# Detecting information-driven trading in a dealers' market

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**Abstract**

We focus on the extent of information-driven trading originating from the behavior of the market makers on an emerging market. The goal of the paper is to introduce an automatic procedure that can be used for identifying suspicious behavior in a dealers' market.

We use the classical Easley et al. (1996) model in a combination of a probability of informed trading measurement and a jackknife approach in which trades of one particular market maker at a time are left out from the sum of all buys and sells. Using the estimates from the jackknife approach, for each market maker we construct and test whether the market maker behaved significantly different from the others.

Data from the Prague Stock Exchange SPAD trading platform are used to demonstrate our methodology. Finding significant differences in the behavior of market makers, we conclude that they affect the extent of information-driven trading to a remarkable extent. Under current regulation they have been able to keep their private information and not reveal all of it for a surprisingly long period.

Our study could significantly contribute to the detection mechanisms of regulatory authorities on emerging markets in identifying the suspicious behavior of particular market participants.

*JEL Classification:* G14, G15, P34
*Keywords:* dealers' market, emerging markets, informed trading, trading systems.

## INTRODUCTION

A significant number of studies deal with the issue of insider or informed trading on developed and emerging markets. Starting with the seminal work of Kyle (1985), various models were developed for insider or informed trading and many empirical studies attempted to estimate the severity of this problem. Insider trading can be described as a situation where the investor is trading based on private information that is available only to a restricted number of people. Although insider trading is illegal in many countries, the boundary between insider trading and informed trading is not as obvious as it may look.[1]

To measure the probability of information-driven trading (PIN) Easley et al. (1996) developed a model commonly used in the literature to estimate PIN that is based on the imbalance of buy and sell order flows. Note that PIN is not exclusively an insider trading measure as it also captures informed trading by investors who are particularly skillful in analyzing public news (See Vega 2006, among others). Overall, the extent of information-driven trading considerably affects the credibility of a given financial market as it also increases the cost of acquiring information on the appropriate timing of a trade.

Informed traders are often trying to hide their information and react dynamically to the behavior of other market participants, naturally preferring a trading environment with a high degree of anonymity (see Barclay et al. 2003, Anand et al. 2005, Boehmer 2005, Lee and Yi 2001, and Brunnermeier and Pederssen 2005, among others). Hence, an electronic dealers market is an ideal platform for executing informed trades (see also Sherwood, 1997). Obviously informed trades are not negligible in size and therefore are conducted via a market maker (MM). Such a practice may lead to a situation where one or several of the MMs are informed. In other words the MMs and large investors are often somehow sharing private information and therefore the MMs may become a significant source of information-driven trading on small emerging markets.[2]

[1] While there is a broad consensus that trading on the knowledge of, for example, company profits or disclosures is considered insider trading, there is not a similar consensus for trading connected with the execution of large orders or the dual trading practices of some brokers or market makers.

[2] For example there are publicly known cases of the government of the Czech Republic selling shares of the energy company CEZ or CEZ buying its own shares through market makers.

To the best of our knowledge, our study is the first to analyze the extent of the information-driven trading of MMs. We developed a methodology based on the Easley et al (1996) model to be able to detect the suspicious trading behavior of particular MMs on the Prague Stock Exchange (PSE). By an innovative combination of PIN measurement and a jackknife approach we leave out the trades of one particular MM at a time from the sum of all buys and sells. We then test the hypothesis that due to private information about a large block order the MM behaved significantly different from the other MMs, using the estimates from the jackknife approach. Finding significant differences in the behavior of Czech MMs we conclude that contrary to previous studies the MMs may not only screen out the large informed traders but on less regulated emerging markets they greatly affect the extent of information-driven trading by sharing private information with key large customers. Therefore, our methodology could significantly contribute to the detection mechanisms of regulatory authorities on emerging markets in order to identify the suspicious behavior of particular market participants.

## LITERATURE REVIEW

The literature on information-driven trading and the behavior of dealers or MMs can be viewed from several perspectives. The first stream of literature deals with the problem of whether dual traders are informed or not. Most of the theoretical studies start with the assumption that dual traders are informed traders and then investigate the effect of their trading strategies (see Roell, 1990 and Sarkar, 1995, among others). Empirically the issue is not very clear, for example Fishman and Longstaff (1992) viewed dual trading brokers at the Chicago Board of Trade as informed, while Chakravarty and Li (2003), when controlling for the overall trading profit, suggest that dual traders are uninformed.[3]

[3] The difference between these studies could be associated with the different level of regulation; the earlier study is based on data over a period just before the FBI launched a federal investigation into fraudulent trading practices on the Chicago future exchanges.

The second stream of literature focuses rather on the overall information advantage of MMs, dealers or brokers than on a particular behavior like dual trading. It is well known that MMs significantly facilitate price discovery compared to a pure auction with only public orders and that their informational advantage comes primarily from the obtained order flow (e.g. Madhavan and Panchapagesan, 2000 and Kurov and Lasser, 2004). Typically, the specialists are able to generate short-term trade profits, mostly as a consequence of the bid-ask spread. Further, although the specialists are capable of rapidly adjusting their positions they usually opt for adjustment lags of days or weeks (see Hasbrouck and Sofianos, 1993).

Nevertheless, the dealers or MMs may gain advantage over the other participants on the market not only from the order flow but also from other privileges. Focusing on the pure limit order market Wang and Chae (2003) found a strong positive correlation between dealers' weekly trades and weekly returns, mainly for large dealers. Their results imply that the large dealers on the Taiwan Stock Exchange act as informed traders rather than liquidity suppliers. However, only brokers on the market are able to view the order flow of their customers. Therefore, the informational advantage of the dealers on the market originates probably from a privileged position of direct access to the electronic exchange without any trading fees or trading delays.

So far, the literature suggests that the MMs or dealers may anticipate private information from the order flow. Nevertheless, studies analyzing trader behavior suggest that the profit-maximizing informed trader will protect his information using a stealth trading practice. Barclay and Warner (1993) were the first to propose the stealth trading hypothesis, that informed traders split their orders and use medium-sized trades to avoid detection. Due to the lack of anonymity on the market for large orders, Barclay and Warner reason that informed traders may achieve a more favorable price by breaking up their large orders into multiple medium-sized trades and therefore they expect that most of the stock's cumulative price change should take place on medium-size trades.[4] Therefore, on markets with MMs and due to the ability of MMs to identify large informed orders, medium-sized orders are the most informed. On the other hand, Charoenwong and Jenwittayaroje (2007) showed that in a pure limit order market (the

[4] For more recent results see Anand and Chakravarty, 2007 and Anand et al., 2005, among others.

Stock Exchange of Thailand) informed traders use larger trades compared to dealership markets.

Comparisons of trades on NYSE and NASDAQ suggest that NYSE, as a less anonymous market, has a lower extent of informed trading (Garfinkel and Nimalendran, 2003). Moreover, the change in listing from a dealership to an auction market (NASDAQ to NYSE or AMEX) leads to a significant decrease in the extent of information-driven trading. Therefore, either specialists on the NYSE have a better ability to identify informed traders or the informed investors prefer to trade on a market with a higher degree of anonymity (Heidl and Huang, 2002). Similar results were confirmed by Grammig et al. (2001) from the Frankfurt Stock Exchange via a comparison of non-anonymous floor trading versus anonymous electronic trading systems (IBIS and later XETRA), showing that informed traders prefer to execute their orders in the anonymous environment.

All of the above-mentioned studies assume that the MMs are either using the information from the order flow to act against their customers or screening out informed traders. In addition, the results of Hanousek and Podpiera (2002, 2004) support the hypothesis that MMs in an emerging market (the PSE) may share private information with their key large customers. Furthermore, Hanousek and Podpiera (2004) present more intriguing results—despite many improvements in regulation and increased trading volume the extent of information-driven trading was nearly the same for the years 1999 and 2002. They particularly point out that the extent of informed trading was about the same for shares of Ceska sporitelna and Erste bank.[5] Let us note that these stocks have little in common except having the same set of MMs, therefore, one could ask to what extent the MMs on the PSE affect the probability of informed trading.

The studies reviewed above suggest that informed traders' behavior differs according to market microstructure and also that MMs are important participants on the market who are able to recognize informed traders. Several studies demonstrate the ability of the MMs to identify informed traders and the effect this has on the probability of information-driven trading. They conclude that a higher degree of anonymity is

[5] In 2000, Ceska sporitelna (a major Czech bank) was privatized to the Austrian Erste Bank. Erste Bank, already listed in Vienna, started dual listing on the PSE in October 2002.

associated with a higher probability of information-driven trading, and that informed and insider trading is a widespread practice in emerging financial markets.

## METHODOLOGY

### THE EASLEY ET AL. (1996) MODEL

Our model is based on a well known framework developed by Easley et al. (1996). Let us first shortly review their model and then introduce our extension. There exist three types of agents on the market: uninformed (noisy) traders, informed traders and MMs. Trading is divided into *n* separate trading days. See Figure 1 for a tree diagram of a trading day.

**INSERT FIGURE 1 ABOUT HERE**

Before each day an information event may occur. An information event is defined as the occurrence of a signal *s* about the value of the asset. The probability that a signal occurs is $\alpha$, and if a signal occurs, it takes on two possible values: low with probability $\delta$ and high with probability $1-\delta$.[6] If a signal occurs, some fraction of the traders receive the signal. If no signal occurs, all traders stay uninformed.

Using the scheme of Figure 1 we can express the probability of observing a given number of buys and sells as

$$\begin{aligned} L((B,S)\,|\,\theta) = {} & (1-\alpha) * e^{-\varepsilon T}\frac{(\varepsilon T)^B}{B!}e^{-\varepsilon T}\frac{(\varepsilon T)^S}{S!} && (\textit{no event day}) \\ & + \alpha\delta * e^{-\varepsilon T}\frac{(\varepsilon T)^B}{B!}e^{-(\mu+\varepsilon)T}\frac{((\mu+\varepsilon)T)^S}{S!} && (\textit{bad news}) \\ & + \alpha(1-\delta) * e^{-(\mu+\varepsilon)T}\frac{((\mu+\varepsilon)T)^B}{B!}e^{-\varepsilon T}\frac{(\varepsilon T)^S}{S!} && (\textit{good news}) \end{aligned}, \quad (1)$$

where *S* is the number of sells and *B* the number of buys. The first part of the expression (1) denotes a no event day, the second part a bad event day and the third part a good event day. According to the assumptions of the model the days are independent and

[6] In the case of a bad signal the value of the asset is $\underline{V}$, for a good signal $\overline{V}$ and for no signal unchanged.

therefore the probability of observing a series of days with a given sum of buys and sells for each day is a product of the probability for the individual days.

$$L(B_1, S_1, \text{K}\ , B_I, S_I \,|\, \theta) = \prod_{i=1}^{I} L((B_i, S_i) | \theta)\,. \tag{2}$$

The parameter $\theta = (\alpha, \delta, \varepsilon, \mu)$ is then estimated using the maximum likelihood method. The probability of information-driven trading is the chance that a MM will trade with the informed trader and therefore can be computed as a ratio of the arrival rate of informed traders and the arrival rate of all traders:

$$PIN = \frac{\alpha\mu}{\alpha\mu + 2\varepsilon}\,. \tag{3}$$

This is actually a conditional probability of an information-driven trade given the occurrence of a trade at the beginning of a trading day. Therefore the numerator is the product of the probability of an information event times the arrival rate of informed traders. The denominator is then the probability of the occurrence of a trade, which is the probability of an incoming informed trader plus the probability of an incoming uninformed buyer and seller.

#### LARGE BLOCK TRADES AND INFORMED MMS

As an extension of the original model let us assume two types of MMs : informed and uninformed. So far we have not considered a dealers' market with informed MMs or the effect of large orders on the market. Suppose that there is other information affecting the price of an asset: information about a large order that is independent of the above private signal of informed investors and that lasts for several trading days. Only one informed MM has private information about this large order coming on the market from one of his clients. The large order consists of a random volume of shares and a random length K of trading days that can be the number of trading days till the deadline when the client would like to have the trade processed.[7] The uninformed MMs do not know about the large order or the occurrence of the signal and therefore post prices for selling

[7] Even though block trades must be reported in 5 minutes in the open session and in 60 minutes in the closed session the behavior of MMs suggests that they are either aware of the block trade in advance or set the block trade *ex-post*.

and buying. The informed MM on the other hand will trade actively only on the buy side or the sell side, according to his private information.

Similarly to the existing literature, we expect that large orders are usually broken into medium-size trades. Such an implementation of a trade order has a higher chance to minimize the impact on the stock price; practically it means that a MM trades against his account and once he secures the deal (accumulates or sells shares) then a block trade with his client closes the trade. In other words, the MM has an incentive to act strategically in that he is trying to choose the optimal timing of several trades to process the whole big order at the best possible price.[8]

We assume that there is only one informed MM in a given time period. If more than one MM receives the large order and if the MMs do not act in consonance with each other, the order will be revealed to the whole market and the new value of the asset will be revealed immediately by the competitive behavior of two or more informed MMs.[9]

If the MM is informed, we assume that he does not set quotes in a way that will immediately reveal his information about the order. Therefore, in the case of a large buy order the informed MM will just try to have the best quote[10]—he would post his quotes for buys more actively and therefore will end up with the best quote with a higher probability than the uninformed MM. Although the other MMs may anticipate that the MM is informed, they will still be unaware of the size and limit price of the large order. Therefore, even though they will know that some new information exists, the price will not reach the new value of the asset immediately as the other MMs will not post better quotes than the informed MM, facing the risk that they are above or under the new price.

Similarly, in the case of a large sell order the informed MMs will post their quotes such that they would avoid ending up with the best quote on the buy side. Another point of view is that the MMs without outside information about the large order

[8] However, we do not expect that he is necessarily trying to manipulate the price or abusing the market illegally.
[9] Given the trading environment (dealers' market) we expect a relatively low number of market makers, therefore, due to the competition of two or more informed market makers we expect that the information about the large order will be revealed quite quickly.
[10] The pair of the best buy and best sell quotes from all the market maker's quotes.

will try to avoid risky unbalanced positions and therefore will post quotes such that they would finish with somewhat balanced inventories. On the other hand, the informed MMs contingent on their information may venture more risky positions from the point of view of uninformed MMs and therefore may afford to actively quote only buys or sells. The uninformed MMs generate profit from the trading fees and spread, however, the informed MM generates profit also from proprietary trading. Therefore they will likely end up with an unbalanced number of buys and sells after a trading day or series of trading days.

To estimate the extent of information-driven trading due to large orders or, in other words, due to informed MMs, we at first run the estimations for the whole sum of buys and sells. Further, to estimate the PIN originating from large orders or other private information the MMs have we propose a procedure to estimate PIN with and without the trades of informed MMs. Therefore, we will step by step exclude each MM's trades from the sum of buys and sells and estimate the model. Having all the parameters $\theta_i = (\alpha_i, \delta_i, \varepsilon_i, \mu_i)$ estimated for each MM we will then test whether PIN using the estimated parameters $\theta = (\alpha, \delta, \varepsilon, \mu)$ and PIN without considering the trades of given MM are significantly different.

Both estimators of PIN have asymptotically normal distributions and the estimators are positively correlated. Therefore using the test of the equality of the mean of two normal distributions and neglecting the correlation will imply an even more significant difference than the p-value suggests. Having identified the informed MMs we can estimate the effect of the large orders on the probability of information-driven trading:

$$PIMM(t) = \left| \frac{\alpha\mu}{\alpha\mu + 2\varepsilon} - \frac{\alpha_i\mu_i}{\alpha_i\mu_i + 2\varepsilon_i} \right| \quad , \tag{4}$$

where $\theta = (\alpha, \delta, \varepsilon, \mu)$ are estimated parameters $\theta = (\alpha, \delta, \varepsilon, \mu)$ from the classic Easley et al. (1996) model using the sum of all buys and sells for each day and $\theta_i = (\alpha_i, \delta_i, \varepsilon_i, \mu_i)$ are the estimated parameters using the sum of all buys and sells for each day without the

trades of a given identified informed MM. The extent of information-driven trading coming from the behavior of an informed MM is therefore the difference between the probability of informed trading with and without the trades of the informed MM.

## DATA

For our analysis, we use intra-day data from the Prague Stock Exchange (PSE) SPAD trading system for all stocks traded from 1 January 2003 till 30 September 2006, publicly available online.[11] SPAD was founded in 1998 to increase the liquidity of the market. The trading system is designed as a dealer market with at least three MMs for each stock, who are required to quote ask and bid prices for a standardized number of shares with a limited maximum possible spread for each stock. If a given quote is the best available on the market the particular MM is obliged to trade on the posted quote for a buy or sell.

Each trading day is divided into two phases, open and closed. The actual trading occurs during the open phase of the system, from 9:30 a.m. to 4:00 p.m. each trading day. We use data on all SPAD trades during the sample time period. Each trade record in our database consists of security identification, date, time, type of trade, price, and for the standard SPAD trades also the identification of the MM who traded it. We are also able to identify cross trades, trades conducted between the inventory of the MM and the MM's client. The key feature of our dataset is that we are able to identify not only whether the given trade was buyer- or seller-initiated but also which MM was on which side of the trade.

The sample period consists of 945 trading days and we focus on all ten companies traded during the period (see Table 1 for descriptive statistics of market capitalization and traded volumes).[12] We have eleven MMs in our sample period—six

[11] Available at www.akcie.cz. The last access for this paper was on 30 June 2007.

[12] Let us note that only six of them were traded during the whole period: two banks (Erste Bank and Komercni banka), a petrochemical company (Unipetrol), an electricity utility (CEZ), a telecommunications company (Telefonica O2) and a cigarette producer (Philip Morris). Another telecommunications company (Ceske Radiokomunikace) was removed from the market in September 2004. One IPO, Zentiva, was introduced to the market in June 2004. In February 2005 a construction company (ORCO), already listed in Paris, started dual listing on PSE and in June 2005 a media company (CME), already traded on NASDAQ for over 10 years, started dual trading on PSE.

brokerage firms and five banks.[13] The MMs also differ in their specialization in different types of customer—retail vs. large institutional investors.

**INSERT TABLE 1 ABOUT HERE**

As we can see from

[13] The brokerage firms are ATLANTIK finanční trhy, a.s., BH Securities a.s., CA IB Securities, a.s., Fio, burzovní společnost, a.s., Patria Finance, a.s. and WOOD & Company Financial Services, a.s.; the banks are Česká spořitelna, a.s., HVB Bank Czech Republic a.s., Raiffeisenbank a.s., ING Bank N.V. and Komerční banka, a.s.

Table **2**, none of the eleven MMs on SPAD had a significantly higher market share in any of the analyzed stocks. The maximum market share reached about 25 percent for one MM and each traded stock had at least six MMs with a more or less comparable market share.

**INSERT TABLE 2 ABOUT HERE**

The average number of trades during a day differs significantly among the stocks during the sample period. However, the average for each stock was moderately increasing and did not change significantly for most of the analyzed time periods. Newly introduced stocks attracted the attention of investors quickly and the activity of these new blue chips on the PSE was almost immediately comparable to the already established stocks. Also, according to the average number of trades, two important events changed the trading of the two new blue chips ORCO and CME.[14]

Our model assumes a significant role of block trades as a source of the information of some MMs and the data seem to comply with this assumption. Block trades are defined by a limit set by the PSE and this limit is considerably larger than the market capitalization of the trading lots in SPAD. According to current regulations every block trade has to be registered within 5 minutes during the open phase (9:15 a.m. to 4:00 p.m.) and within 60 minutes during the closed phase.

**INSERT TABLE 3 ABOUT HERE**

[14] On 30 November 2005 Morgan Stanley included CME in its MSCI index resulting in the increased attention of mainly foreign investors. Similarly, on 4 January 2006 Citigroup analysts significantly increased the target price for ORCO, interesting a large amount of investors.

Table **3** clearly shows that a significant percentage of the volume traded on SPAD was done using block trades. Let us note a significant decrease in the percentage of block trades in 2006, probably caused by the increased regulation of MMs.[15] One can speculate that according to the high percentage in 2003 to 2005 the MMs (MMs) who were focused on large customers also used standard SPAD trades to be able to gather stocks in order to execute block trades. Such MMs are actually informed traders and thus the block trades may have been an indication of private information on PSE.

**INSERT TABLE 4 ABOUT HERE**

SPAD was introduced to increase the liquidity on the PSE. However, due to the size of the trading lots only medium and large investors could trade in the system. As Table 4 demonstrates, the trading lots have varied quite a lot as during the sample period the prices of some stocks were growing significantly. For example, the smallest trading lot (ORCO) started at 0.6 million CZK, while the largest lot was 5.5 million (CEZ).[16] The effect of changing the lot size can significantly affect the extent of information-driven trading as according to the Easley et al. (1996) model the informed traders are more likely to trade larger volumes. Therefore, regarding the significant increase of retail investors in the Czech Republic, lowering the lot size may attract more uninformed investors as on SPAD the fees are significantly lower compared to the other trading channels.

## RESULTS

Trading at the PSE *per se*, the structure of potential investors as well as the behavior of MMs follow specific and significantly different patterns during the morning and afternoon sessions, therefore, we decided to estimate the extent of information-driven trading for both sessions separately. Basically, new information comes to the Czech capital market before the morning session and then again in the afternoon when there is

[15] Since early 2006, all MMs and brokers are obligated to strictly report their activities to the regulation authority, including their dealings book.
[16] Using the average exchange rate to USD over the period studied (~23.7CZK=$1), the lot size varies from 25,000 to 232,000 USD.

news from U.S. capital markets. Note that only a negligible fraction of trades takes place between 12:00 p.m. and 2:00 p.m. and even these are mainly automatic. Therefore, we decided to divide each day into two main parts, the morning session from 9:30 a.m. to 12:00 p.m. and the afternoon session from 2:00 p.m. to 4:00 p.m.

For (automatic) identification purposes we first run a rolling window of 90 trading days through our sample period and for each window estimate the extent of information-driven trading. We believe that the 90-trading day window is an optimal balance between the assumption of stationarity of the underlying Poisson process and length, which effects the precision of estimates.[17] Second, based on the results we focus on particular stocks for which the rolling window analysis suggested significantly different behavior of particular MMs.

**INSERT TABLE 5 ABOUT HERE**

[17] We have run the estimation also for shorter rolling windows, nevertheless our results suggest that that the 90-day rolling window still satisfies the assumptions of the model as the results are similar for the shorter rolling windows. Detailed results are available upon request.

Table **5** presents the results of tests for the time periods and stocks identified in the automatic identification phase described above. Overall, our results suggest that during our sample period there were several MMs who behaved significantly different from the rest of the group.[18] Nevertheless, rejecting the null hypothesis of the equality of the estimates means that the MM has a considerable imbalance between his mandatory sells and buys and his behavior differs from the behavior of other MMs during the particular time period.

The second column of Table 5 shows the identified time period for the particular stock. To demonstrate the practical use of the method all identification and estimation was done using a 90-day trading window. It is striking that all of the identified periods coincide with significant events or news related to the particular stock. First we discuss the results for Ceske Radiokomunikace (CRA) which was removed from the market in September 2004, although the decision on removal had to be made in 2003. Therefore, our results that MM4 behaved significantly different from other MMs in the second half of 2003 may suggest that he cooperated with some large informed customer who had better information about the buyout of CRA.

**INSERT FIGURE 2 ABOUT HERE**

Similarly, results for Telefonica O2 resonate with its privatization, especially indicating that some investors may have been aware of the privatization results and traded on this information ahead of time (See Figure 2 for graphical summary of the test, MM7, afternoon). The results for CEZ, Komercni banka and Phillip Morris confirm the perception that the high percentage of block trades (around 30%) or large orders may have a significant impact on the behavior of some MMs. Our results suggest that even though market participants might be aware of the different behavior of several MMs, they are not able to compete with them due to the superior information coming for example from detailed information about large orders.

[18] We should point out that the difference does not imply that the market maker is an insider as he may be just processing a large trade order or using dual trading, which is not illegal in the Czech Republic.

Let us note that our trade data consists of precise information on whether the trade is a mandatory buy or mandatory sell, contrary to most of the existing studies.[19] Boehmer et al. (2007) point out that using only the estimation whether the trade is buyer- or seller-initiated leads to downward-biased PIN estimates and that the magnitude of the bias is related to the security's trading intensity. This may partly explain the difference in our results compared to the results of Hanousek and Podpiera (2004), as they were using data for the whole day and were estimating whether the trade was buyer- or seller-initiated using Lee and Ready (1991)'s methodology. Hanousek and Podpiera (2004) concluded that through the years 1999–2002 they did not see any improvements in the extent of information-driven trading. Nevertheless, our results suggest that all the blue chips experienced a significant decrease in the PIN during the years 2003–2006. Dividing the trading day into morning and afternoon sessions, however, reflects more properly the specific characteristics of a small emerging market. Further, possibly due to the strengthening of the regulation of the MMs by introducing the requirement to regularly report detailed information about their activities, the extent of information-driven trading decreased significantly during our sample period.

Finally we focused on the effect of changes in the trading lot size on trading behavior and on PIN. As we already mentioned, changing the lot size may affect the extent of information-driven trading as the informed traders are more likely to trade larger volumes. Smaller lot volumes may attract more uninformed investors. The estimation and test results are summarized in

[19] If the quote is the best available on the market and if some investor reacts to it, the market maker is obliged to execute the trade.

Table **6**.

**INSERT TABLE 6 ABOUT HERE**

As we can see, most of the changes in the lot volume significantly affected the extent of information-driven trading as lot breakups would attract more retail and therefore uninformed investors. Changing the lot size for Unipetrol, as we can see from Table 6, attracted many new investors, however, because the PIN changed significantly only in the morning session, one can assume that they were only from Europe or the Czech Republic (most likely they were Czech retail investors).

## CONCLUSION

In this paper we analyze the behavior of MMs and the ability to maintain private information about large orders. We propose an automatic procedure to detect and test specific positions of particular MMs in an electronic dealers market. Trading data with one side of mandatory buy/sell trade orders identified are used to demonstrate our method.

We found significant differences in behavior among MMs on the Prague Stock Exchange, supporting the previous perception that they play a dominant role in affecting the price for a short time interval as well as for a longer period. Although the other participants of the market may be aware that some of the MMs may possess private information about the value of the asset they are not able to reveal the full information. Further, our analysis confirms that important changes like decreasing the volume of the trading lot may affect (decrease) the extent of information-driven trading.

Despite the fact that our results suggest that MMs have a strong position on PSE the optimal policy from the regulatory point of view is not so straightforward. MMs should be somehow protected to be able to maintain private information about their block orders and be able to face the threat of predatory trading and increased volatility during such trades. Nevertheless, the current practice of MMs threatens minority and uninformed investors because prices can then no longer fully reflect all the relevant

information. This observation leads to the conclusion that the further regulation may be beneficial.

Given that this study uses an automatic procedure, has only modest assumptions, and includes a model that is relatively easy to use, we believe that the methodology in this paper could be used by regulatory authorities on emerging markets in identifying the suspicious behavior of particular market participants.

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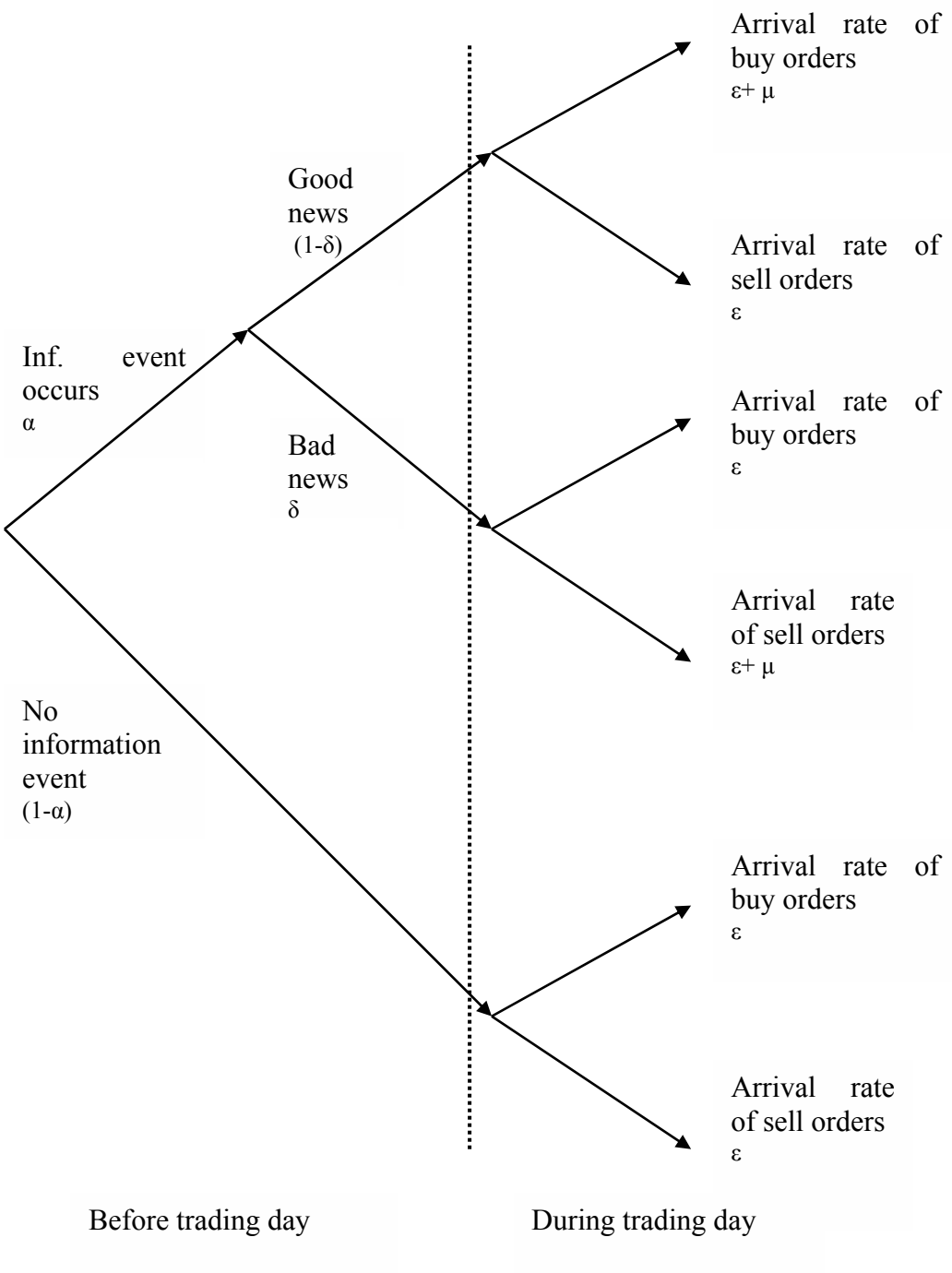
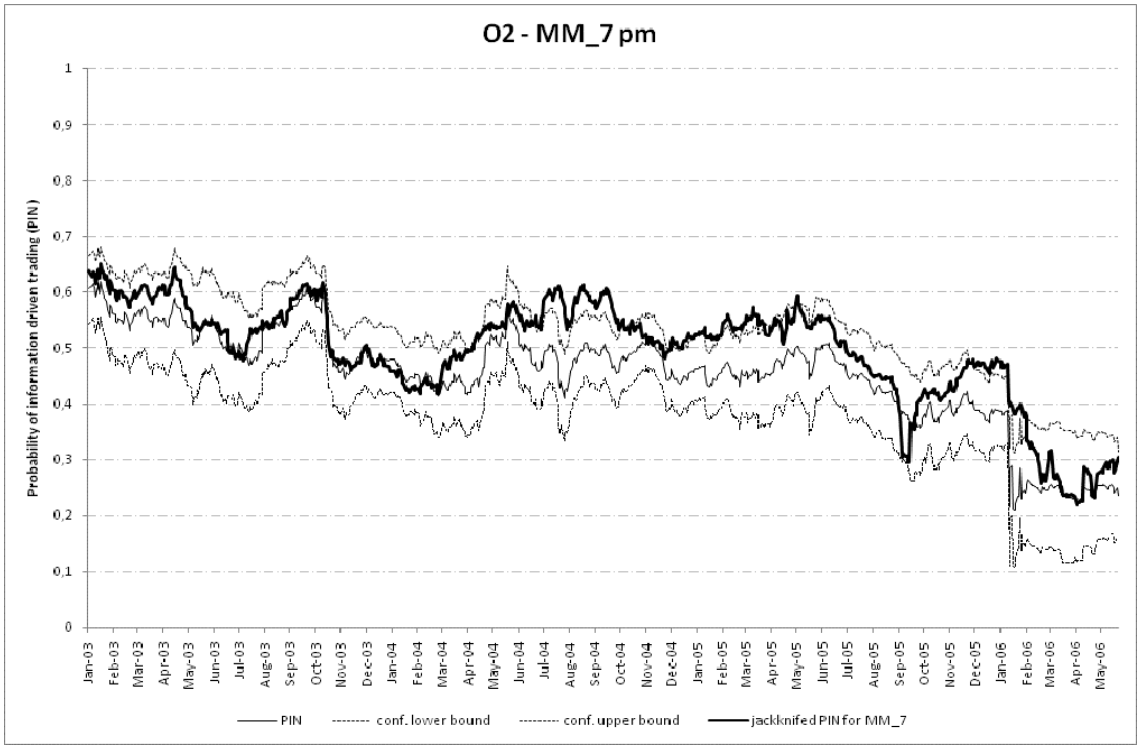
Figure 1: Trading tree diagram




Note: this diagram depicts the structure of arriving buy and sell orders during a trading day, where α is the probability of the information event occurring, δ is the probability of bad news, μ is the arrival rate of informed traders and ε is the arrival rate of uninformed traders.

Figure 2: Results for Telefonica O2, afternoon trading




Note: This figure represents a graphical version of the test; suspicious behavior is identified when results for particular MMs (thick line) exceed the limits of the confidence interval.

Table 1: Market capitalization and overall traded volumes

| Stock | year | Mkt. cap. | Turnover | SPAD trades | Sys. trades | APD | B/S | price | price chng. | MM |
|---|---|---|---|---|---|---|---|---|---|---|
| **CME** | 2005 | 43 | 14% | 0.81 | 0.56 | 18.3 | 1.3 | 1,409 | 18% | 6 |
| | 2006 | 50 | 50% | 0.95 | 0.62* | 41.4 | 1.0 | 1,462 | 4% | 6 |
| **CEZ** | 2003 | 86 | 51% | 0.64 | 0.31 | 18.4 | 1.1 | 146 | 58% | 10 |
| | 2004 | 202 | 54% | 0.73 | 0.42 | 42.0 | 1.3 | 341 | 134% | 9 |
| | 2005 | 436 | 69% | 0.68 | 0.45 | 124.5 | 1.0 | 736 | 116% | 10 |
| | 2006 | 569 | 61% | 0.91 | 0.50* | 161.8 | 0.9 | 960 | 30% | 9 |
| **CRA** | 2003 | 11 | 45% | 0.72 | 0.25 | 5.3 | 2.0 | 345 | 83% | 8 |
| | 2004 | 14 | 67% | 0.61 | 0.29 | 9.8 | 1.1 | 444 | 29% | 8 |
| **EB** | 2003 | 191 | 7% | 0.78 | 0.61 | 17.4 | 1.2 | 798 | 59% | 6 |
| | 2004 | 287 | 11% | 0.85 | 0.63 | 31.6 | 1.2 | 1,187 | 49% | 6 |
| | 2005 | 334 | 14% | 0.83 | 0.63 | 43.5 | 1.0 | 1,372 | 16% | 8 |
| | 2006 | 505 | 12% | 0.93 | 0.63* | 48.4 | 1.0 | 1,601 | 17% | 9 |
| **KB** | 2003 | 92 | 110% | 0.65 | 0.4 | 38.0 | 1.0 | 2,418 | 16% | 9 |
| | 2004 | 124 | 120% | 0.6 | 0.34 | 61.1 | 1.0 | 3,272 | 35% | 9 |
| | 2005 | 131 | 158% | 0.64 | 0.43 | 95.1 | 0.9 | 3,441 | 5% | 10 |
| | 2006 | 118 | 90% | 0.92 | 0.57* | 70.2 | 0.9 | 3,099 | -10% | 8 |
| **O2** | 2003 | 94 | 69% | 0.49 | 0.17 | 22.5 | 1.2 | 291 | 19% | 10 |
| | 2004 | 119 | 102% | 0.52 | 0.16 | 35.9 | 1.2 | 369 | 27% | 9 |
| | 2005 | 169 | 171% | 0.44 | 0.14 | 43.0 | 1.0 | 525 | 42% | 10 |
| | 2006 | 153 | 64% | 0.91 | 0.44* | 56.6 | 0.8 | 476 | -9% | 10 |
| **ORCO** | 2005 | na | na | 0.78 | 0.61 | 18.8 | 1.1 | 1,809 | 41% | 6 |
| | 2006 | 22 | 125% | 0.95 | 0.72* | 62.1 | 1.1 | 2,755 | 52% | 6 |
| **PM** | 2003 | 30 | 64% | 0.67 | 0.38 | 9.1 | 1.2 | 15,728 | 41% | 9 |
| | 2004 | 32 | 91% | 0.72 | 0.41 | 22.2 | 1.1 | 16,776 | 7% | 8 |
| | 2005 | 35 | 101% | 0.68 | 0.43 | 28.2 | 1.2 | 18,251 | 9% | 8 |
| | 2006 | 21 | 89% | 0.9 | 0.49* | 24.9 | 0.9 | 10,840 | -41% | 7 |
| **UNI** | 2003 | 12 | 72% | 0.6 | 0.34 | 8.2 | 1.3 | 66 | 92% | 8 |
| | 2004 | 18 | 79% | 0.68 | 0.35 | 9.5 | 1.0 | 98 | 48% | 8 |
| | 2005 | 42 | 122% | 0.78 | 0.54 | 45.1 | 1.0 | 233 | 137% | 8 |
| | 2006 | 42 | 114% | 0.9 | 0.59* | 46.1 | 0.9 | 234 | 1% | 6 |
| **ZEN** | 2004 | 29 | 59% | 0.65 | 0.3 | 17.0 | 1.1 | 758 | 50% | 8 |
| | 2005 | 43 | 232% | 0.61 | 0.38 | 48.5 | 1.0 | 1,136 | 50% | 8 |
| | 2006 | 48 | 222% | 0.92 | 0.60* | 75.5 | 1.0 | 1,268 | 12% | 9 |

Mkt. cap. – market capitalization in millions of CZK; Turnover – turnover ratio; SPAD trades – ratio of the SPAD traded volume on overall traded volume; Sys. Trades – ratio of system trades (usually classic trades with the identification of the market maker) to the overall traded volume; APD – average number of trades during a trading day; B/S – buy over sells ratio; price – price at the beginning of the year; price chng. – percentage change of price during the last year; MM – number of MM.; * computed using information about trades just from the first half of 2006. Source: PSE fact books, www.akcie.cz and authors' computations.

**Table 2: Market share of market makers on the PSE during the sample period**

| Stock | CME | CEZ | CRA | EB | KB | O2 | ORCO | PM | UNI | ZEN |
|---|---|---|---|---|---|---|---|---|---|---|
| MM 1 | **21%** | **15%** | **12%** | **17%** | **16%** | **13%** | **20%** | **15%** | **21%** | **16%** |
| | 1870 | 9648 | 297 | 4629 | 8327 | 4455 | 2617 | 2505 | 4190 | 3718 |
| MM 2 | **15%** | **9%** | **8%** | **6%** | **1%** | **6%** | | **11%** | **9%** | **11%** |
| | 1356 | 6059 | 199 | 1725 | 571 | 1961 | | 1732 | 1870 | 2511 |
| MM 3 | | **0%** | **2%** | | **1%** | **1%** | | **0%** | **0%** | |
| | | 165 | 46 | | 320 | 305 | | 79 | 97 | |
| MM 4 | **16%** | **12%** | **14%** | **14%** | **13%** | **12%** | **15%** | **13%** | **15%** | **13%** |
| | 1443 | 7461 | 355 | 3820 | 6449 | 4070 | 2007 | 2147 | 3089 | 2922 |
| MM 5 | **15%** | **10%** | **14%** | **12%** | **12%** | **9%** | **16%** | **14%** | **18%** | **9%** |
| | 1395 | 6476 | 348 | 3313 | 6103 | 3075 | 2108 | 2244 | 3591 | 2079 |
| MM 6 | | **9%** | **7%** | **5%** | **10%** | **8%** | | **11%** | **2%** | **10%** |
| | | 5973 | 169 | 1277 | 4906 | 2669 | | 1713 | 317 | 2322 |
| MM 7 | **18%** | **15%** | **16%** | **14%** | **14%** | **26%** | **17%** | **16%** | **18%** | **15%** |
| | 1612 | 9589 | 423 | 3725 | 7327 | 8721 | 2178 | 2547 | 3597 | 3419 |
| MM 8 | | **1%** | | | **1%** | **2%** | | | | |
| | | 703 | | | 680 | 622 | | | | |
| MM 9 | | **9%** | **10%** | **12%** | **11%** | **7%** | **15%** | **6%** | **4%** | **11%** |
| | | 5639 | 258 | 3305 | 5478 | 2323 | 1985 | 969 | 806 | 2511 |
| MM 10 | | **6%** | | **1%** | **7%** | **3%** | | | | **3%** |
| | | 4167 | | 302 | 3791 | 1026 | | | | 636 |
| MM 11 | **16%** | **13%** | **18%** | **17%** | **14%** | **14%** | **17%** | **15%** | **14%** | **14%** |
| | 1414 | 8276 | 475 | 4469 | 7050 | 4880 | 2299 | 2379 | 2739 | 3189 |

Note: each row consists of the percentage and number of trades of a given market maker during the sample period 1 January 2003 to 30 September 2006.

Table 3: SPAD traded volume and percentage of block trades

| Stock | Year | Volume 000,000 CZK | Block trades | SPAD with ID | SPAD no ID | SPAD ID no cross |
|---|---|---|---|---|---|---|
| CME | 2005 | 5.9 | **17%** | 55% | 26% | **52%** |
| CME | 2006 | 19.3 | **4%** | 64% | 28% | **60%** |
| CRA | 03-04 | 14.2 | **32%** | 25% | 41% | **23%** |
| CEZ | 03-05 | 445.6 | **30%** | 42% | 27% | **40%** |
| CEZ | 2006 | 262.0 | **7%** | 49% | 39% | **46%** |
| EB | 03-05 | 91.4 | **16%** | 62% | 20% | **59%** |
| EB | 2006 | 39.0 | **6%** | 65% | 28% | **62%** |
| KB | 03-05 | 448.6 | **37%** | 39% | 24% | **36%** |
| KB | 2006 | 80.9 | **7%** | 58% | 30% | **55%** |
| ORCO | 2005 | 5.6 | **20%** | 60% | 19% | **56%** |
| ORCO | 2006 | 20.9 | **5%** | 75% | 18% | **70%** |
| PM | 03-05 | 82.7 | **30%** | 39% | 30% | **36%** |
| PM | 2006 | 15.7 | **8%** | 46% | 41% | **43%** |
| O2 | 03-05 | 472.4 | **53%** | 14% | 32% | **13%** |
| O2 | 2006 | 75.8 | **15%** | 40% | 40% | **37%** |
| UNI | 03-05 | 70.9 | **22%** | 45% | 31% | **41%** |
| UNI | 2006 | 38.5 | **6%** | 58% | 34% | **52%** |
| ZEN | 03-05 | 119.9 | **39%** | 35% | 25% | **33%** |
| ZEN | 2006 | 84.4 | **6%** | 61% | 30% | **58%** |

Volume – traded volume on SPAD; Block trades – percentage of the SPAD volume; SPAD with ID (no ID) – percentage of SPAD traded volume with (without) the identification of the market maker; SPAD ID no cross – percentage of SPAD traded volume analyzed in our study (standard SPAD trades through the market maker). Source: www.akcie.cz and authors' computations.

Table 4: Changes in the trading lot size

| Stock | Time period | LOT size | Price (CZK) | | Volume (000,000) CZK | |
|---|---|---|---|---|---|---|
| | | | First | Last | First | Last |
| **CME** | Jun -Sep 05 | **1,000** | 1,194 | 1,516 | 1.2 | 1.5 |
| **CRA** | Jan 03-April 04 | **3,000** | 188 | 450 | 0.6 | 1.4 |
| **CEZ** | Jan 03-Oct 04 | **20,000** | 92 | 265 | 1.8 | 5.3 |
| **CEZ** | Oct 04-Aug 05 | **10,000** | 259 | 549 | 2.6 | 5.5 |
| **CEZ** | Aug 05-Sept 06 | **5,000** | 554 | 791 | 2.8 | 4.0 |
| **EB** | Jan 03-Sep 03 | **500** | 2,022 | 2,805 | 1.0 | 1.4 |
| **EB** | Sep 03-Mar 04 | **1,000** | 2,757 | 3,793 | 2.8 | 3.8 |
| **EB** | Mar 04-Jul 04 | **500** | 3,761 | 4,189 | 1.9 | 2.1 |
| **EB** | Jul 04-Sep 06 | **2,000** | 1,041 | 1,405 | 2.1 | 2.8 |
| **KB** | Jan 03-Sep 03 | **2,000** | 2,118 | 2,485 | 4.2 | 5.0 |
| **KB** | Sep 03-Sep 06 | **1,000** | 2,447 | 3,308 | 2.4 | 3.3 |
| **ORCO** | Feb 05-Sep 06 | **500** | 1,286 | 2,802 | 0.6 | 1.4 |
| **PM** | Jan 03-Mar 04 | **200** | 11,432 | 19,860 | 2.3 | 4.0 |
| **PM** | Mar 04-Sep 06 | **100** | 19,470 | 9,828 | 1.9 | 1.0 |
| **O2** | Jan 03-Sep 06 | **5,000** | 248 | 442 | 1.2 | 2.2 |
| **UNI** | Jan 03-Feb 05 | **20,000** | 35 | 169 | 0.7 | 3.4 |
| **UNI** | Feb 05-Sep 06 | **10,000** | 170 | 197 | 1.7 | 2.0 |
| **ZEN** | Jun 04-Sep 06 | **3,000** | 505 | 1,301 | 1.5 | 3.9 |

LOT – number of shares in the trading lot; Price and Volume first – price and volume at the beginning of the corresponding time period, Price and Volume last – price and volume at the end of the time period in CZK.

Table 5: Extent of information-driven trading originating from the behavior of informed market makers

| Stock | Time period | am/ pm | PIN | PIN MM | Diff | T-stat | P-value |
|---|---|---|---|---|---|---|---|
| **CRA** | 26.6.2003-15.10.2003 | pm | **0.531** (0.101) | **0.808** (0.084) | **0.277** (0.138) | 2.01 | 0.045 |
| **CEZ** | 2.1.2003-2.8.2004 | pm | **0.504** (0.020) | **0.555** (0.020) | **0.051** (0.029) | 1.79 | 0.074 |
| **EB** | 25.5.2004-1.11.2004 | am | **0.328** (0.036) | **0.227** (0.039) | **-0.102** (0.053) | 1.92 | 0.055 |
| **KB** | 5.2.2003-7.7.2003 | pm | **0.540** (0.034) | **0.613** (0.031) | **0.074** (0.046) | 1.61 | 0.108 |
| **KB** | 2.9.2005-26.1.2006 | pm | **0.368** (0.040) | **0.466** (0.038) | **0.099** (0.055) | 1.80 | 0.071 |
| **PM** | 14.6.2004-31.3.2005 | pm | **0.470** (0.037) | **0.580** (0.033) | **0.110** (0.049) | 2.23 | 0.026 |
| **PM** | 21.7.2004-29.11.2004 | pm | **0.480** (0.053) | **0.584** (0.044) | **0.104** (0.069) | 1.52 | 0.129 |
| **O2** | 21.5.2004-31.8.2004 | am | **0.497** (0.052) | **0.648** (0.045) | **0.151** (0.068) | 2.21 | 0.027 |
| **O2** | 11.6.2004-19.8.2005 | pm | **0.452** (0.025) | **0.538** (0.023) | **0.085** (0.034) | 2.47 | 0.013 |
| **O2** | 11.6.2004-27.12.2004 | pm | **0.474** (0.034) | **0.573** (0.032) | **0.098** (0.047) | 2.09 | 0.036 |
| **O2** | 20.4.2005-9.9.2005 | am | **0.546** (0.045) | **0.648** (0.039) | **0.101** (0.059) | 1.71 | 0.088 |
| **O2** | 8.11.2005-16.3.2006 | am | **0.349** (0.048) | **0.443** (0.045) | **0.094** (0.065) | 1.44 | 0.151 |
| **O2** | 21.12.2005-16.5.2006 | pm | **0.391** (0.038) | **0.474** (0.036) | **0.082** (0.053) | 1.57 | 0.117 |

PIN MM is the estimate of information-driven trading using the sum of buys and sells except the buys and sells of given market maker. Standard deviations are in parentheses below each estimation.

Table 6: Extent of information-driven trading before and after changing the lot size

| Stock | Date | LOT 1 | LOT 2 | am/ pm | PIN 1 | PIN 2 | Diff | T-stat | P-value |
|---|---|---|---|---|---|---|---|---|---|
| **CEZ** | 15.10.2004 | 20,000 | 10,000 | am | **0.457** (0.040) | **0.333** (0.034) | **-0.123** (0.053) | 2.35 | 0.019 |
| **CEZ** | 15.10.2004 | 20,000 | 10,000 | pm | **0.514** (0.044) | **0.372** (0.037) | **-0.141** (0.057) | 2.46 | 0.014 |
| **CEZ** | 12.8.2005 | 10,000 | 5,000 | am | **0.286** (0.034) | **0.247** (0.036) | **-0.039** (0.049) | 0.78 | 0.434 |
| **CEZ** | 12.8.2005 | 10,000 | 5,000 | pm | **0.411** (0.039) | **0.334** (0.038) | **-0.077** (0.055) | 1.41 | 0.160 |
| **KB** | 5.9.2003 | 2,000 | 1,000 | am | **0.457** (0.032) | **0.295** (0.036) | **-0.161** (0.048) | 3.36 | 0.001 |
| **KB** | 5.9.2003 | 2,000 | 1,000 | pm | **0.584** (0.034) | **0.465** (0.031) | **-0.119** (0.046) | 2.59 | 0.010 |
| **PM** | 12.3.2004 | 200 | 100 | am | **0.769** (0.033) | **0.525** (0.040) | **-0.244** (0.051) | 4.74 | 0.000 |
| **PM** | 12.3.2004 | 200 | 100 | pm | **0.732** (0.041) | **0.488** (0.058) | **-0.245** (0.071) | 3.43 | 0.001 |
| **UNI** | 15.2.2005 | 20,000 | 10,000 | am | **0.481** (0.079) | **0.259** (0.051) | **-0.222** (0.094) | 2.36 | 0.018 |
| **UNI** | 15.2.2005 | 20,000 | 10,000 | pm | **0.393** (0.073) | **0.392** (0.049) | **-0.001** (0.086) | 0.01 | 0.993 |

Note: the table shows the extent of information-driven trading within the 90 trading days before and after the change in the lot size. Standard deviations are in parentheses below each estimation.