange. Further evidence in this direction is also provided in a study of Peng (2001) for the US market.

The results presented in this paper indicate that the time between trades contributes substantially to the determination of the adverse selection component of the spread. Challenging previous evidence we find that trades occurring after inactivity periods (long durations) are more informative than trades in active periods (short durations). This effect is particularly strong for small cap stocks traded in the automated auction market. To a smaller extend (from an economic point of view) the effect is also discernible for NYSE traded Dow Jones stocks. Taking into account the stylized fact that spreads have a distinct intra-day pattern, we split up the adverse selection component in a deterministic time of day part and a part which can be explained by trade duration. We find that the adverse selection component of the spread as well as the share attributable to a duration effect, decreases with trading activity. For the Xetra sample we also document that adverse selection costs of the least actively traded stocks are much heavier affected by the time between transactions than more actively traded stocks. While adverse selection costs almost double for the quartile of the most actively traded stocks, they more than triple for the quartile of the least actively traded stocks.

The remainder of the paper is organized as follows. Section 2 describes the market struc-

ture, the data and the empirical methodologies employed in our study. The empirical results are discussed in section 3. Section 4 concludes.

## 2 Data and Methodology

### 2.1 Market structure and descriptives of the data

In our empirical analysis we use data from the automated auction system Xetra which operates at various European trading venues, like the Vienna Stock Exchange, the Irish Stock Exchange, the Frankfurt Stock Exchange (FSE) and the European Energy Exchange.<sup>2</sup> We also use more familiar TAQ data for the NYSE traded Dow Jones stocks. Since the NYSE trading process has been outlined in many papers and textbooks (see e.g. Bauwens and Giot (2001) and Harris (2003) for lucid surveys) we refrain from adding another description. The Xetra trading system, however, warrants some explanations.

Xetra is a pure open order book system developed and maintained by the German Stock Exchange. It has operated since 1997 as the main trading platform for German blue chip stocks at the FSE. Since the Xetra/FSE trading protocol is the data generating process for this study we will briefly describe its important features.<sup>3</sup>

Between an opening and a closing call auction - and interrupted by another mid-day call auction - Xetra/FSE trading is based on a continuous double auction mechanism with automatic matching of orders based on the usual rules of price and time priority. During pre- and post-trading hours it is possible to enter, revise and cancel orders, but order executions are not conducted, even if possible. During the year 2004, the Xetra/FSE hours extended from 9 a.m. C.E.T to 5.30 p.m. C.E.T. For blue chip stocks there are no dedicated market makers like the Specialists at the New York Stock Exchange (NYSE) or the Tokyo Stock Exchange's Saitori. For some small capitalized stocks listed in Xetra there may exist so-called Designated Sponsors - typically large banks - who are required to provide a minimum liquidity level by simultaneously submitting competitive buy and sell limit orders. In addition to the traditional limit and market orders, traders can submit so-called iceberg (or hidden)

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<sup>2</sup>The Xetra technology was recently licensed to the Shanghai Stock Exchange, China's largest stock exchange.

<sup>3</sup>The Xetra trading system resembles in many features other important limit order book markets around the world like Euronext, the joint trading platform of the Amsterdam, Brussels, Lisbon and Paris stock exchanges, the Hong Kong stock exchange described in Ahn et al. (2001), and the Australian stock exchange, described in Cao et al. (2004).

orders. An iceberg order is similar to a limit order in that it has pre-specified limit price and volume. The difference is that a portion of the volume is kept hidden from the other traders and is not visible in the open book.

Xetra/FSE faces some local, regional and international competition for order flow. The FSE maintains a parallel floor trading system, which bears some similarities with the NYSE, and, like in the US, some regional exchanges participate in the hunt for liquidity. Furthermore, eleven out of the thirty stocks we analyze in our empirical study are also cross listed at the NYSE, as an ADR or, in the case of DaimlerChrysler, as a globally registered share. However, the electronic trading platform clearly dominates the regional and international competitors in terms of market shares, at least for the blue chip stocks that we study in the present paper.

The Frankfurt Stock Exchange granted access to a database containing complete information about Xetra open order book events (entries, cancellations, revisions, expirations, partial-fills and full-fills of market, limit and iceberg orders) which occurred during the first three months of 2004 (January, 2nd - March, 31st). The sample comprises the thirty German blue chip stocks constituting the DAX30 index. Based on the event histories we perform a real time reconstruction of the sequence of best bid and ask prices and associated depths, and record a time stamped series of transactions (with transaction price and volume) initiated by market order or marketable limit order traders. The resulting data are comparable to the Trade and Quote (TAQ) data supplied by the New York Stock Exchange. Contrary to the TAQ data set we are provided with the correct trade direction identifier and do not have to apply trade classification algorithms, e.g. Lee and Ready (1991).

insert table 1 about here

Table 1 reports descriptive statistics for the thirty stocks that constitute the DAX30 index. Table 2 contains the corresponding table for the NYSE traded Dow Jones stocks.

insert table 2 about here

The table also displays the sorting of the thirty stocks into four groups. The stocks are grouped according to their trading frequency (measured as the average number of trades per day). Group one contains the most frequently traded stocks, while group four the least frequently traded stocks. The table contains the market capitalization, the daily turnover

and the average daily number of trades as well as the average midquote price, the quoted spread and the average relative quoted spread. The tables show that the trading frequencies of the Xetra and the NYSE stocks are broadly comparable.

## 2.2 Empirical Methodology

As in the MRR model there are two factors driving the fundamental value of a stock. First, we have the public news factor denoted with  $\varepsilon_i$  which is i.i.d with zero mean and variance  $\sigma_\varepsilon$ . The second factor is private information which can be inferred from order flow and consists of the surprise in order flow multiplied with a measure for the degree of asymmetric information. For the post-trade expected value of a stock  $\mu_i$  results the following expression:

$$\mu_i = \mu_{i-1} + \theta(T_i, t_i) \cdot (Q_i - E[Q_i|Q_{i-1}]) + \varepsilon_i \quad (1)$$

where  $Q_i - E[Q_i|Q_{i-1}]$  is the surprise in order flow and  $\theta(T_i, t_i)$  the degree of asymmetric information. In contrast to MRR the parameter  $\theta$  is modelled as a function of the time of the day  $t_i$  and the time span between the two consecutive trades in  $t_i$  and  $t_{i-1}$ . Bid and ask prices are set to reflect the expected value of the stock plus a fixed component  $\phi(t)$  which can be interpreted as a compensation for order processing<sup>4</sup>:

$$\text{ask price: } P^a(t) = \mu_{i-1} + \theta(t - t_i, t)(1 - E[Q_i|Q_{i-1}]) + \phi(t) + \varepsilon_i \quad (2)$$

$$\text{bid price: } P^b(t) = \mu_{i-1} - \theta(t - t_i, t)(1 + E[Q_i|Q_{i-1}]) - \phi(t) + \varepsilon_i \quad (3)$$

Contrary to a market with a specialist where some transactions may be executed inside spread, on the Xetra trading system all buys are executed at the prevailing best ask price and all sells at the prevailing best bid price. The general transaction price can then be expressed as

$$P_i = \mu_i + \phi(t_i) \cdot Q_i + \xi_i. \quad (4)$$

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<sup>4</sup>In the original paper of Madhavan, Richardson, and Roomans (1997),  $\phi$  is a mixture of transaction costs and inventory costs. Since there is no central market maker on Xetra prevailing best bid and ask prices, and hence, the spread, result from incoming or existing limit orders in the order book. Limit order traders are not obliged to provide liquidity but are voluntary liquidity providers. Thus, inventory costs should play, if at all, only a minor role.

The term  $\xi_i$  is another i.i.d disturbance term with mean zero and captures possible rounding errors due to price discretion. We derive from (1) and (4) together with  $P_{i-1} = \mu_{i-1} + \phi(t_{i-1})Q_{i-1} + \xi_{i-1}$  the expression<sup>5</sup>:

$$\Delta P_i = \theta(T_i, t_i)(Q_i - \rho Q_{i-1}) + \phi(t_i)Q_i - \phi(t_{i-1})Q_{i-1} + \varepsilon_i + \xi_i - \xi_{i-1} \quad (5)$$

The novelty of our approach is the specification of the functions  $\phi(t_i)$  and  $\theta(T_i, t_i)$ . Both spread components are assumed to depend on time of day dummies  $d_\tau$ . This accounts for the stylized fact that the spread has a pronounced deterministic time of day pattern. Further, following Dufour and Engle (2000) we also allow the log-duration between the last and the current trade as a factor to impact on the adverse selection component of the spread  $\theta(T_i, t_i)$ , i.e.:

$$\phi(t_i) = \gamma^\phi + \sum_{m=1}^M \lambda_m^\phi d_m \quad (6)$$

$$\theta(T_i, t_i) = \gamma^\theta + \sum_{m=1}^M \lambda_m^\theta d_m + \delta \ln T_i \quad (7)$$

where  $T_i$  denotes the duration between the trade in  $t_{i-1}$  and time  $t_i$ <sup>6</sup>. Incorporating a deterministic time of day pattern in the objective function directly instead of estimating the model separately for different periods of the day has the advantage that we can easily check for statistical significance of the estimated parameters  $\lambda_m^\phi$  and  $\lambda_m^\theta$ . We choose time of day intervals similarly as in Madhavan, Richardson, and Roomans (1997). Because of different opening times of the exchange in New York and in Frankfurt an exact match was obviously not possible.

Moment conditions can be derived as follows. Using

$$u_i = \Delta P_i - (\phi(t_i)(Q_i - Q_{i-1}) + \theta(T_i, t_i) \cdot (Q_i - \rho Q_{i-1}))$$

along with a vector of time-of-day dummy variables  $\mathbf{d} = (d_1, \dots, d_I)'$  and  $\mathbf{z} = (Q_i, Q_{i-1})'$ ,

<sup>5</sup>Let  $\rho$  be the first order autocorrelation of the trade indicator series. Then, it can easily be shown that the conditional expectation  $E[Q_i|Q_{i-1}]$  equals  $\rho Q_{i-1}$ .

<sup>6</sup>Following Dufour and Engle (2000), we added one second to each duration before taking logarithms in order to avoid negative values.

the moment conditions are given by

$$E \begin{bmatrix} Q_i Q_{i-1} - \rho \\ u_i(\mathbf{d} \otimes \mathbf{z}) \\ u_i \otimes \mathbf{z} \\ u_i T_i \otimes \mathbf{z} \end{bmatrix} = 0$$

We use the moment conditions to estimate the unknown parameter vector with GMM.

### 3 Results

#### 3.1 Descriptive Analysis

Table 3 provides a descriptive overview of the intra-day spread patterns for the four Xetra trade activity deciles. To conserve space, we report these results only for the Xetra sample as the main conclusions also apply for the Dow Jones/NYSE stocks. These results are available upon request.

insert table 3 about here

In an open order book market like Xetra, effective spreads are equivalent to the quoted spread if the trades do not exceed the depth at the best quotes. Trades inside spread do not occur as trades occur either at the best bid or at the best ask price. We also report mean realized spreads where the midpoint five minutes after the trade is used and mean price impacts as the mean difference of effective and realized spread. As in Madhavan, Richardson, and Roomans (1997) we split the day into six periods. For the NYSE sample, the same time intervals are chosen as in Madhavan, Richardson, and Roomans (1997). For Xetra the intra-day intervals are adapted to the trading hours. The six intervals are: 9:00a.m - 9:30a.m; 9:30a.m - 11:00a.m; 11:00a.m - 2:00p.m; 2:00p.m - 3:30p.m; 3:30p.m - 5:00p.m, 5:00p.m - 5:30p.m. We divide Xetra and NYSE traded stocks into four trade activity quartiles taking the average daily number of trades as the measure of trade activity. For Xetra the most active (quartile 1) and the least active quartile (quartile 4) contain seven stocks while each of the two intermediate quartiles contains eight stocks.

Table 3 shows that in Xetra the drop in the effective spread and the price impact after the first half hour of the day is most pronounced for the least actively traded stocks. Although the remaining three quartiles have a similar level and intra-day pattern of the spread this result is somewhat misleading since spreads measured in absolute terms contain a level effect induced by the price of the stock. Naturally, stocks with a higher average price will also have a higher spread in absolute terms. To make the spread measures comparable we calculate a relative effective spread, realized spread and relative price impact by dividing each spread component by the sample average midquote of the respective stock (see table 4).

insert table 4 about here

Although, the stocks in the most actively traded quartile seem to have the second highest effective spread on average throughout the day (top left panel in Figure 1) they have the lowest *relative* effective spread (top right panel in Figure 1).

insert figure 1 about here

This is due to the fact that the price differences between the stocks constituting the four trade activity quartiles are quite substantial and that frequently traded stocks tend to have higher prices on average.<sup>7</sup>

### 3.2 Estimation Results

The estimation results in Table 5 (Xetra/DAX) and 6 (NYSE/Dow Jones) indicate that both the adverse selection component and the order processing cost component are significantly higher in the first half hour of the day.

insert table 5 about here

insert table 6 about here

The reference period captured in the constants is the midday period ranging from 11:00a.m - 2:00p.m. (Xetra) and 11:30a.m - 2:00p.m. (NYSE). This result holds for each stock in the sample and is consistent with previous research studying the intra-day pattern of the spread.

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<sup>7</sup>The average stock price in trade activity quartile 1 is €61.4, in quartile 2 €42, in quartile 3 €25.8 and in quartile 4 €51.8.

Only two stocks out of thirty Xetra stocks show a significant positive increase in adverse selection costs in the last hour of the day. In contrast, the order processing cost component is significantly higher at the end of the day for 24 Xetra stocks (and for all Dow Jones stocks traded at NYSE). This indicates that even in a market where providing liquidity is completely voluntary the liquidity providers demand a compensation for holding inventory overnight. The vast majority of the dummy variables for the remaining time periods are not significantly different from zero. The U-shaped pattern of the effective spread in Xetra is therefore due to higher adverse selection costs as well as higher order processing costs in the morning and higher order processing costs shortly before closing.<sup>8</sup>

The novelty in our model is that the adverse selection component of the spread is additionally dependent on the duration between the trade in time  $t$  and  $t - 1$  captured by the parameter  $\delta$ . As can be seen in Tables 5 and 6, for each Xetra/DAX and NYSE/Dow Jones stock, the estimates of  $\delta$  are positive and significantly different from zero. This implies that longer no-trade intervals increase the information related costs of a trade. This result is at odds with the key prediction derived from the theoretical model of Easley and O'Hara (1992). According to their theory longer intervals of no trading are a signal that no news occurred, and a high trading intensity implies informational content of trades. The result also contradicts the study of Dufour and Engle (2000). Their VAR analysis yields the result that longer no-trade intervals decrease the price impact of the next trade. The results are more in line with those in the paper by Beltran, Grammig, and Menkveld (2005) who report a positive relation between trade informativeness and trade durations (for Xetra data) and in the paper by Peng (2001), who also uses a structural framework and reports (for NYSE data) a positive relation of the informational content of trades and trade durations.

### 3.3 Assessing the Importance of Time on the Price Impact of Trades

To point out the economic importance of including trading intensity in the model we split the adverse selection component  $\theta(T_i, t_i)$  into a deterministic part

$$\theta(t_i) = \gamma^\theta + \sum_{m=1}^M \lambda_m^\theta d_m$$

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<sup>8</sup>When we disaggregate the observed spread further at a five minute frequency we observe that the largest increase in spreads in the last half hour actually happens in the last five minutes of the trading day.

and a part explained by the duration of the subsequent no-trade interval

$$\theta(T_i) = \delta \ln T_t.$$

Both terms constitute the complete adverse selection component,  $\theta(T_i, t_i) = \theta(t_i) + \theta(T_i)$ . We can then compute for each stock the adverse selection share of the spread

$$asr(T_i, t_i) = \frac{\theta(T_i, t_i)}{\theta(T_i, t_i) + \phi(t_i)},$$

the adverse selection share of the spread due to duration

$$asr(T_i) = \frac{\theta(T_i)}{\theta(T_i, t_i) + \phi(t_i)},$$

and the share of adverse selection explained by duration to the complete adverse selection component

$$dasr = \frac{\theta(T_i)}{\theta(T_i, t_i)}.$$

insert table 7 about here

Table 7 shows that information related share of the implied effective spread is highest (68.6%) for the least actively traded Xetra stocks. In contrast, the average adverse selection share of trade activity quartile 1 only amounts to 50%.<sup>9</sup> The overall mean across all stocks of this indicator is quite comparable across Xetra/DAX stocks (average: 53.8%) and NYSE/Dow Jones stocks (average: 50.1%), see Table 8.

insert table 8 about here

Table 7 shows that the effect of trade durations on trade informativeness is also stronger for less frequently traded stocks. We focus our attention on the indicator  $asr(T_i)$  which measures the importance of the duration component relative to the complete spread. The mean of the indicator  $asr(T_i)$  ranges from 19.6% for Xetra trade activity quartile 1 to 38.5% for Xetra trade activity quartile 4. For two stocks, ADS and FME, over 42% of the spread is

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<sup>9</sup>Note, that this number is strongly influenced by the stock DTE which has an  $asr(T_i, t_i)$  of 23.6% while all the other stocks in the quartile have an  $asr(T_i, t_i)$  of 53% and higher. However, compared to trade activity 4, the information related component of the spread is substantially smaller.

attributable to trading intensity. Only for two stocks, IFX and DTE, the economic effect of trading intensity seems to be negligible. However, for the remaining 28 stocks trade durations matter for the size of the spread and especially for the information related component of the spread. Averaged across stocks, the share of the duration component relative to the complete spreads is quite comparable for the Xetra/DAX stocks (24.1%) and the NYSE/Dow Jones stocks (22.3%).

insert figure 2 about here

Figure 2 provides a graphical illustration of the intra-day pattern of the adverse selection component in Xetra. The corresponding illustration for the NYSE/Dow Jones stocks is provided in Figure 7.

As above, we eliminate the price level effect by dividing the spread components by the average mid-quote of the respective stock. While the deterministic pattern was estimated for six periods of the day, the duration component varies with every trade. To capture any possible systematic intra-day variation in the duration component, but not overload the figure, we compute ten minute means for the duration component. One can see that the standardized duration component does not vary substantially throughout the day but rather floats around a constant mean. In contrast, the deterministic portion resembles the well known L-shaped intra-day pattern of the adverse selection component. Adding up the two parts yields the complete adverse selection component. Comparing the four panels for the Xetra stocks in Figure 2, one can also recognize the diminishing effect of duration for the more frequently traded stocks.

insert table 9 about here

Table 9 reports further evidence for the negative relationship between the duration effect and trading frequency.<sup>10</sup> The correlation coefficient is approximately -0.5 and significant. Moreover, the correlations of the estimated standardized spread components with their observed "counterparts", the relative quoted spread, the relative effective spread, the relative realized spread and the relative price impact as well as the market capitalization and the trading frequency measured in daily number of trades have the expected signs and are significant. For example, the adverse selection component is positively correlated with the price

<sup>10</sup>To conserve space, we report only the Xetra results, the NYSE/Dow Jones results are qualitatively similar.

impact while the correlation of the estimated order processing cost component is, if at all, only weakly related to the price impact. Another expected result is that order processing costs, mainly consisting of institutional fees are not related to size or trading frequency of the stock. In contrast, adverse selection is strongly negatively correlated with both, size and trading frequency.

insert figure 3 about here

insert figure 4 about here

insert figure 5 about here

insert figure 6 about here

insert figure 7 about here

The importance of trading intensity for the information content of a trade is further illustrated in Figures 3, 4 and 6. The corresponding illustrations for the NYSE/Dow Jones stocks are given in Figure 7. To produce these plots we have sorted all trade durations for groups of stocks in ascending order into deciles. Decile 1 contains the shortest trade durations while decile 10 contains the longest trade durations. For each decile, we calculate the average standardized adverse selection component  $\tilde{\theta}(T_i, t_i)$ , the average raw adverse selection component  $\theta(\tau, t)$  and the average standardized order processing cost component  $\tilde{\phi}(t_i)$ . The Figures depict averages for each trade activity quartile. As expected, we do not find any systematic change in the order processing cost component for short or long trade durations. The line connecting the means of the deciles remains flat for each trade activity quartile (see Figure 6). The relation between adverse selection costs and trade duration is quite different. As can be seen in Figure 4, even in the quartile with the most actively traded stocks the adverse selection component doubles from trade intensity decile 1 to decile 10. A much stronger effect can be observed for the fourth quartile containing observations of the least actively traded stocks. Here, the adverse selection component more than triples when comparing the shortest trade durations in decile 1 with the longest trade durations in decile 10. In all four trade activity quartiles especially very long trade durations have a large impact on the asset price. The slope of the line connecting the mean of decile 9 with the mean of decile 10 is steeper in every quartile.

Note, that this result is not due to cross section or time-of-day variations of the trade durations. We have argued above that stocks traded less frequently tend to have higher adverse selection costs. To confirm that the upward sloping curve in Figure 4 is not an artefact caused by intra-group variation of trading frequency in each trade activity quartile, we provide additional figures for a selected representative stock in each trade activity quartile in Figure 5. We find for individual stocks the same relation between duration and adverse selection.

Note that the duration effect can also not be ascribed to co-movements in the intra-daily pattern of the trade duration and the adverse selection component. We have seen in Figure 2 that the information induced part of the spread is high in the first half hour and lower for the rest of the day.

insert figure 8 about here

Figure 8 shows that trade durations rather have an inverted U-shaped intra-day pattern. Hence, at the beginning of the trading day, when adverse selection costs are high, trade durations tend to be short. So, we would rather expect a dampening of the positive duration effect through the intra-day variation. Therefore, we conclude that neither intra-group variation in the average trading frequency of the stocks nor the intra-day pattern in the deterministic part of the adverse selection component is responsible for the strong impact of trade durations.

Figure 7 shows that the conclusions for the Xetra/DAX stocks also hold on average for the NYSE/Dow Jones stocks:<sup>11</sup> The plots show the same upward sloping curve that suggests that the informational content of trades is higher after relatively long no-trade periods. However, from an economic point of view, the informational importance of trade durations for the spread seems smaller for the NYSE/Dow Jones stocks compared to the Xetra/DAX stocks.

## 4 Conclusion and Outlook

This paper provided new evidence regarding the role of time in measuring the informational content of trades. Two novelties characterize our contribution. First, instead of the vector autoregressive methodology employed by Dufour and Engle (2000), who address this issue

<sup>11</sup>We have also conducted trading frequency sorted quartiles of the NYSE stocks and stock specific analysis for the Dow Jones stocks. The results are qualitatively the same.

for NYSE traded stocks, this paper advocated a structural model approach. Specifically, we have extended Madhavan et al's (1997) model to account for a time varying trade intensity. Second, we estimate the model on a larger cross section of stocks traded in an automated open order book market, the Xetra system maintained by the German Stock Exchange. In Xetra, the trading process is organized quite different to the NYSE. There are no dedicated market makers, trading is anonymous, and a fully computerized trading protocol matches liquidity supply and demand using an open limit order book. As a matter of fact, these are the characteristic features of all large Continental European stock markets. For comparability, the analysis was also conducted using data on the NYSE traded Dow Jones stocks.

Dufour and Engle's (2000) paper made a strong case for the argument that trading intensity carries informational content with respect to the price impact of a trade. Specifically, their results provided evidence for the hypothesis that "no trade means no information" one of the key predictions implied by Easley and O'Hara's (1992) microstructure model. The results reported in this paper provide contrasting evidence. As in their paper we also found that "time matters", both from a statistical and an economic point of view. However, it was shown that the informational content of a trade increases with the duration since the last trade. Especially in an automated order book market with no dedicated market makers, the direction of the impact of time on trade informativeness seems more in accord with the predictions from the Admati/Pfleiderer (1988) model. Given that the no-trade-means-no-information conclusion is part of the conventional wisdom of market microstructure our results are quite challenging.

Ticker	Company Name	Daily Turnover (Mill.)	Market cap. (Mill.)	Daily nb. trades	Avg. Price (€)	Effective Spread (€)	Effective Spread (%)	Realized Spread (€)	Realized Spread (%)	Price Impact (€)	Price Impact (%)	Trade Activity Quartile
ALV	ALLIANZ	289.98	33805	4523	100.1	0.049	0.049	0.010	0.010	0.039	0.039	1
DTE	DEUTSCHE TELEKOM	350.63	34858	4445	15.7	0.011	0.072	0.005	0.031	0.006	0.041	
SIE	SIEMENS	321.70	52893	4418	64.0	0.026	0.041	0.004	0.006	0.022	0.035	
DBK	DEUTSCHE BANK	309.28	38228	3961	67.2	0.030	0.044	0.003	0.004	0.027	0.039	
MUV2	MUENCH.RUECKVERS.	207.35	16396	3425	93.9	0.046	0.049	0.005	0.005	0.042	0.045	
DCX	DAIMLERCHRYSLER	187.74	30316	3309	36.4	0.020	0.055	0.004	0.010	0.016	0.044	
EOA	E.ON	160.63	33753	2871	52.5	0.025	0.048	0.001	0.003	0.024	0.046	
SAP	SAP	184.63	27412	2806	131.5	0.065	0.049	0.002	0.001	0.063	0.048	2
IFX	INFINEON	146.46	4790	2799	11.6	0.012	0.104	0.005	0.040	0.007	0.064	
BAS	BASF	124.43	25425	2580	43.3	0.022	0.051	0.001	0.002	0.021	0.049	
VOW	VOLKSWAGEN	104.25	9688	2545	39.2	0.022	0.056	0.002	0.004	0.020	0.052	
BAY	BAYER	88.78	15911	2400	23.1	0.017	0.076	0.003	0.012	0.015	0.064	
RWE	RWE	97.66	12653	2314	33.8	0.021	0.062	0.001	0.002	0.020	0.060	
BMW	BMW BAY.MOTOREN WERKE	87.85	12211	2110	34.7	0.021	0.060	0.001	0.003	0.020	0.057	
HVM	BAY.HYPO-VEREINSBK	98.35	6629	1937	18.7	0.018	0.098	0.003	0.019	0.015	0.079	
SCH	SCHERING	51.41	7055	1523	40.8	0.029	0.071	0.002	0.004	0.027	0.067	3
CBK	COMMERZBANK	53.17	7569	1450	15.4	0.015	0.100	0.004	0.023	0.012	0.077	
LHA	LUFTHANSA	43.95	4548	1352	14.2	0.016	0.111	0.003	0.022	0.012	0.088	
DPW	DEUTSCHE POST	43.84	6806	1315	18.2	0.018	0.097	0.003	0.018	0.014	0.079	
TKA	THYSSENKRUPP	37.89	6450	1262	15.9	0.018	0.111	0.005	0.029	0.013	0.083	
MEO	METRO	38.87	5018	1235	35.0	0.031	0.089	0.000	0.000	0.031	0.090	
ALT	ALTANA	30.99	3338	1095	48.6	0.039	0.079	0.004	0.008	0.035	0.071	
TUI	TUI	26.28	2025	1063	18.7	0.023	0.125	0.003	0.015	0.020	0.109	
MAN	MAN	27.69	2434	1057	27.7	0.027	0.096	0.001	0.003	0.026	0.094	4
CONT	CONTINENTAL	25.63	4060	1002	31.6	0.029	0.092	-0.003	-0.011	0.032	0.103	
DB1	DEUTSCHE BOERSE	35.70	4847	982	46.9	0.035	0.075	0.001	0.003	0.034	0.072	
ADS	ADIDAS-SALOMON	31.98	4104	980	92.6	0.065	0.070	-0.002	-0.002	0.067	0.072	
LIN	LINDE AG	22.38	3448	896	43.6	0.035	0.080	-0.004	-0.009	0.039	0.090	
HEN3	HENKEL	18.17	3682	702	65.9	0.050	0.077	0.003	0.005	0.047	0.072	
FME	FRESENIUS MEDICAL CARE	12.85	1944	621	54.0	0.053	0.098	0.006	0.010	0.047	0.088	
	Average	108.68	14076	2099	44.5	0.030	0.076	0.002	0.009	0.027	0.067	

Table 1: **Characteristics of the stocks in the sample (Xetra/DAX stocks)** The table reports characteristics of the stocks constituting the DAX30 index and our sample. The statistics are computed based on the data on the market events during the sample period January 2, 2004 to March 31, 2004 except for the column *Market cap.* which gives the market capitalization of the respective stock in million euros at the end of December 2003. *Daily turnover* is the total average turnover (in mill. euros) per trading day and *Daily nb. trades* is the average daily number of trades. *Price*, denotes the average midquote. *Effective Spread* (in euros) and *Effective Spread (%)* report the average effective spread and the average relative effective spread. *Realized Spread* (in euros) and *Realized Spread (%)* report the average realized spread and the average relative realized spread. *Price Impact* (in euros) and *Price Impact (%)* report the average price impact and the average relative price impact over the 3 months sample period.. The price impact was obtained by subtracting the realized spread from the effective spread. The stocks are sorted into four groups according to their trading frequency, i.e. by the column *Daily nb. trades*. The horizontal lines separate the four trading activity quartiles.

Ticker	Company Name	Daily Turnover (Mill.)	Market cap. (Mill.)	Daily nb. trades	Avg. Price (\$)	Effective Spread (\$)	Effective Spread (%)	Realized Spread (\$)	Realized Spread (%)	Price Impact (\$)	Price Impact (%)	Trade Activity Quartile
GE	GEN'L ELECTRIC	541.19	387892	5591	32.1	0.011	0.035	0.002	0.007	0.009	0.028	1
XOM	EXXON MOBIL CORP.	347.01	329324	5317	41.4	0.011	0.027	0.001	0.002	0.010	0.025	
C	CITIGROUP INC.	478.12	250925	5310	49.8	0.013	0.025	0.002	0.005	0.010	0.020	
PFE	PFIZER INC.	481.96	203418	5276	36.3	0.012	0.032	0.003	0.007	0.009	0.025	
IBM	INT'L BUSINESS MACH.	416.69	163640	5158	95.3	0.020	0.021	0.002	0.002	0.018	0.019	
JPM	JPMORGAN CHASE	320.88	139747	4660	40.3	0.012	0.030	0.001	0.004	0.011	0.026	
WMT	WAL-MART STORES	447.07	225422	4630	57.4	0.014	0.025	-0.002	-0.004	0.017	0.029	2
HD	HOME DEPOT	211.97	94034	4500	36.1	0.013	0.036	0.001	0.003	0.012	0.033	
HPQ	HEWLETT-PACKARD	219.54	64327	4347	23.4	0.012	0.050	0.003	0.012	0.009	0.037	
AIG	AMER. INT'L GROUP	292.12	181285	4294	71.4	0.020	0.028	0.001	0.001	0.019	0.027	
DIS	DISNEY (WALT)	230.87	57184	4210	25.3	0.013	0.051	0.005	0.020	0.008	0.032	
VZ	VERIZON COMMUNIC.	191.00	113334	4089	37.3	0.013	0.036	0.001	0.003	0.012	0.033	
JNJ	JOHNSON & JOHNSON	286.26	189267	4006	52.4	0.013	0.024	0.002	0.003	0.011	0.022	3
PG	PROCTER & GAMBLE	270.70	140635	3870	102.0	0.019	0.018	-0.003	-0.003	0.022	0.022	
MO	ALTRIA GROUP	241.30	126386	3868	55.0	0.015	0.027	0.001	0.001	0.014	0.026	
MMM	3M COMPANY	208.20	64611	3860	80.3	0.018	0.022	0.001	0.001	0.017	0.021	
SBC	SBC COMMUNICATIONS	196.62	86356	3768	25.2	0.011	0.043	0.002	0.009	0.009	0.034	
UTX	UNITED TECHNOLOGIES	192.53	53527	3664	91.7	0.025	0.027	-0.001	-0.001	0.026	0.028	
CAT	CATERPILLAR INC.	163.69	33601	3640	78.6	0.025	0.032	-0.002	-0.003	0.027	0.035	4
MRK	MERCK & CO.	251.04	71386	3557	46.7	0.012	0.026	0.000	0.000	0.012	0.026	
AA	ALCOA INC.	150.52	27577	3533	35.9	0.014	0.039	-0.002	-0.005	0.016	0.044	
KO	COCA-COLA	206.81	101117	3529	49.8	0.014	0.028	0.002	0.004	0.012	0.024	
AXP	AMER. EXPRESS	185.96	70719	3511	51.4	0.012	0.024	0.001	0.001	0.012	0.023	
GM	GEN'L MOTORS	191.85	22575	3349	49.4	0.016	0.032	-0.002	-0.005	0.018	0.037	
DD	DU PONT	124.37	48839	3301	43.7	0.015	0.034	0.003	0.007	0.012	0.027	4
BA	BOEING	110.80	44758	3217	42.1	0.016	0.038	-0.001	-0.001	0.017	0.039	
MCD	MCDONALD'S CORP.	102.41	40809	2925	27.1	0.011	0.042	0.003	0.011	0.009	0.032	
HON	HONEYWELL INT'L	96.80	31026	2919	34.7	0.015	0.044	0.000	0.001	0.015	0.043	
	Average	256	120133	4068	50.4	0.015	0.032	0.001	0.003	0.014	0.029	

Table 2: **Characteristics of the stocks in the sample (NYSE/Dow Jones stocks)** The table reports characteristics of the 28 NYSE traded stocks constituting the DJ Industrial Average30 index and our sample. The statistics are computed based on the data on the market events during the sample period January 2, 2004 to March 31, 2004 except for the column *Market cap.* which gives the market capitalization of the respective stock in million euros at the end of December 2003. *Daily turnover* is the total average turnover (in euros) per trading day and *Daily nb. trades* is the average daily number of trades. *Avg. Price*, denotes the average midquote. *Effective Spread* (in dollar) and *Effective Spread (%)* report the average effective spread and the average relative effective spread. *Realized Spread* (in dollar) and *Realized Spread (%)* report the average realized spread and the average relative realized spread. *Price Impact* (in dollar) and *Price Impact (%)* report the average price impact and the average relative price impact over the 3 months sample period. The price impact was obtained by subtracting the realized spread from the effective spread. The stocks are sorted into four groups according to their trading frequency, i.e. by the column *Daily nb. trades*. The horizontal lines separate the four trading activity quartiles.

**Table 3: Effective spread, realized spread and price impact for different periods of the day. (Xetra/DAX stocks)** The table presents the mean, median and standard deviation within the respective stock group and across all thirty stocks.

Trade Activity Quartile		9:00-9:30	9:30-11:00	11:00-14:00	14:00-15:30	15:30-17:00	17:00-17:30
		effective spread (in euro cent)					
1	Mean	4.63	3.05	2.71	2.78	2.78	2.87
	Median	3.77	2.73	2.47	2.54	2.52	2.54
	Std	2.84	1.37	1.16	1.22	1.23	1.24
2	Mean	3.52	2.57	2.38	2.39	2.30	2.36
	Median	2.99	2.18	1.93	1.97	1.97	2.15
	Std	2.51	1.80	1.70	1.64	1.47	1.31
3	Mean	3.92	2.49	2.17	2.16	2.15	2.40
	Median	3.01	2.14	1.95	1.87	1.87	2.19
	Std	1.96	0.96	0.75	0.78	0.76	0.91
4	Mean	8.38	4.56	3.79	3.81	3.80	4.31
	Median	6.23	3.85	3.14	3.30	3.31	3.74
	Std	3.72	1.45	1.34	1.34	1.24	1.21
all	Mean	5.02	3.12	2.73	2.75	2.72	2.94
	Median	3.75	2.71	2.38	2.37	2.39	2.57
	Std	3.27	1.59	1.37	1.37	1.31	1.37
		realized spread (in euro cent)					
1	Mean	1.11	0.57	0.47	0.33	0.27	0.22
	Median	0.25	0.54	0.54	0.30	0.22	0.12
	Std	2.40	0.35	0.20	0.32	0.15	0.38
2	Mean	-0.16	0.31	0.34	0.12	0.09	0.32
	Median	-0.10	0.36	0.31	0.17	0.04	0.33
	Std	0.70	0.11	0.32	0.22	0.20	0.26
3	Mean	0.41	0.28	0.22	0.21	0.23	0.69
	Median	0.55	0.30	0.23	0.29	0.27	0.64
	Std	0.66	0.21	0.18	0.26	0.14	0.30
4	Mean	0.29	-0.21	-0.05	-0.16	0.10	0.80
	Median	0.32	-0.29	0.14	-0.15	0.13	0.73
	Std	0.96	0.39	0.46	0.48	0.47	0.51
all	Mean	0.39	0.24	0.25	0.13	0.17	0.51
	Median	0.23	0.32	0.29	0.17	0.19	0.48
	Std	1.35	0.38	0.35	0.36	0.27	0.43
		price impact (in euro cent)					
1	Mean	3.53	2.48	2.24	2.45	2.51	2.65
	Median	3.26	2.62	2.14	2.48	2.38	2.64
	Std	2.00	1.27	1.11	1.22	1.30	1.23
2	Mean	3.68	2.26	2.04	2.27	2.22	2.04
	Median	2.95	1.87	1.77	1.92	1.93	1.82
	Std	3.16	1.77	1.49	1.79	1.57	1.52
3	Mean	3.51	2.22	1.95	1.95	1.92	1.71
	Median	2.34	1.98	1.69	1.68	1.59	1.54
	Std	2.02	0.98	0.91	0.90	0.85	0.70
4	Mean	8.09	4.77	3.83	3.97	3.70	3.52
	Median	6.78	4.47	3.68	4.06	3.68	3.27
	Std	3.04	1.40	1.43	1.30	1.15	1.18
all	Mean	4.63	2.88	2.48	2.62	2.55	2.44
	Median	3.38	2.40	2.13	2.22	2.26	2.25
	Std	3.15	1.69	1.41	1.49	1.36	1.33

Table 4: **Effective spread, realized spread and price impact for different periods of the day (in percent of the midquote) (Xetra/DAX stocks).** The table presents the mean, median and standard deviation within the respective stock group and across all thirty stocks.

Trade Activity Quartile		9:00-9:30	9:30-11:00	11:00-14:00	14:00-15:30	15:30-17:00	17:00-17:30
		relative effective spread (%)					
1	Mean	0.075	0.053	0.048	0.049	0.049	0.050
	Median	0.073	0.052	0.045	0.045	0.046	0.048
	Std	0.014	0.010	0.011	0.010	0.010	0.011
2	Mean	0.096	0.071	0.066	0.067	0.066	0.069
	Median	0.089	0.064	0.056	0.058	0.058	0.064
	Std	0.024	0.021	0.020	0.020	0.021	0.022
3	Mean	0.156	0.103	0.091	0.090	0.090	0.100
	Median	0.153	0.104	0.093	0.091	0.091	0.098
	Std	0.019	0.018	0.018	0.016	0.017	0.021
4	Mean	0.164	0.092	0.075	0.076	0.077	0.088
	Median	0.157	0.088	0.073	0.076	0.075	0.086
	Std	0.032	0.013	0.010	0.008	0.011	0.015
all	Mean	0.123	0.080	0.071	0.071	0.071	0.077
	Median	0.127	0.079	0.070	0.070	0.070	0.075
	Std	0.044	0.025	0.022	0.021	0.022	0.026
		relative realized spread (%)					
1	Mean	0.015	0.012	0.011	0.008	0.008	0.007
	Median	0.010	0.012	0.008	0.006	0.003	0.003
	Std	0.024	0.011	0.012	0.010	0.010	0.012
2	Mean	0.007	0.012	0.013	0.008	0.006	0.016
	Median	-0.004	0.009	0.007	0.005	0.001	0.009
	Std	0.029	0.011	0.015	0.014	0.011	0.017
3	Mean	0.023	0.014	0.013	0.011	0.012	0.030
	Median	0.026	0.011	0.012	0.012	0.016	0.029
	Std	0.026	0.012	0.011	0.012	0.009	0.011
4	Mean	0.003	-0.006	-0.001	-0.004	0.001	0.016
	Median	0.008	-0.003	0.005	-0.004	0.005	0.016
	Std	0.020	0.010	0.009	0.010	0.011	0.010
all	Mean	0.012	0.009	0.009	0.006	0.007	0.017
	Median	0.008	0.008	0.007	0.005	0.004	0.013
	Std	0.025	0.013	0.013	0.012	0.010	0.015
		relative price impact (%)					
1	Mean	0.060	0.040	0.037	0.040	0.041	0.044
	Median	0.065	0.040	0.036	0.040	0.041	0.041
	Std	0.016	0.007	0.005	0.002	0.003	0.006
2	Mean	0.089	0.059	0.053	0.059	0.059	0.053
	Median	0.088	0.058	0.052	0.059	0.057	0.054
	Std	0.030	0.014	0.008	0.012	0.011	0.008
3	Mean	0.133	0.089	0.078	0.079	0.078	0.071
	Median	0.133	0.086	0.074	0.074	0.078	0.067
	Std	0.016	0.014	0.016	0.016	0.013	0.017
4	Mean	0.161	0.098	0.076	0.080	0.075	0.072
	Median	0.155	0.102	0.082	0.080	0.074	0.069
	Std	0.027	0.019	0.012	0.008	0.014	0.016
all	Mean	0.111	0.072	0.061	0.065	0.064	0.060
	Median	0.116	0.076	0.059	0.065	0.063	0.057
	Std	0.044	0.026	0.020	0.019	0.018	0.017

Table 5: **Estimation results of the extended MRR model. (Xetra/DAX stocks)** The table reports the first stage GMM estimates of the extended MRR model for each of the 30 stocks constituting the DAX30. The spread components are specified as a function of the time of day. Additionally, the adverse selection component depends on the duration between the trade in  $t_i$  and  $t_{i-1}$ :

$$\phi(t_i) = \gamma^\phi + \sum_{m=1}^M \lambda_m^\phi D_m$$

$$\theta(T_i, t_i) = \gamma^\theta + \sum_{m=1}^M \lambda_m^\theta D_m + \delta \ln \tilde{T}_i$$

We included five dummy variables to capture the deterministic time of day pattern. The period from 11:00 a.m. to 2:00 p.m. is the reference for both equations. P-values based on Newey-West standard errors are reported in parentheses.

TICKER	$\lambda_1^\phi$	$\lambda_2^\phi$	$\lambda_3^\phi$	$\lambda_4^\phi$	$\lambda_5^\phi$	$\gamma^\phi$	$\lambda_1^\theta$	$\lambda_2^\theta$	$\lambda_3^\theta$	$\lambda_4^\theta$	$\lambda_5^\theta$	$\gamma^\theta$	$\delta$	$\rho$
ALV	0.0047 (0.000)	0.0012 (0.000)	-0.0003 (0.242)	-0.0009 (0.000)	-0.0008 (0.007)	0.0086 (0.000)	0.0057 (0.000)	0.0016 (0.000)	0.0003 (0.245)	0.0019 (0.000)	0.0016 (0.000)	0.0047 (0.000)	0.0029 (0.000)	0.1977 (0.000)
DTE	0.0001 (0.081)	0.0004 (0.000)	0.0003 (0.000)	0.0001 (0.000)	0.0005 (0.000)	0.0034 (0.000)	0.0002 (0.000)	-0.0004 (0.000)	-0.0005 (0.000)	-0.0004 (0.000)	-0.0007 (0.000)	0.0011 (0.000)	0.0002 (0.000)	0.2242 (0.000)
SIE	0.0018 (0.000)	0.0010 (0.000)	0.0004 (0.002)	0.0001 (0.312)	0.0005 (0.001)	0.0043 (0.000)	0.0014 (0.000)	0.0002 (0.210)	-0.0004 (0.006)	0.0004 (0.001)	-0.0003 (0.046)	0.0033 (0.000)	0.0017 (0.000)	0.2141 (0.000)
DBK	0.0025 (0.000)	0.0009 (0.000)	0.0004 (0.029)	0.0000 (0.764)	0.0020 (0.000)	0.0045 (0.000)	0.0028 (0.000)	0.0007 (0.000)	-0.0004 (0.021)	0.0006 (0.000)	-0.0003 (0.214)	0.0038 (0.000)	0.0018 (0.000)	0.2165 (0.000)
MUV2	0.0029 (0.000)	0.0014 (0.000)	0.0007 (0.033)	-0.0004 (0.090)	0.0009 (0.016)	0.0074 (0.000)	0.0073 (0.000)	0.0023 (0.000)	0.0002 (0.457)	0.0024 (0.000)	0.0016 (0.000)	0.0034 (0.000)	0.0036 (0.000)	0.2104 (0.000)
DCX	0.0011 (0.000)	0.0006 (0.000)	0.0004 (0.001)	0.0002 (0.106)	0.0008 (0.000)	0.0033 (0.000)	0.0014 (0.000)	0.0003 (0.021)	-0.0003 (0.012)	-0.0001 (0.612)	-0.0005 (0.000)	0.0027 (0.000)	0.0010 (0.000)	0.2281 (0.000)
EOA	0.0017 (0.000)	0.0010 (0.000)	0.0005 (0.006)	0.0006 (0.000)	0.0017 (0.000)	0.0032 (0.000)	0.0032 (0.000)	0.0004 (0.041)	-0.0008 (0.000)	0.0000 (0.858)	-0.0005 (0.012)	0.0032 (0.000)	0.0017 (0.000)	0.2440 (0.000)
SAP	0.0040 (0.000)	0.0002 (0.699)	-0.0010 (0.065)	-0.0010 (0.021)	-0.0014 (0.008)	0.0107 (0.000)	0.0074 (0.000)	0.0021 (0.000)	0.0008 (0.126)	0.0004 (0.300)	-0.0005 (0.290)	0.0057 (0.000)	0.0046 (0.000)	0.1954 (0.000)
IFX	0.0004 (0.000)	0.0003 (0.000)	0.0003 (0.000)	0.0002 (0.000)	0.0006 (0.000)	0.0030 (0.000)	0.0001 (0.170)	-0.0004 (0.000)	-0.0006 (0.000)	-0.0003 (0.000)	-0.0007 (0.000)	0.0013 (0.000)	0.0003 (0.000)	0.1992 (0.000)
BAS	0.0015 (0.000)	0.0006 (0.000)	0.0005 (0.002)	0.0001 (0.288)	0.0016 (0.000)	0.0026 (0.000)	0.0030 (0.000)	0.0001 (0.570)	-0.0005 (0.008)	0.0001 (0.724)	-0.0007 (0.000)	0.0031 (0.000)	0.0014 (0.000)	0.2403 (0.000)
VOW	0.0013 (0.000)	0.0008 (0.000)	0.0007 (0.000)	0.0004 (0.007)	0.0015 (0.000)	0.0029 (0.000)	0.0024 (0.000)	0.0002 (0.254)	-0.0003 (0.057)	0.0001 (0.351)	-0.0005 (0.006)	0.0026 (0.000)	0.0014 (0.000)	0.2274 (0.000)
BAY	0.0008 (0.001)	0.0005 (0.000)	0.0004 (0.003)	0.0002 (0.063)	0.0007 (0.000)	0.0028 (0.000)	0.0018 (0.000)	-0.0002 (0.194)	-0.0006 (0.000)	-0.0003 (0.001)	-0.0008 (0.000)	0.0024 (0.000)	0.0008 (0.000)	0.1857 (0.000)
RWE	0.0019 (0.000)	0.0011 (0.000)	0.0006 (0.000)	0.0002 (0.084)	0.0014 (0.000)	0.0027 (0.000)	0.0028 (0.000)	0.0003 (0.136)	-0.0005 (0.004)	0.0003 (0.062)	-0.0001 (0.622)	0.0022 (0.000)	0.0014 (0.000)	0.2163 (0.000)

Table 5: (continued)

TICKER	$\lambda_1^\phi$	$\lambda_2^\phi$	$\lambda_3^\phi$	$\lambda_4^\phi$	$\lambda_5^\phi$	$\gamma^\phi$	$\lambda_1^\theta$	$\lambda_2^\theta$	$\lambda_3^\theta$	$\lambda_4^\theta$	$\lambda_5^\theta$	$\gamma^\theta$	$\delta$	$\rho$
BMW	0.0013 (0.000)	0.0011 (0.000)	0.0005 (0.002)	0.0007 (0.000)	0.0016 (0.000)	0.0027 (0.000)	0.0027 (0.000)	-0.0001 (0.608)	-0.0007 (0.000)	-0.0002 (0.238)	-0.0001 (0.626)	0.0024 (0.000)	0.0013 (0.000)	0.2025 (0.000)
HVM	0.0015 (0.000)	0.0008 (0.000)	0.0005 (0.000)	0.0005 (0.000)	0.0011 (0.000)	0.0030 (0.000)	0.0021 (0.000)	0.0001 (0.507)	-0.0004 (0.004)	-0.0004 (0.001)	-0.0005 (0.008)	0.0018 (0.000)	0.0009 (0.000)	0.1862 (0.000)
SCH	0.0024 (0.001)	0.0011 (0.000)	0.0002 (0.464)	-0.0001 (0.538)	0.0000 (0.986)	0.0045 (0.000)	0.0062 (0.000)	0.0009 (0.001)	-0.0001 (0.806)	0.0000 (0.934)	0.0014 (0.000)	0.0021 (0.000)	0.0018 (0.000)	0.2052 (0.000)
CBK	0.0009 (0.000)	0.0004 (0.001)	0.0004 (0.001)	0.0001 (0.392)	0.0008 (0.000)	0.0025 (0.000)	0.0017 (0.000)	0.0002 (0.111)	-0.0007 (0.000)	-0.0002 (0.033)	-0.0006 (0.001)	0.0017 (0.000)	0.0006 (0.000)	0.2058 (0.000)
LHA	0.0011 (0.000)	0.0007 (0.000)	0.0005 (0.000)	0.0004 (0.001)	0.0006 (0.000)	0.0024 (0.000)	0.0015 (0.000)	0.0000 (0.846)	-0.0007 (0.000)	-0.0003 (0.011)	-0.0001 (0.448)	0.0019 (0.000)	0.0006 (0.000)	0.2259 (0.000)
DPW	0.0013 (0.000)	0.0008 (0.000)	0.0000 (0.826)	0.0001 (0.363)	0.0004 (0.042)	0.0035 (0.000)	0.0021 (0.000)	0.0002 (0.147)	-0.0003 (0.036)	-0.0001 (0.319)	0.0002 (0.413)	0.0015 (0.000)	0.0007 (0.000)	0.1982 (0.000)
TKA	0.0015 (0.000)	0.0010 (0.000)	0.0003 (0.060)	0.0001 (0.358)	0.0004 (0.052)	0.0032 (0.000)	0.0019 (0.000)	0.0002 (0.310)	-0.0005 (0.000)	0.0000 (0.798)	0.0000 (0.976)	0.0017 (0.000)	0.0007 (0.000)	0.1943 (0.000)
MEO	0.0028 (0.001)	0.0008 (0.016)	-0.0002 (0.565)	0.0001 (0.577)	0.0011 (0.003)	0.0025 (0.000)	0.0066 (0.000)	0.0018 (0.000)	0.0004 (0.217)	0.0009 (0.002)	0.0007 (0.067)	0.0031 (0.000)	0.0021 (0.000)	0.2311 (0.000)
ALT	0.0072 (0.000)	0.0015 (0.001)	0.0002 (0.569)	0.0002 (0.592)	0.0015 (0.009)	0.0050 (0.000)	0.0078 (0.000)	0.0017 (0.000)	-0.0002 (0.659)	-0.0001 (0.817)	0.0007 (0.235)	0.0036 (0.000)	0.0023 (0.000)	0.2142 (0.000)
TUI	0.0022 (0.000)	0.0011 (0.000)	0.0001 (0.665)	0.0002 (0.390)	0.0005 (0.082)	0.0033 (0.000)	0.0025 (0.000)	0.0000 (0.851)	-0.0006 (0.012)	-0.0003 (0.234)	-0.0002 (0.590)	0.0030 (0.000)	0.0010 (0.000)	0.2142 (0.000)
MAN	0.0051 (0.000)	0.0011 (0.000)	-0.0001 (0.714)	0.0004 (0.107)	0.0024 (0.000)	0.0030 (0.000)	0.0049 (0.000)	0.0014 (0.000)	-0.0004 (0.240)	-0.0001 (0.807)	0.0003 (0.491)	0.0024 (0.000)	0.0017 (0.000)	0.2477 (0.000)
CONT	0.0048 (0.000)	0.0014 (0.000)	0.0004 (0.181)	0.0009 (0.001)	0.0026 (0.000)	0.0021 (0.000)	0.0056 (0.000)	0.0012 (0.001)	-0.0005 (0.153)	0.0001 (0.722)	0.0005 (0.257)	0.0034 (0.000)	0.0017 (0.000)	0.2414 (0.000)
DB1	0.0032 (0.003)	0.0010 (0.014)	0.0005 (0.270)	0.0009 (0.013)	0.0020 (0.000)	0.0041 (0.000)	0.0073 (0.000)	0.0019 (0.000)	0.0005 (0.310)	0.0007 (0.096)	0.0009 (0.097)	0.0027 (0.000)	0.0022 (0.000)	0.2680 (0.000)
ADS	0.0081 (0.001)	0.0025 (0.004)	0.0024 (0.002)	0.0006 (0.348)	0.0017 (0.084)	0.0067 (0.000)	0.0168 (0.000)	0.0013 (0.096)	-0.0011 (0.174)	0.0004 (0.574)	0.0010 (0.297)	0.0043 (0.000)	0.0046 (0.000)	0.2079 (0.000)
LIN	0.0047 (0.001)	0.0012 (0.011)	0.0007 (0.099)	0.0003 (0.418)	0.0029 (0.000)	0.0017 (0.000)	0.0072 (0.000)	0.0028 (0.000)	0.0005 (0.272)	0.0017 (0.000)	0.0012 (0.054)	0.0039 (0.000)	0.0022 (0.000)	0.2593 (0.000)
HEN3	0.0028 (0.267)	0.0010 (0.218)	-0.0003 (0.670)	0.0000 (0.932)	0.0031 (0.000)	0.0048 (0.000)	0.0127 (0.000)	0.0024 (0.003)	-0.0010 (0.168)	-0.0010 (0.145)	-0.0010 (0.228)	0.0053 (0.000)	0.0033 (0.000)	0.2667 (0.000)
FME	0.0077 (0.003)	0.0006 (0.462)	0.0003 (0.656)	0.0018 (0.003)	0.0047 (0.000)	0.0045 (0.000)	0.0096 (0.001)	0.0025 (0.003)	-0.0007 (0.351)	-0.0004 (0.609)	-0.0014 (0.099)	0.0043 (0.000)	0.0032 (0.000)	0.2306 (0.000)

Table 6: **Estimation results of the extended MRR model. (NYSE/Dow Jones stocks)** The table reports the first stage GMM estimates of the extended MRR model for each of the 28 NYSE traded stocks constituting the Dow Jones Industrial Average. The spread components are specified as a function of the time of day. Additionally, the adverse selection component depends on the duration between the trade in  $t_i$  and  $t_{i-1}$ :

$$\phi(t_i) = \gamma^\phi + \sum_{m=1}^M \lambda_m^\phi D_m$$

$$\theta(T_i, t_i) = \gamma^\theta + \sum_{m=1}^M \lambda_m^\theta D_m + \delta \ln \tilde{T}_i$$

We included four dummy variables to capture the deterministic time of day pattern. The period from 11:30 a.m. to 2:00 p.m. is the reference for both equations. P-values based on Newey-West standard errors are reported in parentheses.

TICKER	$\lambda_1^\phi$	$\lambda_2^\phi$	$\lambda_3^\phi$	$\lambda_4^\phi$	$\gamma^\phi$	$\lambda_1^\theta$	$\lambda_2^\theta$	$\lambda_3^\theta$	$\lambda_4^\theta$	$\gamma^\theta$	$\delta$	$\rho$
MMM	0.0014 (0.000)	0.0006 (0.000)	0.0003 (0.000)	0.0013 (0.000)	0.0016 (0.000)	0.0018 (0.000)	0.0007 (0.000)	0.0001 (0.425)	-0.0008 (0.000)	0.0005 (0.000)	0.0023 (0.000)	0.2706 (0.000)
AA	0.0004 (0.004)	0.0003 (0.000)	0.0004 (0.000)	0.0008 (0.000)	0.0022 (0.000)	0.0012 (0.000)	0.0001 (0.137)	-0.0003 (0.000)	-0.0008 (0.000)	0.0013 (0.000)	0.0009 (0.000)	0.2859 (0.000)
AIG	0.0010 (0.000)	0.0004 (0.000)	0.0001 (0.413)	0.0006 (0.000)	0.0021 (0.000)	0.0013 (0.000)	0.0005 (0.000)	0.0003 (0.006)	-0.0008 (0.000)	0.0023 (0.000)	0.0011 (0.000)	0.2780 (0.000)
MO	0.0004 (0.001)	0.0003 (0.001)	0.0002 (0.030)	0.0008 (0.000)	0.0024 (0.000)	0.0010 (0.000)	0.0003 (0.004)	-0.0002 (0.040)	-0.0006 (0.000)	0.0022 (0.000)	0.0006 (0.000)	0.2740 (0.000)
AXP	0.0002 (0.133)	0.0002 (0.014)	0.0003 (0.000)	0.0008 (0.000)	0.0022 (0.000)	0.0008 (0.000)	0.0001 (0.081)	-0.0003 (0.000)	-0.0008 (0.000)	0.0011 (0.000)	0.0009 (0.000)	0.2766 (0.000)
BA	0.0009 (0.000)	0.0003 (0.001)	0.0000 (0.674)	0.0006 (0.000)	0.0023 (0.000)	0.0012 (0.000)	0.0004 (0.000)	0.0000 (0.622)	-0.0010 (0.000)	0.0022 (0.000)	0.0005 (0.000)	0.2746 (0.000)
CAT	0.0017 (0.000)	0.0008 (0.000)	0.0000 (0.686)	0.0003 (0.021)	0.0023 (0.000)	0.0022 (0.000)	0.0006 (0.001)	0.0000 (0.814)	-0.0008 (0.000)	0.0034 (0.000)	0.0009 (0.000)	0.2491 (0.000)
C	0.0003 (0.000)	0.0002 (0.001)	0.0002 (0.000)	0.0007 (0.000)	0.0024 (0.000)	0.0006 (0.000)	0.0002 (0.012)	0.0000 (0.997)	-0.0007 (0.000)	0.0012 (0.000)	0.0008 (0.000)	0.2662 (0.000)
KO	0.0007 (0.000)	0.0002 (0.012)	0.0004 (0.000)	0.0007 (0.000)	0.0023 (0.000)	0.0012 (0.000)	0.0002 (0.007)	-0.0001 (0.138)	-0.0006 (0.000)	0.0014 (0.000)	0.0009 (0.000)	0.2466 (0.000)
DD	0.0010 (0.000)	0.0003 (0.001)	0.0002 (0.008)	0.0007 (0.000)	0.0024 (0.000)	0.0015 (0.000)	0.0005 (0.000)	-0.0001 (0.099)	-0.0008 (0.000)	0.0021 (0.000)	0.0004 (0.000)	0.2390 (0.000)
XOM	0.0003 (0.000)	0.0002 (0.000)	0.0002 (0.000)	0.0006 (0.000)	0.0026 (0.000)	0.0005 (0.000)	0.0000 (0.591)	-0.0001 (0.037)	-0.0004 (0.000)	0.0015 (0.000)	0.0003 (0.000)	0.2211 (0.000)
GE	0.0004 (0.000)	0.0002 (0.000)	0.0002 (0.000)	0.0006 (0.000)	0.0033 (0.000)	0.0005 (0.000)	-0.0001 (0.040)	-0.0001 (0.015)	-0.0007 (0.000)	0.0007 (0.000)	0.0006 (0.000)	0.2257 (0.000)
GM	0.0008 (0.000)	0.0003 (0.001)	0.0002 (0.035)	0.0006 (0.000)	0.0026 (0.000)	0.0013 (0.000)	0.0004 (0.000)	-0.0001 (0.131)	-0.0007 (0.000)	0.0023 (0.000)	0.0005 (0.000)	0.2556 (0.000)

Table 6: (continued)

TICKER	$\lambda_1^\phi$	$\lambda_2^\phi$	$\lambda_3^\phi$	$\lambda_4^\phi$	$\gamma^\phi$	$\lambda_1^\theta$	$\lambda_2^\theta$	$\lambda_3^\theta$	$\lambda_4^\theta$	$\gamma^\theta$	$\delta$	$\rho$
HPQ	0.0003 (0.001)	0.0002 (0.000)	0.0002 (0.000)	0.0008 (0.000)	0.0027 (0.000)	0.0007 (0.000)	0.0000 (0.716)	-0.0002 (0.003)	-0.0007 (0.000)	0.0012 (0.000)	0.0005 (0.000)	0.2389 (0.000)
HD	0.0007 (0.000)	0.0003 (0.000)	0.0002 (0.000)	0.0006 (0.000)	0.0028 (0.000)	0.0010 (0.000)	0.0000 (0.461)	-0.0002 (0.001)	-0.0007 (0.000)	0.0015 (0.000)	0.0006 (0.000)	0.2400 (0.000)
HON	0.0009 (0.000)	0.0002 (0.059)	0.0001 (0.073)	0.0007 (0.000)	0.0023 (0.000)	0.0017 (0.000)	0.0006 (0.000)	-0.0002 (0.019)	-0.0011 (0.000)	0.0022 (0.000)	0.0005 (0.000)	0.2589 (0.000)
IBM	0.0016 (0.000)	0.0005 (0.000)	0.0003 (0.004)	0.0010 (0.000)	0.0024 (0.000)	0.0015 (0.000)	0.0006 (0.000)	0.0002 (0.171)	-0.0009 (0.000)	0.0011 (0.000)	0.0024 (0.000)	0.2488 (0.000)
JPM	0.0006 (0.000)	0.0003 (0.000)	0.0003 (0.000)	0.0008 (0.000)	0.0025 (0.000)	0.0010 (0.000)	0.0000 (0.506)	-0.0002 (0.004)	-0.0006 (0.000)	0.0014 (0.000)	0.0005 (0.000)	0.2528 (0.000)
JNJ	0.0004 (0.000)	0.0002 (0.000)	0.0002 (0.000)	0.0007 (0.000)	0.0026 (0.000)	0.0007 (0.000)	0.0001 (0.187)	-0.0002 (0.023)	-0.0005 (0.000)	0.0014 (0.000)	0.0006 (0.000)	0.2191 (0.000)
MCD	0.0004 (0.001)	0.0003 (0.000)	0.0004 (0.000)	0.0008 (0.000)	0.0024 (0.000)	0.0013 (0.000)	0.0001 (0.135)	-0.0005 (0.000)	-0.0006 (0.000)	0.0014 (0.000)	0.0004 (0.000)	0.2399 (0.000)
MRK	0.0004 (0.003)	0.0003 (0.000)	0.0003 (0.000)	0.0006 (0.000)	0.0024 (0.000)	0.0008 (0.000)	0.0000 (0.764)	-0.0002 (0.001)	-0.0005 (0.000)	0.0012 (0.000)	0.0006 (0.000)	0.2656 (0.000)
PFE	0.0003 (0.000)	0.0002 (0.000)	0.0002 (0.000)	0.0006 (0.000)	0.0027 (0.000)	0.0006 (0.000)	0.0001 (0.192)	-0.0002 (0.000)	-0.0006 (0.000)	0.0012 (0.000)	0.0005 (0.000)	0.2317 (0.000)
PG	0.0012 (0.000)	0.0002 (0.012)	0.0003 (0.000)	0.0010 (0.000)	0.0015 (0.000)	0.0017 (0.000)	0.0006 (0.000)	-0.0001 (0.487)	-0.0005 (0.001)	0.0015 (0.000)	0.0018 (0.000)	0.2603 (0.000)
SBC	0.0001 (0.314)	0.0002 (0.000)	0.0003 (0.000)	0.0007 (0.000)	0.0026 (0.000)	0.0008 (0.000)	0.0000 (0.704)	-0.0002 (0.000)	-0.0007 (0.000)	0.0011 (0.000)	0.0004 (0.000)	0.2475 (0.000)
UTX	0.0017 (0.000)	0.0007 (0.000)	0.0004 (0.002)	0.0008 (0.000)	0.0024 (0.000)	0.0024 (0.000)	0.0009 (0.000)	-0.0002 (0.339)	-0.0010 (0.000)	0.0021 (0.000)	0.0018 (0.000)	0.2458 (0.000)
VZ	0.0006 (0.000)	0.0002 (0.003)	0.0003 (0.000)	0.0007 (0.000)	0.0024 (0.000)	0.0010 (0.000)	0.0002 (0.011)	-0.0001 (0.048)	-0.0005 (0.000)	0.0017 (0.000)	0.0004 (0.000)	0.2747 (0.000)
WMT	0.0007 (0.000)	0.0004 (0.000)	0.0002 (0.002)	0.0009 (0.000)	0.0022 (0.000)	0.0009 (0.000)	0.0002 (0.024)	0.0001 (0.261)	-0.0004 (0.001)	0.0009 (0.000)	0.0013 (0.000)	0.2463 (0.000)
DIS	0.0008 (0.000)	0.0003 (0.000)	0.0000 (0.511)	0.0007 (0.000)	0.0029 (0.000)	0.0008 (0.000)	0.0001 (0.053)	-0.0002 (0.000)	-0.0005 (0.000)	0.0019 (0.000)	0.0001 (0.000)	0.2331 (0.000)

Table 7: **Adverse selection in percent of the spread. (Xetra/DAX stocks)** The table reports the several adverse selection shares for each stock as well as the average for each trade activity quartile. In the first column,  $asr(T_i, t_i) = \frac{\theta(T_i, t_i)}{\theta(T_i, t_i) + \phi(t_i)}$  denotes the average adverse selection share of the spread computed for each stock. Additionally, in the second column,  $asr(T_i) = \frac{\theta(T_i)}{\theta(T_i) + \phi(t_i)}$  denotes the average adverse selection share of the spread explained by trade duration computed for each stock.  $dasr$  denotes the average fraction of the adverse selection component which can be explained by trade duration or  $dasr = \frac{\theta(T_i)}{\theta(T_i, t_i)}$ . The three ratios are averaged over all trades for each stock, for each trade activity quartile and for the whole sample. Note, that the adverse selection component  $\theta(T_i, t_i)$  is the sum of the deterministic time of day component  $\theta(t_i)$  and the duration dependent component  $\theta(T_i)$ .

TICKER	$asr(T_i, t_i)$	$asr(T_i)$	$dasr$	TICKER	$asr(T_i, t_i)$	$asr(T_i)$	$dasr$
1 <sup>st</sup> Quartile (most active)				2 <sup>nd</sup> Quartile			
EOA	59.9	26.2	41.4	HVM	48.4	23.1	45.2
DCX	53.9	18.8	32.9	BMW	58.1	28.8	47.2
MUV2	55.7	28.2	47.8	RWE	58.1	28.9	47.0
DBK	56.7	21.0	35.0	BAY	53.4	19.8	35.4
SIE	53.9	20.9	36.5	VOW	58.4	26.3	42.6
DTE	23.6	5.7	23.8	BAS	63.8	26.9	40.2
ALV	53.0	20.7	36.8	IFX	30.9	9.8	30.4
				SAP	56.4	28.8	48.1
group Q1	50.0	19.6	35.8	group Q2	53.2	23.8	41.7
3 <sup>rd</sup> Quartile				4 <sup>th</sup> Quartile (least active)			
TUI	58.1	24.7	40.7	FME	68.1	42.4	60.0
ALT	61.3	33.1	51.6	HEN3	71.0	41.3	56.2
MEO	74.0	38.2	49.9	LIN	80.4	38.7	46.9
TKA	49.2	23.4	45.0	ADS	64.5	42.5	63.1
DPW	45.4	22.1	46.1	DB1	63.5	36.2	54.7
LHA	52.5	22.7	41.3	CONT	71.2	34.7	46.9
CBK	51.0	23.0	43.2	MAN	63.6	36.2	54.3
SCH	56.2	32.5	55.0				
group Q3	55.6	27.4	46.7	group Q4	68.6	38.5	54.3
all stocks	53.8	24.1	41.2				

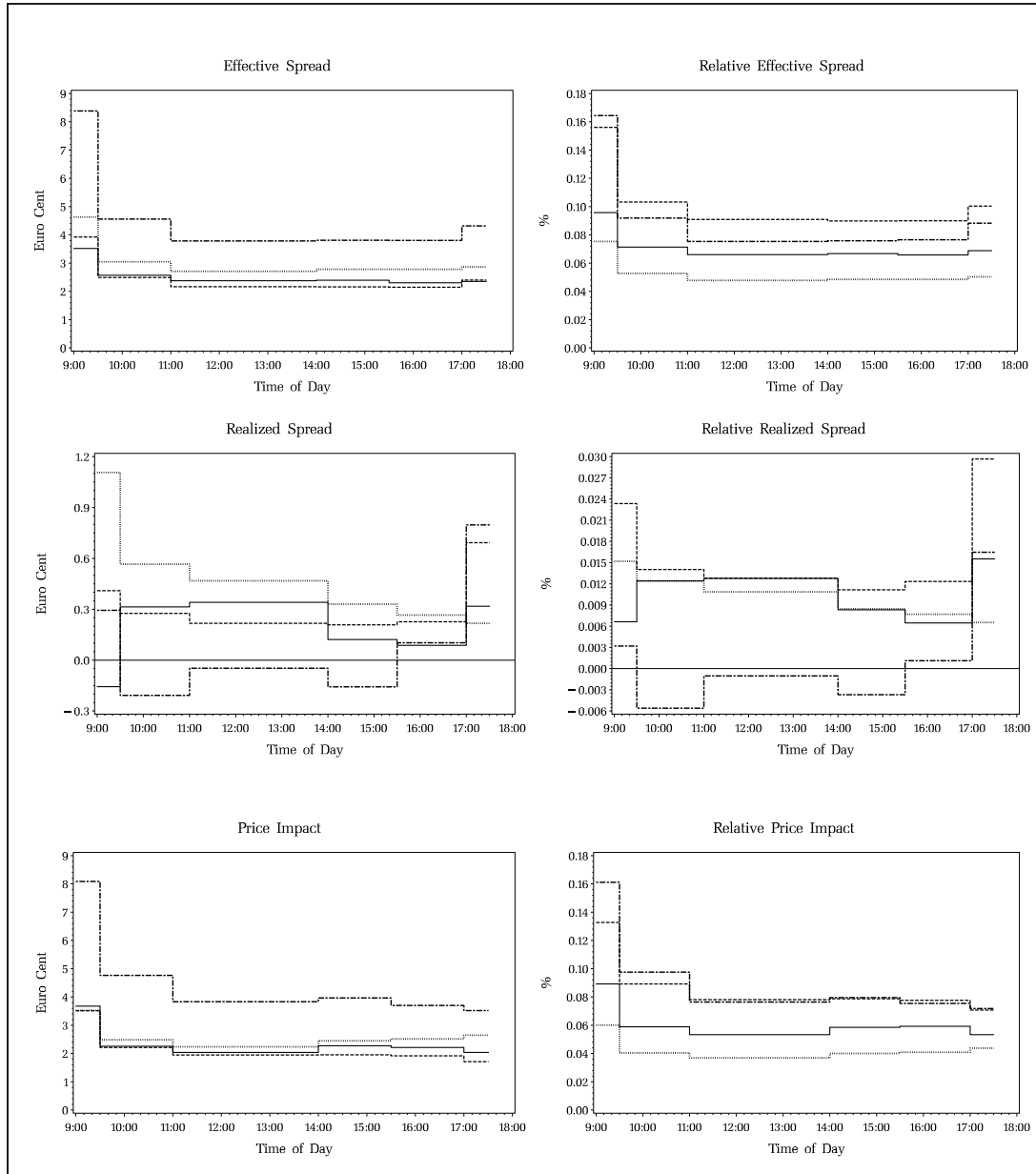
Table 8: **Adverse selection in percent of the spread. (NYSE/Dow Jones stocks)**

The table reports the several adverse selection shares for each stock as well as the average for each trade activity quartile. In the first column,  $asr(T_i, t_i) = \frac{\theta(T_i, t_i)}{\theta(T_i, t_i) + \phi(t_i)}$  denotes the average adverse selection share of the spread computed for each stock. Additionally, in the second column,  $asr(T_i) = \frac{\theta(T_i)}{\theta(T_i, t_i) + \phi(t_i)}$  denotes the average adverse selection share of the spread explained by trade duration computed for each stock.  $dasr$  denotes the average fraction of the adverse selection component which can be explained by trade duration or  $dasr = \frac{\theta(T_i)}{\theta(T_i, t_i)}$ . The three ratios are averaged over all trades for each stock, for each trade activity quartile and for the whole sample. Note, that the adverse selection component  $\theta(T_i, t_i)$  is the sum of the deterministic time of day component  $\theta(t_i)$  and the duration dependent component  $\theta(T_i)$ .

TICKER	$asr(T_i, t_i)$	$asr(T_i)$	$dasr$	TICKER	$asr(T_i, t_i)$	$asr(T_i)$	$dasr$
1 <sup>st</sup> Quartile (most active)				2 <sup>nd</sup> Quartile			
JPM	43.6	16.1	36.4	PG	71.3	44.5	61.8
WMT	54.1	35.6	64.7	JNJ	46.6	19.6	41.4
XOM	41.1	10.3	24.7	VZ	46.8	12.4	26.1
IBM	62.7	45.7	72.2	DIS	39.5	3.9	9.8
C	48.4	23.6	48.2	HPQ	38.8	15.6	39.9
PFE	39.9	15.8	38.9	AIG	64.2	24.8	38.1
GE	29.5	17.2	58.1	HD	42.5	16.0	37.1
group Q1	45.4	23.4	49.1	group Q2	49.7	19.3	36.1
3 <sup>rd</sup> Quartile				4 <sup>th</sup> Quartile (least active)			
MRK	44.6	20.3	44.6	HON	55.7	16.1	28.9
AA	51.5	27.0	51.9	MCD	43.7	16.2	36.9
CAT	66.0	19.3	28.7	BA	55.5	16.5	29.6
UTX	64.7	35.6	54.2	GM	53.8	14.6	26.8
SBC	36.5	13.9	38.0	DD	52.5	13.3	25.0
MO	54.6	16.5	29.7	AXP	50.5	29.5	58.1
MMM	66.6	55.3	82.9	KO	53.3	26.5	48.8
group Q3	55.0	27.0	47.3	group Q4	52.2	19.2	36.6
all stocks	50.1	22.3	42.8				

**Table 9: Correlations of the estimated standardized spread components with several relative spread measures, market capitalization and the daily number of trades. (Xetra/DAX stocks)** The table reports the Pearson correlation coefficients of the estimated standardized spread components with several relative spread measures, market capitalization and the daily number of trades.  $\tilde{\phi}(t_i)$  is the standardized order processing component,  $\tilde{\theta}(T_i, t_i)$  is the standardized adverse selection component,  $\tilde{\theta}(T_i)$  is the standardized adverse selection component due to duration and  $\tilde{I}S_i = 2[\tilde{\theta}(T_i, t_i) + \tilde{\phi}(t_i)]$  denotes the implied spread.  $asr(T_i, t_i) = \frac{\theta(T_i, t_i)}{\theta(T_i, t_i) + \phi(t_i)}$  denotes the average adverse selection share of the spread computed for each stock.  $asr(T_i) = \frac{\theta(T_i)}{\theta(T_i, t_i) + \phi(t_i)}$  denotes the average adverse selection share of the spread explained by trade duration computed for each stock.  $dasr = \frac{\theta(T_i)}{\theta(T_i, t_i)}$  denotes the average fraction of the adverse selection component which can be explained by trade duration. Correlations were computed across the sample of the 30 stocks constituting the DAX30. P-values for the correlation coefficients are in parentheses.

Variable	Effective Spread (%)	Realized Spread (%)	Price Impact (%)	Market cap. (Mill.)	Daily nb. trades
$\tilde{\phi}(t_i)$	0.731 (0.000)	0.895 (0.000)	0.329 (0.076)	-0.310 (0.095)	-0.108 (0.571)
$\tilde{\theta}(T_i, t_i)$	0.785 (0.000)	-0.140 (0.462)	0.965 (0.000)	-0.802 (0.000)	-0.892 (0.000)
$\tilde{\theta}(T_i)$	0.530 (0.003)	-0.391 (0.033)	0.816 (0.000)	-0.761 (0.000)	-0.876 (0.000)
$\tilde{I}S_i$	0.996 (0.000)	0.495 (0.005)	0.851 (0.000)	-0.732 (0.000)	-0.658 (0.000)
$asr(T_i, t_i)$	-0.081 (0.671)	-0.845 (0.000)	0.379 (0.039)	-0.314 (0.091)	-0.542 (0.002)
$asr(T_i)$	-0.170 (0.369)	-0.820 (0.000)	0.264 (0.158)	-0.333 (0.072)	-0.505 (0.004)
$dasr$	-0.201 (0.286)	-0.635 (0.000)	0.126 (0.508)	-0.308 (0.098)	-0.391 (0.033)



**Figure 1: Intra-day Pattern for the effective spread, the realized spread and the price impact. (Xetra/DAX stocks)** The dotted line depicts trade size quartile 1, the straight line depicts trade size quartile 2, the dashed line depicts trade size quartile 3 and the dash-dotted line depicts trade size quartile 4. Top left: Intra-day pattern for the effective spread for each trade size quartile. Top right: Intra-day pattern for the relative effective spread for each trade size quartile. Middle left: Intra-day pattern for the realized spread for each trade size quartile. Middle right: Intra-day pattern for the relative realized spread for each trade size quartile. Lower left: Intra-day pattern for the price impact for each trade size quartile. Lower right: Intra-day pattern for the relative price impact for each trade size quartile.

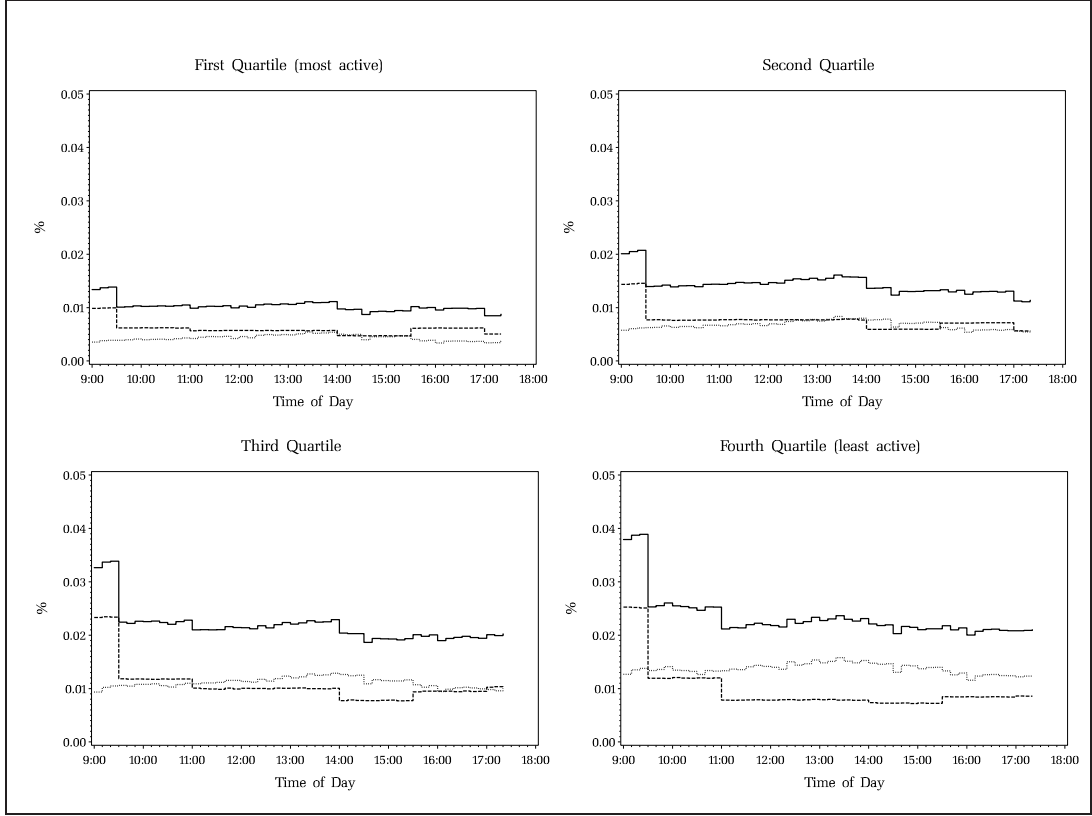
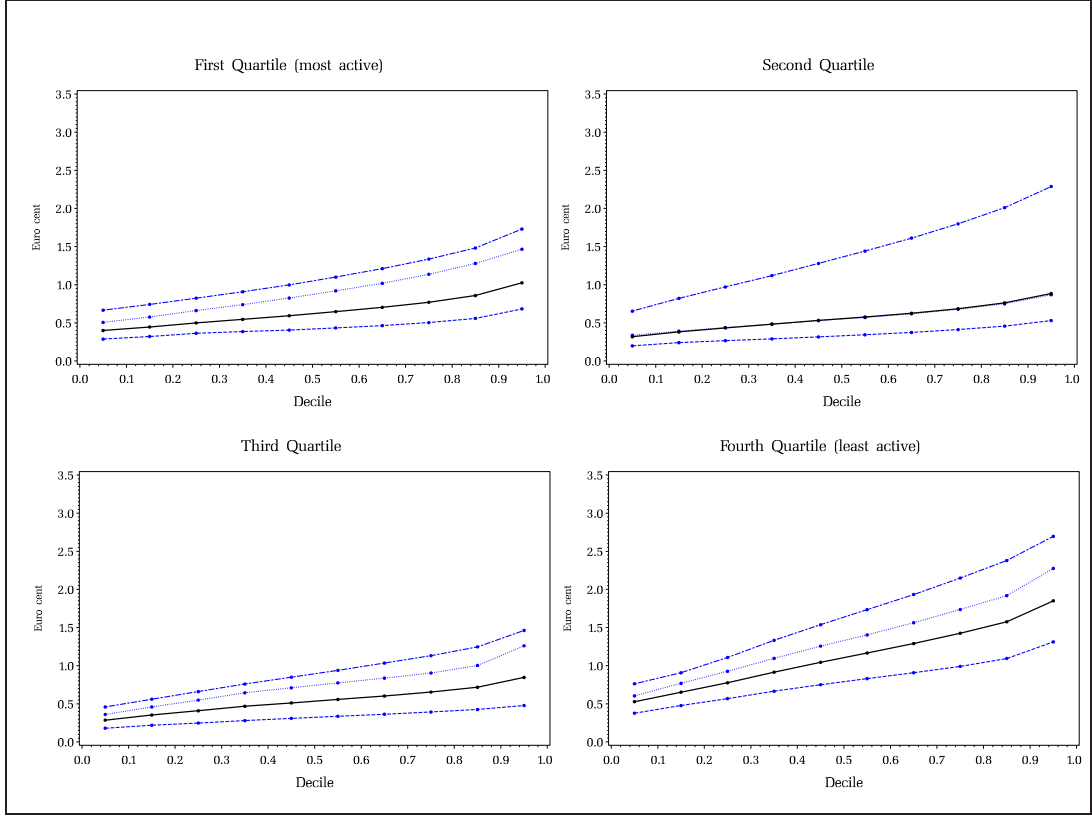
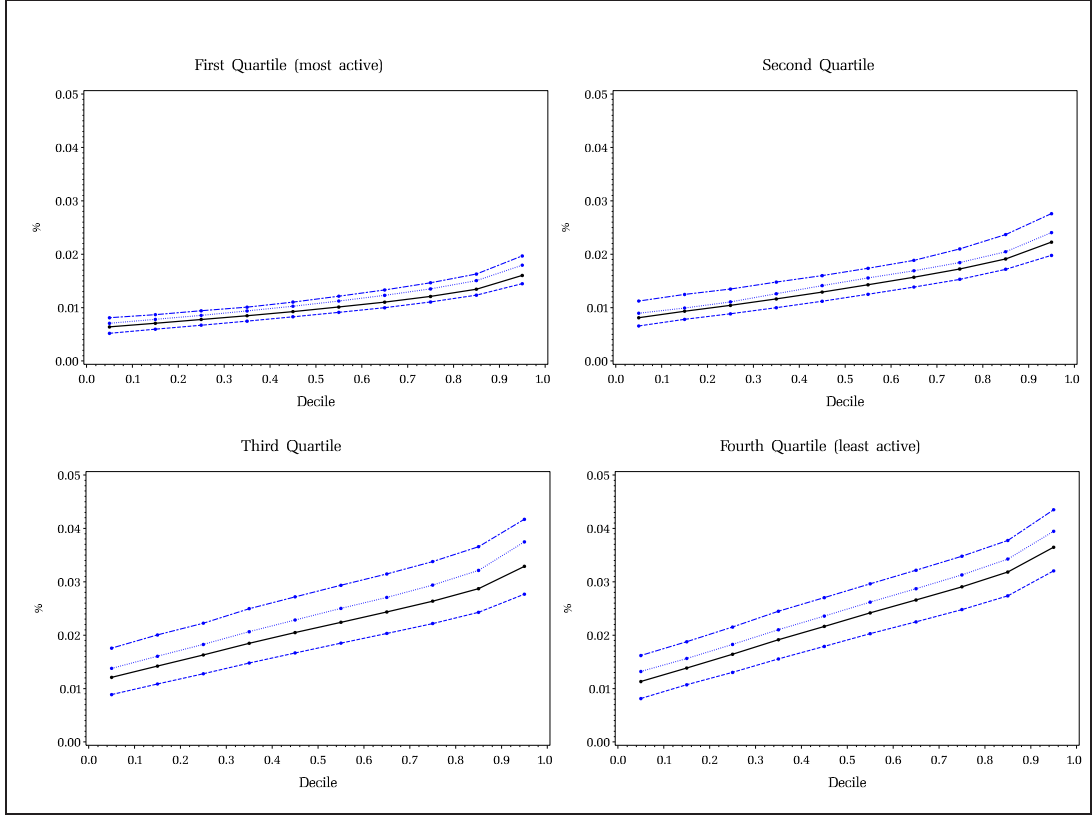


Figure 2: Intra-day patterns for the estimated standardized adverse selection components. (Xetra/DAX stocks) The dotted line depicts the average standardized adverse selection component due to duration  $\theta(T_i)$ . The dashed line depicts the deterministic part of the average standardized adverse selection component  $\theta(t_i)$ . The solid line depicts the sum of  $\theta(T_i)$  and  $\theta(t_i)$ , the complete adverse selection component  $\theta(T_i, t_i)$ . Top left: Intra-day patterns for the trade activity quartile 1. Top right: Intra-day patterns for the trade activity quartile 2. Lower left: Intra-day patterns for the trade activity quartile 3. Lower right: Intra-day patterns for the trade activity quartile 4.



**Figure 3: Time between trades versus adverse selection component. (Xetra/DAX stocks)** We sort (in ascending order) the trade duration into deciles and compute the mean, 0.25, 0.75 and 0.9 quantile of the adverse selection component  $\theta(T_i, t_i)$  in each decile and graphically display the results. The 0.25-quantiles are connected with dashed lines. The 0.75-quantiles are connected with dotted lines. The 0.9-quantiles are connected with dash-dotted lines. The decile means are connected with solid lines. All trade events of the stocks belonging to the same trading activity quartile are pooled. The top left panel displays the results for the group of most frequently trades stocks. The top right panel shows the results for the second and the lower left panel depicts the result for the third trading activity quartile. The lower right panel presents the results for the least frequently traded stocks.



**Figure 4: Time between trades versus standardized adverse selection component. (Xetra/DAX stocks)** We sort (in ascending order) the trade duration into deciles and compute the mean, 0.25, 0.75 and 0.9 quantile of the standardized adverse selection component  $\tilde{\theta}(T_i, t_i)$  in each decile and graphically display the results. The 0.25-quantiles are connected with dashed lines. The 0.75-quantiles are connected with dotted lines. The 0.9-quantiles are connected with dash-dotted lines. The decile means are connected with solid lines. All trade events of the stocks belonging to the same trading activity quartile are pooled. The top left panel displays the results for the group of most frequently trades stocks. The top right panel shows the results for the second and the lower left panel depicts the result for the third trading activity quartile. The lower right panel presents the results for the least frequently traded stocks.

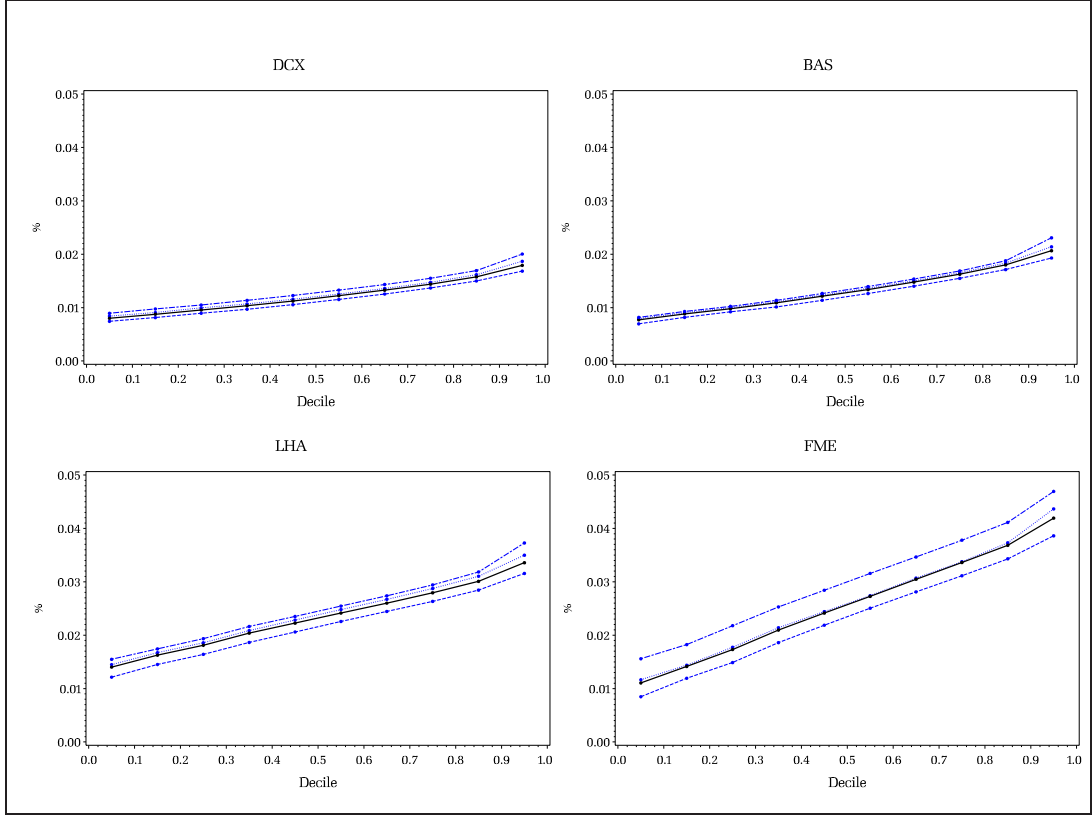
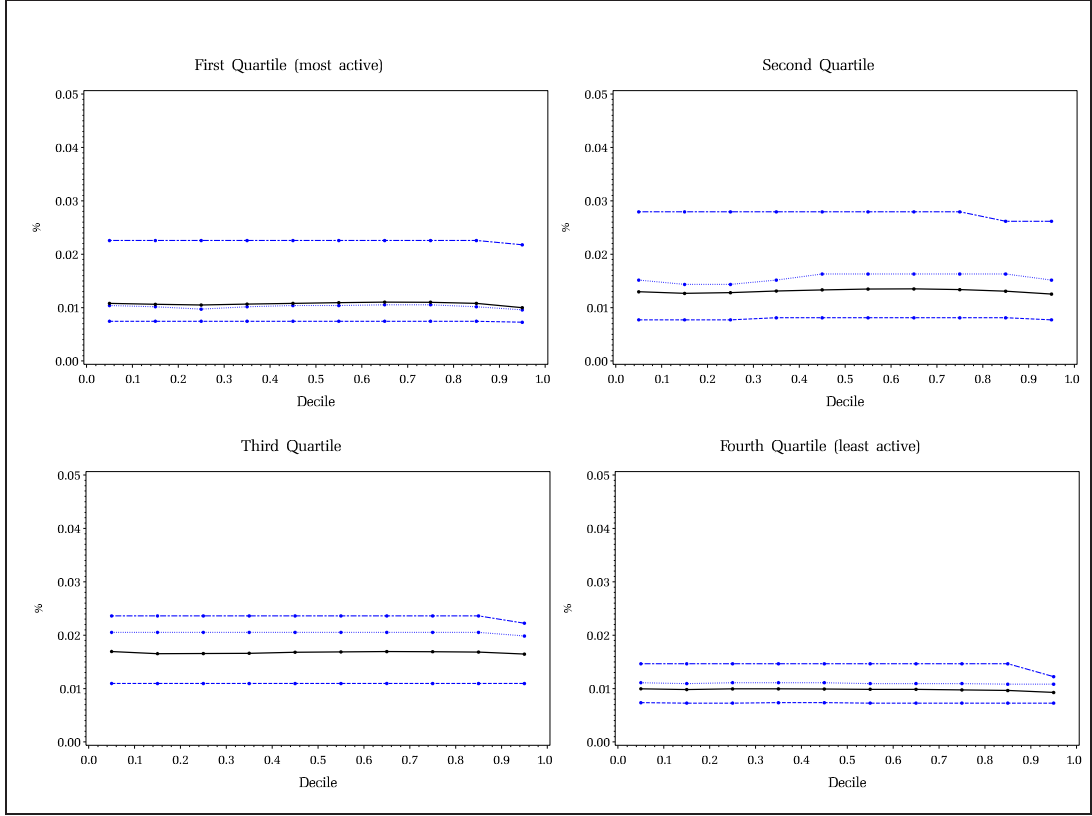
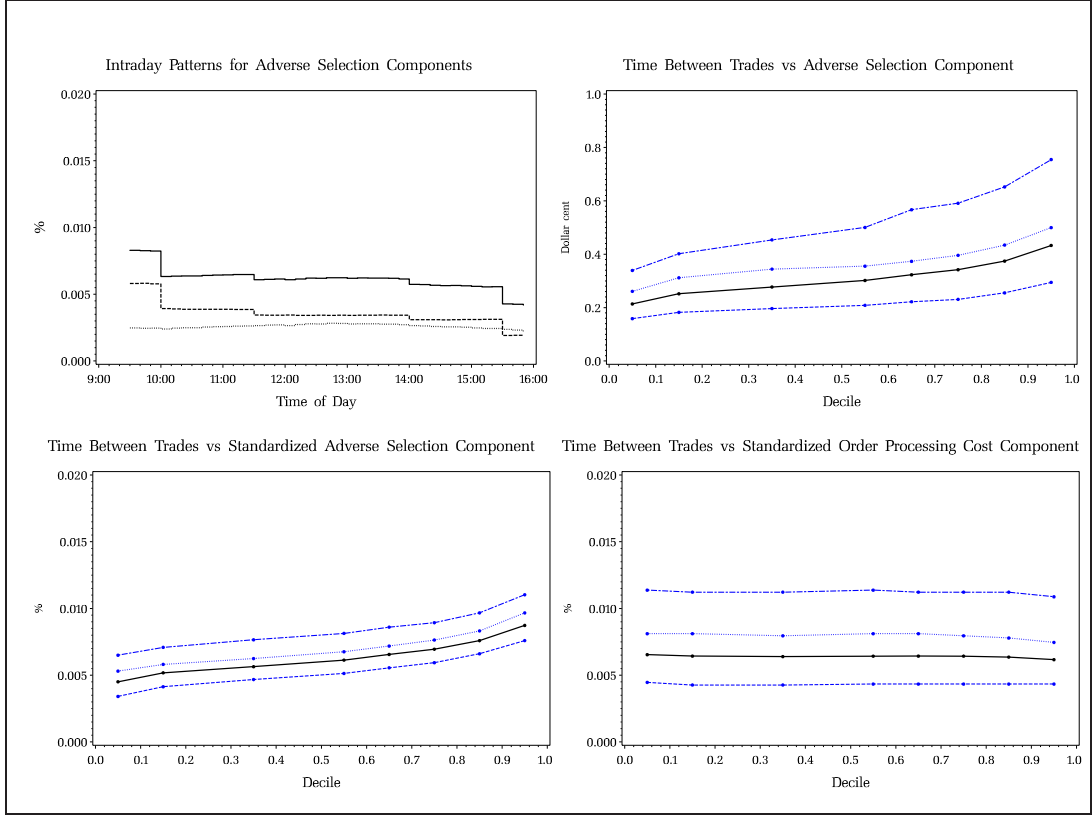


Figure 5: **Time between trades versus standardized adverse selection component for individual stocks. (selected Xetra/DAX stocks)** We sort (in ascending order) the trade duration into deciles and compute the mean, 0.25, 0.75 and 0.9 quantile of the adverse selection component  $\theta(T_i, t_i)$  in each decile and graphically display the results. The 0.25-quantiles are connected with dashed lines. The 0.75-quantiles are connected with dotted lines. The 0.9-quantiles are connected with dash-dotted lines. The decile means are connected with solid lines. The top left panel displays the results for a representative stock of trade activity quartile 1. The top right panel shows the results for a representative stock of trade activity quartile 2. The lower left panel depicts the result for a representative stock of trade activity quartile 3 and the lower right panel presents the results for a representative stock of trade activity quartile 4. All trade events of the particular stock are pooled.



**Figure 6: Time between trades versus standardized order processing cost component. (Xetra/DAX stocks)** We sort (in ascending order) the trade duration into deciles and compute the mean, 0.25, 0.75 and 0.9 quantile of the standardized order processing cost component  $\tilde{\phi}(\tau)$  in each decile and graphically display the results. The 0.25-quantiles are connected with dashed lines. The 0.75-quantiles are connected with dotted lines. The 0.9-quantiles are connected with dash-dotted lines. The decile means are connected with solid lines. All trade events of the stocks belonging to the same trading activity quartile are pooled. The top left panel displays the results for the group of most frequently trades stocks. The top right panel shows the results for the second and the lower left panel depicts the result for the third trading activity quartile. The lower right panel presents the results for the least frequently traded stocks.



**Figure 7: Results for the NYSE/Dow Jones stocks.** The upper left panel depicts the intra-day pattern of the adverse selection components. We pool all trade events of the 28 NYSE traded Dow Jones stocks and compute means of the components for each ten minute interval. The dotted line depicts the average standardized adverse selection component due to duration  $\theta(T_i)$ . The dashed line depicts the deterministic part of the average standardized adverse selection component  $\theta(t_i)$ . The solid line depicts the sum of  $\theta(t_i)$  and  $\theta(T_i)$ , the complete adverse selection component  $\theta(T_i, t_i)$ . In the remaining three panels we sort (in ascending order) the trade duration into deciles and compute the mean, 0.25, 0.75 and 0.9 quantile of the adverse selection component  $\theta(T_i, t_i)$  (upper right panel), standardized adverse selection component  $\tilde{\theta}(T_i, t_i)$  (lower left panel) and the standardized order processing cost component  $\tilde{\phi}(t_i)$  (lower right panel) in each decile and graphically display the results. The 0.25-quantiles are connected with dashed lines. The 0.75-quantiles are connected with dotted lines. The 0.9-quantiles are connected with dash-dotted lines. The decile means are connected with solid lines. All trade events of the 28 NYSE traded Dow Jones stocks are pooled.

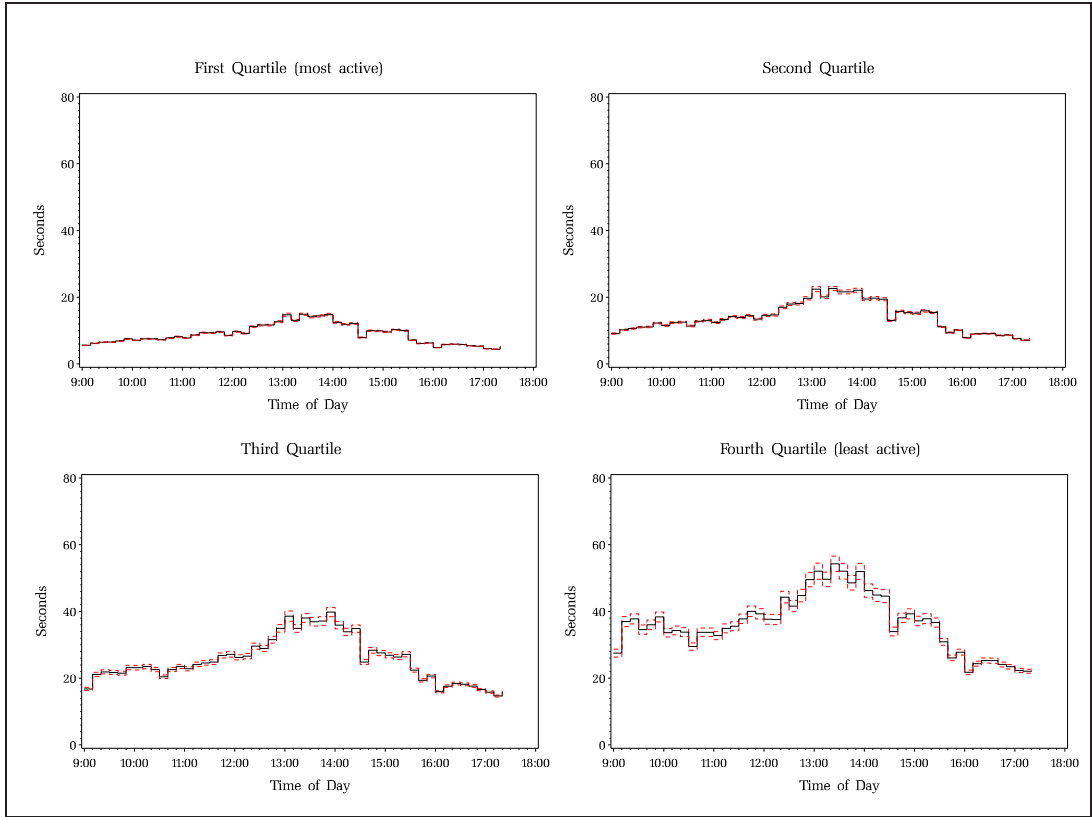


Figure 8: **Intra-day pattern of trade durations. (Xetra/DAX stocks)** We compute for each ten minute interval of the day the average trade duration and plot the means against time of day. All trade events of the stocks belonging to the same trading activity quartile are pooled. The top left panel displays the results for the group of most frequently trades stocks. The top right panel shows the results for the second and the lower left panel depicts the result for the third trading activity quartile. The lower right panel presents the results for the least frequently traded stocks. The dashed lines are the 95% confidence intervals for the ten minute means.

## Appendix

### A Detailed Results for Dow Jones Stocks

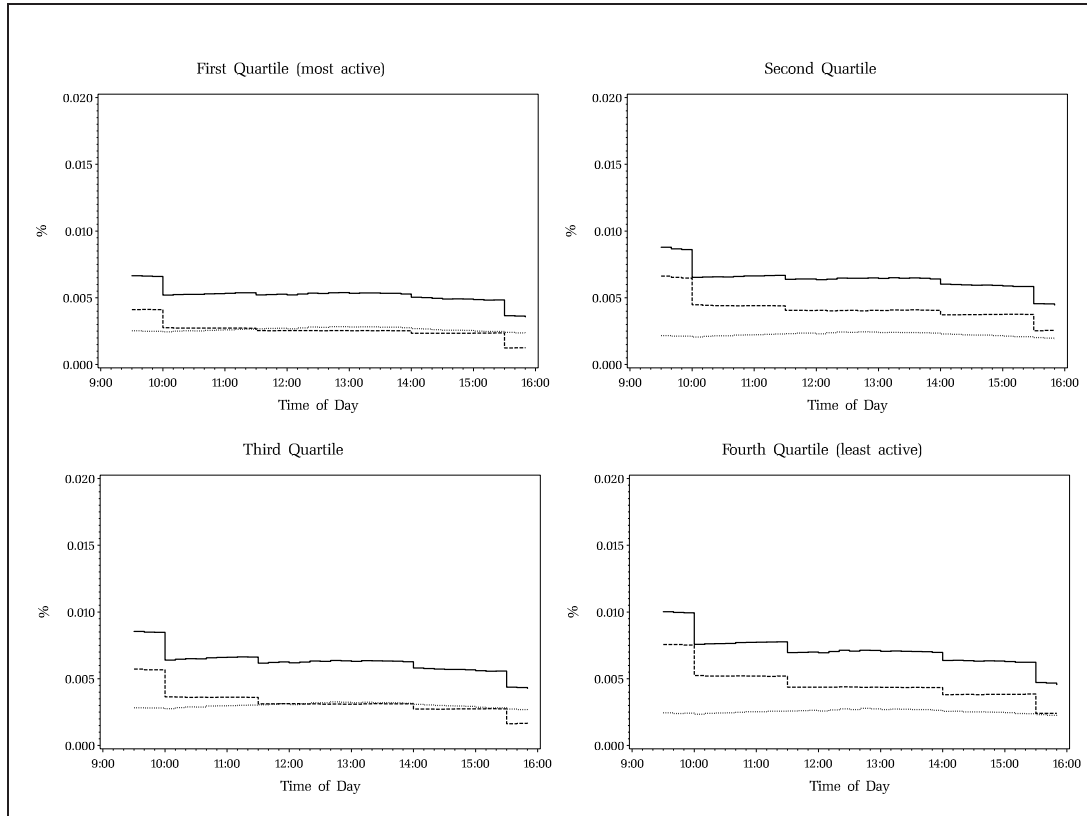
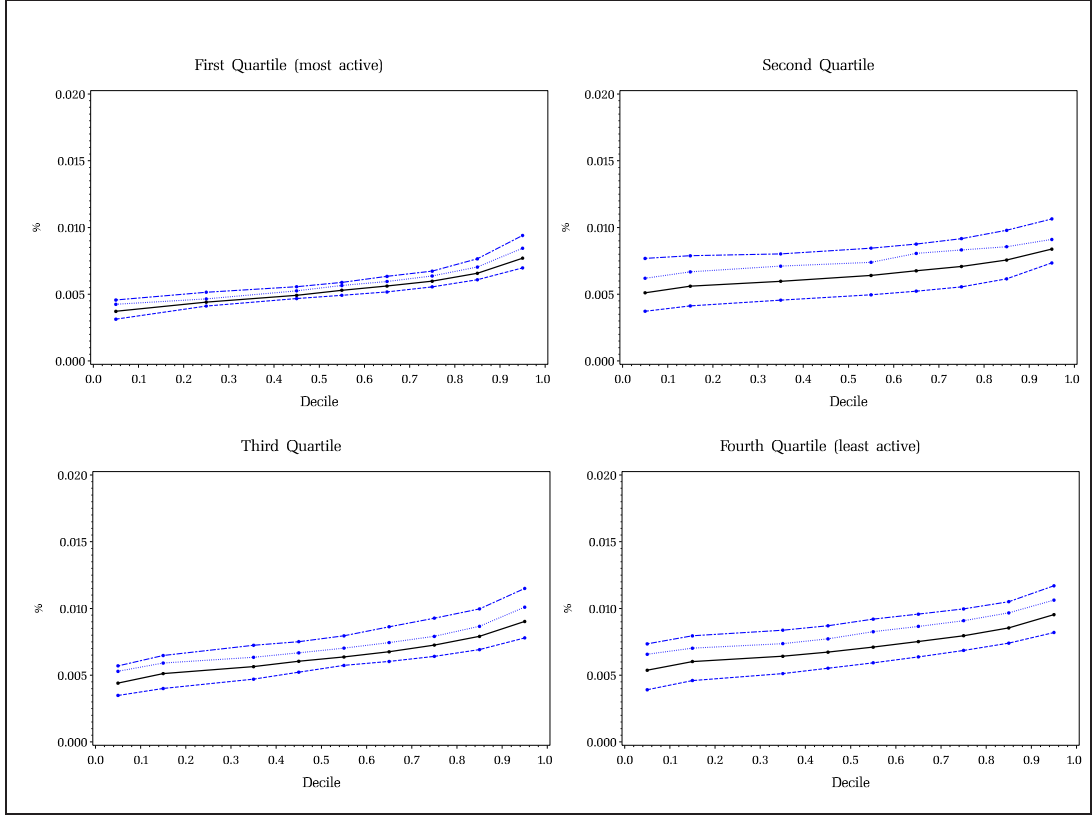


Figure A.1: Intra-day patterns for the estimated standardized adverse selection components. (NYSE/Dow Jones stocks) The dotted line depicts the average standardized adverse selection component due to duration  $\theta(T_i)$ . The dashed line depicts the deterministic part of the average standardized adverse selection component  $\theta(t_i)$ . The solid line depicts the sum of  $\theta(T_i)$  and  $\theta(t_i)$ , the complete adverse selection component  $\theta(T_i, t_i)$ . Top left: Intra-day patterns for the trade activity quartile 1. Top right: Intra-day patterns for the trade activity quartile 2. Lower left: Intra-day patterns for the trade activity quartile 3. Lower right: Intra-day patterns for the trade activity quartile 4.



**Figure A.2: Time between trades versus standardized adverse selection component. (NYSE/Dow Jones stocks)** We sort (in ascending order) the trade duration into deciles and compute the mean, 0.25, 0.75 and 0.9 quantile of the standardized adverse selection component  $\hat{\theta}(T_i, t_i)$  in each decile and graphically display the results. The 0.25-quantiles are connected with dashed lines. The 0.75-quantiles are connected with dotted lines. The 0.9-quantiles are connected with dash-dotted lines. The decile means are connected with solid lines. All trade events of the stocks belonging to the same trading activity quartile are pooled. The top left panel displays the results for the group of most frequently trades stocks. The top right panel shows the results for the second and the lower left panel depicts the result for the third trading activity quartile. The lower right panel presents the results for the least frequently traded stocks.

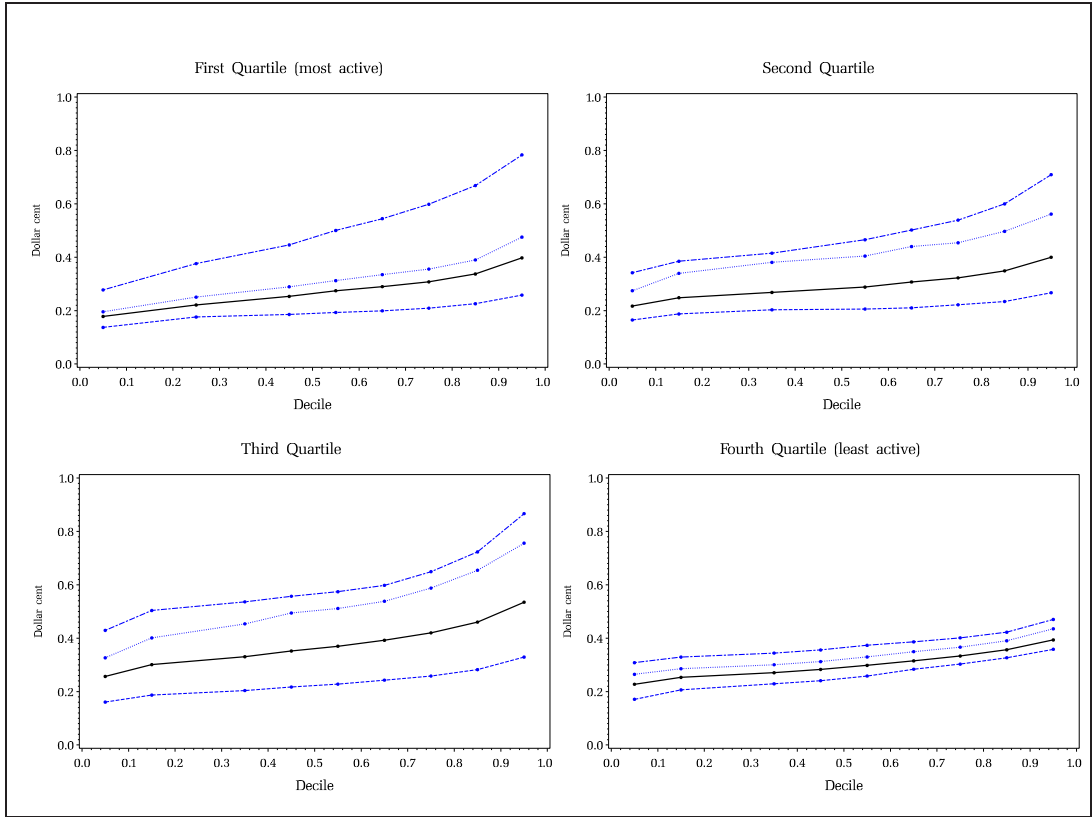


Figure A.3: Time between trades versus adverse selection component. (NYSE/Dow Jones stocks) We sort (in ascending order) the trade duration into deciles and compute the mean, 0.25, 0.75 and 0.9 quantile of the adverse selection component  $\theta(T_i, t_i)$  in each decile and graphically display the results. The 0.25-quantiles are connected with dashed lines. The 0.75-quantiles are connected with dotted lines. The 0.9-quantiles are connected with dash-dotted lines. The decile means are connected with solid lines. All trade events of the stocks belonging to the same trading activity quartile are pooled. The top left panel displays the results for the group of most frequently trades stocks. The top right panel shows the results for the second and the lower left panel depicts the result for the third trading activity quartile. The lower right panel presents the results for the least frequently traded stocks.

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