

**A STATISTICAL ANALYSIS OF INTRADAY LIQUIDITY, RETURNS AND
VOLATILITY OF AN INDIVIDUAL STOCK FROM THE ISTANBUL STOCK
EXCHANGE**

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Abstract: This paper seeks whether the intraday patterns observed in most stock markets hold for an individual stock from the Istanbul Stock Exchange where the trading ceases for two hours during lunchtime. It investigates the most treated topics in market finance like liquidity, returns and volatility through their various indicators by periodically regrouping transaction data and making use of parametric and nonparametric tests. It excludes the analysis of spread due to its uninformativeness in the presence of very discrete prices. The results show that liquidity-related variables' path can be described by an asymmetric “W” curve, namely a “reverse J” curve in the morning session and a “U” curve in the afternoon session. While returns do not exhibit a precise path, overnight returns are apparent. Price and return volatilities are very high in level and stable during the day. Sensitivity analyses suggest that choice of 5-minute versus 15-minute intervals slightly matters.

Key words: microstructure, liquidity, returns, volatility, Istanbul Stock Exchange

JEL Classification: C12, C13, C14, G10

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1. INTRODUCTION

Microstructure theory considers peculiarities in financial markets. It searches for the role specific rules play in the operation of a market. The acceleration gained thanks to accessing to transaction and order data improves this research in many ways. Intraday activities have thus found a broad academic interest in many countries and for various markets. This is more recently the case for European and East Asian exchanges that are order driven, centralized and transparent.

Theoretical work on intraday processes backs to late eighties. Admati and Pfleiderer (1988) develop a model in which trades endogenously concentrate as a result of strategic behavior of informed and liquidity traders. Brock and Kleidon (1992) rather attribute this concentration to the increased and inelastic demand for transactions during some periods of the day, namely in session openings and closings, without referring to informational asymmetry. Empirical studies, in their turn, are abundant. The first category involves in processing transaction data in order to obtain regular patterns in such variables as volume, returns, volatility and spread (McInish and Wood, 1985, 1990a, 1990b and 1991; Wood et al., 1985; Harris, 1986; Hasbrouck, 1991; Ho and Cheung, 1991; Wei, 1992; Foster and Viswanathan, 1993; Lee et al., 1993; Cheung, 1995; Niemeyer and Sandas, 1995; Chan et al., 1996; Abhyankar et al., 1997; Madhavan et al., 1997; Ahn and Cheung, 1999; Gouriéroux et al., 1999; Xu and Wu, 1999; Darolles et al., 2000; Wu and Xu, 2000; Ding and Lau, 2001; Kavajecz and Odders-White, 2001; Rahman et al., 2002; Yüksel, 2002; Küçükkocaoğlu, 2003; and Cai et al., 2004). A further achievement is the analysis of orders, which precede transactions (Biais et al., 1995; Chung et al., 1999; Foucault, 1999; Bisière and Kamionka, 2000; Declerck, 2000; Ahn et al., 2001; Lee et al., 2001; and Ranaldo, 2004). Besides, some

researchers look for intradaily patterns of returns using index data (Jain and Joh, 1988; Chan et al., 1991; Gerety and Mulherin, 1992 and 1994; Tezölmez, 2000; Bildik, 2001; and Copeland and Jones, 2002)¹.

The general finding of the above papers is that volume, volatility and spreads have a U-shape during the day, namely a gradual fall after the session opening and a gradual rise towards the closing, while findings on returns are more ambiguous². All this research can also be categorized into two groups for the conceptualization of time. Especially the early work takes the time in a linear way and forms fixed intervals. The second group focuses on a 'deformed time', and deals with irregularly spaced data. Many researchers have tried to develop new methodologies in order to cope with these tremendous data. Thus, new econometric tools like duration models have been proposed after GARCH processes and stochastic volatility models. Evidently, these advances have been realized thanks to high-frequency data and later on ultra-high frequency data, a term launched by Engle (2000), to call a dataset where all the transactions and quotes are recorded³.

Among the few intraday studies on the Istanbul Stock Exchange, Bildik (2001) uncovers the "W" shape of index returns and "L" shape of volatility. Tezölmez (2000) investigates the intraday return and return volatility patterns as well as the effect of information release on them. Yüksel (2002) compares the volume-volatility relation before and after the Russian Crisis. His findings are similar to Bildik's, but for individual stocks. Finally, Küçükkocaoğlu (2003) works on the intraday returns and day-end price manipulation.

The objective of this paper is to explore the evolution of transaction dynamics during the day in an emerging market and to see whether there exist regular patterns and periodic movements in some market variables related to three crucial concepts, namely liquidity, returns and volatility which are widely shaped by the microstructure of a market and which

should be jointly considered in an investment strategy. If such patterns can be established, they will serve investors to take positions accordingly and help the market participants who suffer from liquidity decide on the timing of their transactions within the day. This last point is especially relevant to those who trade at big amounts and are in need of reducing their liquidity costs. The paper differs from the early work on the ISE by focusing not only on returns and volatility, but also on liquidity. It is similar in spirit to the one by Ding and Lau (2001) who analyze transaction data for the Stock Exchange of Singapore or the one by Copeland and Jones (2002) who investigate the return, volatility and volume patterns on the Korean Index Futures Market. However, it differs in methodology and empirical tools.

The next section describes the market and data. Methodology is given in Section 3. Empirical results follow in Section 4. After some sensitivity checks in Section 5, Section 6 concludes the paper.

2. MARKET AND DATA

Istanbul Stock Exchange (ISE) is an automated order-driven market containing shares of almost three hundred corporations. There are two trading sessions: the morning session from 9:30 to 12:00 and the afternoon session from 14:00 to 16:30⁴. One of our objectives is to see whether this 2-hour pause generates particular intraday seasonalities. There are no market makers, at least explicitly, and the trading is continuous, though a matching procedure, called *trade via diskette orders*, exists before openings⁵. Like in most other markets, orders match through price and time priorities.

The study makes use of transaction data for a three-month period from August to October 2000 of stock of Sabanci Holding Corporation (SAHOL), which, during this period, was one of the leading companies in terms of market capitalization and trading volume among those

included in the ISE30 and the ISE100 indices of the Istanbul Stock Exchange (ISE). This period is deliberately chosen in order to eliminate the aspects of banking (Nov. 2000) and then financial (Feb. 2001) crises that took place in Turkey and to better catch the ‘ordinary’ evolution of stock prices and other indicators. The share (SAHOL) was very active with 83898 transactions in the period concerned. It paid no dividend, nor was it split between the dates mentioned.

The transaction data delivered by the ISE separately give the amounts of each side of a transaction. For example, a big-sized trade-initiating (marketable limit) order usually meets several smaller-sized waiting (limit) orders. Yet, our focus is on the behavior of the initiator. Therefore, we assume that trades taking place at the same second constitute a single transaction and unify all the orders traded at the same second, since time is stamped in one-second base⁶. Transactions with decimal number of shares as well as those taking place during out of the morning and afternoon sessions, namely via diskette orders are not included in the data⁷. Finally, the trades occurred on 29 August 2000 are excluded due to a trading halt for technical reasons in the morning session⁸.

A periodic analysis is adopted throughout this paper. Hence, 5-minute intervals are created for each day. In their study on the Hong Kong Stock Exchange Ahn et al. (2001) use 15-min intervals for an intraday analysis of stocks with 387 transactions per day on average while Lee et al. (2001) construct 6-min intervals with each interval containing nearly 12 trades on average. Capelle-Blancard and Vandelanoite (2002) use 10-min intervals for stock options exchanged 8120 times in 464 days, average time between transactions equaling 29 minutes. In our case, average daily number of transactions is 1311. This means 27.3 trades per interval on average, without any tradeless interval. So, we believe that 5-min intervals are adequate and appropriate for catching the intraday seasonalities. As a result, for each variable

concerned we end up with forty eight 5-min intervals for each of sixty four trading days, in the form of 64x48 matrices.

3. METHODOLOGY

(i) Specifications

(a) Liquidity

Liquidity has been defined by many as “the ability of a market in achieving a high amount of trade without major price effects, that is with low transactions costs, and this to be whenever asked”. Some of its dimensions are volume, immediacy, depth, and resiliency, as mentioned by Kyle (1985). Trading volume (V), defined as the number of shares exchanged, might therefore be considered as a first indicator of liquidity. Volume in an interval, however, has two dimensions, namely number of trades (NT) and trade sizes. Total volume during a period is the sum of sizes of individual trades. On the other hand, recent studies claim that the information contained in intertrade durations, which show trading frequency, is higher than the number of trades, although they are closely interlinked. Therefore, we measure trading frequency, which relates to immediacy dimension of liquidity, by the number of instant trades (NIT), i.e. trades taking place within one or two seconds following a transaction. Magnitude of trades is another item followed attentively by traders. It gives a crude idea on the identity and intention of the trader. Average trade size (ATS) and variance of trade size (VTS) analyze this magnitude and its variation, respectively. Moreover, Easley and O’Hara (1987) argue that big orders signal the presence of informed traders. Therefore, we lay a further emphasis on big trades, i.e. trades with a size greater than the maximum amount allowed (5000 lots) for ordinary orders⁹.

In order to eliminate interday effects, we calculate the above variables except average trade

size and variance of trade size in percentages of the day as well. Table 1 gives the formal definitions of liquidity variables.

(b) Returns

Stock prices are discrete in most world markets. On the ISE, however, the discreteness was so large that there was no a single price change larger than a tick for SAHOL during the period concerned¹⁰. This discreteness generates many price continuations and reduces the sensitivity of the data. Therefore, we define returns as percentage change in average price (PCAP) rather than differences or log-differences in stock prices. Nonetheless, returns generated by simple prices might be misleading in reflecting the market intention, considering that price manipulation is easy with small amounts. Hence, we calculate percentage change in volume-weighted average price (PCVWAP) as an alternative measure of returns. These definitions also allow capturing overnight returns. Table 2 formally gives the definitions of these two proxies.

(c) Price and Return Volatilities

Volatility shows the dispersion of the stock value around its mean. While a certain level of variability is needed for profitable trading in stock markets, highly volatile markets are short in attracting institutional investors.

Variance of trading price (VP) is the first measure of volatility in this study. A high level of this variable generally means either a (bid and/or ask) price shift in that interval after the achievement of nearly half of the volume or a fluctuation in a balanced way so that the average price approaches mid-spread levels, since we do not expect spreads larger than a tick. A new measure suggested in the present study is the volume-weighted variation in price

(VWVP). Here, we assume that variation in the price of trades with higher sizes is more important in affecting market participants' behavior. Similar to the sum of squared returns proposed by Ahn et al. (2001), a third measure is the sum of absolute returns (SAR). Its main difference from the two volatility proxies above is that it does work better in detecting price continuations and reversals. A relatively high level of SAR in an interval means that price is fluctuating between bid and ask, that is reversals occur frequently. In fact, a low level of SAR at an interval is possible despite a high level of VP, for instance in case of a price shift within that interval. In order to get rid of the bias of the number of trades on SAR, we calculate average absolute returns per trade (AART) as a proxy of return volatility. Table 3 formally summarizes the four volatility proxies.

(ii) Statistical Methods and Hypotheses

Tezölmez (2000) compares intervals to the 10:55-11:00 am and 10:45-11:00 am intervals in testing for equality of variances with ANOVA. In fact, on the ISE most of the overnight information is incorporated into prices until 11:00 am, if not within a few minutes after the morning opening. Besides, the actual day's news and macroeconomic announcements are released with the morning opening. These, too, are rapidly incorporated. Therefore, around 11:00 am is a relatively calm period of the day. Accordingly, as a first step, the 13th interval of the day, i.e. between 11:00 and 11:05 am, is chosen as a benchmark in comparing the above variables across intervals.

Student T is the most common test utilized in such analyses. On the other hand, non-normality of intraday variables' distributions is a generally admitted phenomenon faced with financial data¹². Therefore, nonparametric tests that do not require normality assumption such as Wilcoxon Signed-Rank (SR) and Wilcoxon-Mann-Whitney (U) tests are employed for

interval comparison. On the other hand, F and Kruskal-Wallis (H) tests serve for evaluating the joint equality of intervals¹³. In addition, for such variables as PCAP, PCVWAP, SAR and AART, both T and SR tests are run to test for significance. We employ both one-tailed and two-tailed tests for each variable and each hypothesis. The tests we conduct as well as the set of null (equality to the 13th interval (H_{13}), joint equality of 48 intervals (H_{JE}) and insignificance (H_S)) and alternative (inequality, superiority and inferiority) hypotheses are summarized in Table 4.

4. EMPIRICAL RESULTS

In the section below, sixteen market variables in three categories are analyzed intradaily. In addition to the tables showing the test results, figures constructed with 64-day averages of these variables are explored in three subparts. The results show regular patterns for some variables and no patterns at all for the others.

(i) Liquidity

(a) Volume (V), Number of Trades (NT), Number of Instant Trades (NIT), Number of Big Trades (NBT) and their Percentages

A first glance at Figure 1 reveals the “W” shapes of volume and percentage volume during the day compared to “U” shape in most stock markets. This is certainly because of the two-hour lunch break on the ISE. However, the morning and afternoon sessions are not entirely symmetrical. Volume is much more higher towards the evening closing than the lunch closing. The path perhaps is better described as a reverse J-curve in morning and a U-curve (if not a J-curve) in afternoon.

Table 5 shows the T, SR and U test statistics which compare each 5-min interval with the

13th 5-min interval. Results put forward a significant positive difference *vis-à-vis* the 13th interval especially in the first 25 minutes after openings as well as the last 25 minutes before the evening closing. Interestingly, only the last interval of the morning session is significantly higher than the 11:00-11:05 interval. So, Table 5 unveils the asymmetrical form of volume in session closings. We face almost identical results in percentage volume except probably that the seasonality becomes smoother. F and H statistics both reject the null hypothesis that all intervals are statistically the same for volume and percentage volume, and support the alternative hypothesis that there is at least one interval significantly different from the others.

Generally speaking, trading volume falls gradually during the morning session except for the last 5-min interval, and after falling in the first half of the afternoon session, rises gradually reaching a maximum in the evening closing. Figure 1 also makes it clear that the total number of shares exchanged per interval varies markedly in level (and in percentage) during the day, between 19562 lots (0.56%) and 123741 lots (6.70%).

NT patterns appear to be very similar to V patterns, which makes us think that number of trades is the driving determinant of volume. Nonetheless, except the first and last thirty minutes of the day and the first fifteen minutes of the afternoon session, average NT seems stable. By the way, we witness a slightly greater number of transactions committed in afternoon session.

In Table 5, one notices that the intraday variations in NT and %NT become amplified and more obvious *vis-à-vis* V and %V. For instance, we observe that NT and %NT are significantly lower through 16th to 19th intervals (i.e. from 11:15 to 11:35) than they are in the 13th interval. Expectedly, F and H statistics strongly reject the null hypothesis of jointly equal intervals.

Figure 2 as well as Table 6 provides almost identical results with the ones above as for

NIT. There is a need to mention that levels are lower and percentages are higher in the latter. These findings point out once more that trading activity is typically concentrated in session openings and to a larger extent in evening closing. A remark is that almost half of the trades in the opening and day closing are instant trades whereas this proportion falls to one sixth in less active periods.

Plotted in Figure 2, average NBT and average %NBT display a comparable evolution to the ones above with the exceptions that they are less smooth and that they increase monotonically between 14:00 and 14:20 contrarily to NT and %NT that decrease. This pattern of big trades reveals the presence of institutional investors in the early afternoon. Referring to Table 6, the hypothesis of jointly equal intervals is rejected by both F and H tests at the 1% level of significance as in the case of V, NT or NIT. SR test, however, yields very weak evidence on intradaily variations due to its construction that generates noise when the values of the random variable are few and discrete. Notice that rejection areas in all the tests become smaller and in general, evidence is weaker compared to NT and NIT.

(b) Average Trade Size (ATS) and Variance of Trade Size (VTS)

Figure 3 depicts the generally unstable natures of ATS and VTS, although slight “W” shape is observed in ATS. Average ATS varies between 555 and 2303 lots within the day. In its turn, VTS, which rather has a cyclical feature, varies between 15.2 million and 247 million lots and reaches a peak at 10:55-11:00 time interval.

T, SR and U tests given in Table 7, on the other hand, occasionally provide the same results for the same hypotheses. Nonparametric (SR and U) tests reject the null hypothesis of equality of intervals to the 13th interval much more times than does the T test. This is the case especially in the evening closing for ATS and during almost the whole day for VTS.

From Figure 3, one infers that trade sizes vary considerably in 3rd, 10th, 12th, 17th, 36th and 42nd intervals. However, especially the T statistics in Table 7 do not support this inference. As for the equality of the intervals as a whole, F test rejects the null at the 5% level of significance for ATS and fails to reject it for VTS while H test rejects both at the 1% level of significance.

The results illustrate that orders with bigger sizes are placed in the first 20 minutes following the openings and just before closings. As opposed to Figure 3, T statistics suggest that trade size variability measured every 5 minutes does not vary much during the day, though the other tests' findings are very similar to V and NT.

(ii) Returns

Percentage Change in Average Price (PCAP) and Percentage Change in Volume-Weighted Average Price (PCVWAP)

Return patterns seem not as regular as the liquidity patterns. Figure 4 that plots both average PCAP and average PCVWAP gives an idea about price dynamics. A first remark is the existence of considerably high positive returns (0.62% in PCAP and 0.42% in PCVWAP) in the first five minutes of the day *vis-à-vis* the previous day's last interval. By contrast, afternoon opening witnesses negative returns. The second remark is the emergence of relatively higher price changes in afternoon. Both PCAP and PCVWAP vary markedly in afternoon. A final remark is that there are some deviations between PCAP and PCVWAP, mostly during the morning session, at the day opening and closing.

Table 8 certainly constitutes a better reference. It is of use to remember that although returns in intervals are compared to those in the 13th interval, the benchmark of interest is zero. Table 8 suggests that overnight returns calculated by both methods are significantly

positive. Besides, it indicates significantly positive PCAP in the 27th and 37th intervals and negative returns in afternoon opening as well as the 39th, 42nd and 46th intervals by both T and SR tests. It also puts forward positive PCVWAP in the 31st and 37th intervals as well as day closing and negative returns in the 10th and 46th intervals. Minor differences exist between the results of the T and SR tests. F statistics reject the null of equality of returns across intervals at the 1% level of significance for both PCAP and PCVWAP. H statistics, on the other hand, rejects it for PCAP, but fails to reject for PCVWAP.

Evidence on the significance of returns is weaker than that of the previous variables. Amongst the cases of null rejection, positive returns in the 37th interval and to a lesser degree in the morning opening are the most obvious ones. Notice also that day-end positive returns are significant only when returns are weighted by volume. This implies that the market agrees to a large extent on increasing the price in last minutes of the day. This operation is unlikely to be a manipulation and seems to reflect the true intention of the market since the last interval accounts for 6.7% of daily volume on average¹⁴.

(iii) Price and Return Volatilities

(a) Variance of Price (VP) and Volume-Weighted Variation in Price (VWVP)

Average VP plotted in Figure 5 is pretty stable except for the opening interval and a few intervals in afternoon. Concerning this measure of volatility, Table 9 confirms by all the three tests the significantly positive difference of the morning opening as well as the 33rd and 43rd intervals from the 13th interval. This implies that a higher volatility of transaction prices is to be expected in these three intervals.

The relatively fluctuating character of average VWVP *vis-à-vis* average VP is not supported by the test statistics which underline that the only significantly different intervals

from the 13th are the 4th, 17th and 24th and that all are lower than the VWVP of the 13th interval, although the evidence remains weak. By the way, both F and H statistics fail to reject the null of equal volatilities across intervals.

(b) Sum of Absolute Returns (SAR) and Average Absolute Returns per Trade (AART)

Average SAR in Figure 6 looks very much like liquidity variables in Figure 1. In words, SAR is strongly biased to NT. Nevertheless, some differences arise as for statistical significance when Table 5 and Table 10 are compared. Volatility is significantly higher in the first 35 minutes following morning opening and during almost the whole session in afternoon than the 13th interval's volatility. Not surprisingly, F and H statistics strongly reject the hypothesis of joint equality of SAR across intervals.

Figure 6 also illustrates the evolution of average AART during the day. According to this figure, AART is lower in early openings, around 11:00-11:30 am and in evening closing. However, these findings are not supported by Table 10 that designates only the 33rd interval as being significantly different from the 13th interval in terms of AART. That is, volatility measured by AART is found significantly higher in the 33rd interval than it is in the 13th interval by T and U tests at the 5% level of significance. F and H statistics unanimously fail to reject the null of jointly equal AART across intervals.

It is also of interest to notice that T and SR tests in Table 10 very strongly reject the null hypothesis of zero volatility for all intervals of the day without exception. This is a way to demonstrate that, as widely documented, volatility is absolutely high on the ISE.

5. SENSITIVITY ANALYSES

In order to see whether the test results are robust to the choice of interval length, the same

tests are performed forming sixteen 15-min intervals and taking 5th interval (11:00-11:15) as the benchmark. Rejection areas overlap to a large extent, especially for liquidity and volatility variables, though 5-min intervals generally are more sensitive in capturing intradaily variations. Nevertheless, minor differences appear as a result of resizing the intervals. These are given in Table 11.

Secondly, instant trades are defined as occurring within four seconds (instead of two seconds) following a transaction. Identical results are obtained as for the intradaily path.

Thirdly, due to the crucial role big trades play in influencing the market, NBT is scattered at 1-second intervals. Results not very distinct from the general W-curve are obtained. 6, 8 and 8 big orders were traded in the morning opening, afternoon opening and day closing, respectively, *versus* only 3 orders in lunchtime closing within the 64 trading day concerned¹⁵.

6. CONCLUSIONS

This study aims at exposing the intradaily path of the key market variables from a microstructural perspective. Liquidity is mostly related to volume. This is why volume and its components are primarily analyzed. The “W” shapes of trading volume in general and of number of trades and to a lesser degree trade size in particular, are confirmed by parametric and nonparametric tests. It is shown that volume and number of instant, big and overall trades exhibit a reverse J-curve in the morning session and a U (or even J)-curve in afternoon. The analysis of durations on the other hand, reveals that trading frequency is the lowest in the second half of the morning session. Although return paths are not as precise as those of volume, returns in the first five minutes of the day *vis-à-vis* the previous day’s last five minutes are found to be positive by all the tests. Besides, significantly non-zero returns are detected during some intervals of the day, mostly in afternoon. Moreover, return patterns

slightly change when returns are compounded by volume. For instance, positive returns in day closing become significant only when returns are measured by percentage change in volume-weighted average price. Volatility analysis, which aims at discovering price fluctuations, may serve detecting gain opportunities for liquidity traders. This is reasonable since discrete prices allow potential gains by a one-tick price change. Volatility is high in level, but does not vary much across intervals when the effect of number of trades is eliminated.

The paper does not treat bid-ask spread since it does not provide additional information in the presence of the discrete prices. Spreads may nevertheless be analyzed for less liquid stocks, especially when they are larger than a tick.

One question arises as to the liquidity-related variables that exhibit an asymmetric “W” shape. While both session openings follow almost identical paths and indicate very close levels, the session closings do not. It might be suggested that there is a greater uncertainty after day closing (2-hour break in lunchtime versus 18-hour break overnight). However, if this is the case, why are both openings the same?

Repeating this effort with other individual stocks and for larger data sets would provide a generalization of the market¹⁶. A further investigation can be handled by categorizing stocks according to size, index, sector, and so on. Anyway, analyzing individual stocks would yield a better microstructural research than the one achieved by index data since it is free from the noise induced by index, not only in terms of price but also quantity and timing.

NOTES

- 1 Some of these papers treat both transactions and orders (e.g. Niemeyer and Sandas, 1995; Declerck, 2000; Kavajecz and Odders-White, 2001). Gerety and Mulherin (1992) investigate intraday volume in addition to returns. There are a number of intraday

studies in FX, options, futures and bond markets, too. For brevity, they are not cited here.

- 2 Some exceptions include Andersen et al. (2000) and Cheung et al. (1994) who find W-shaped volatilities in the Tokyo and Hong Kong Stock Exchanges, respectively, that have a lunch pause like the Istanbul Stock Exchange. Chan et al. (1995) report stable intraday spreads for Nasdaq stocks instead of the widely documented U-shaped pattern. Bildik (2001) finds W-shaped pattern in returns, like Ding and Lau (2001) and L-shaped pattern in volatility. Lee et al. (2001) indicate J-shaped pattern in trading volume on the Taiwan Stock Exchange.
- 3 Hautsch and Pohlmeier (2002) survey the recent econometric methods dealing with transaction data.
- 4 Before August 2001, trading hours were from 10:00 to 12:00 and from 14:00 to 16:00. For this study considers the total daily working time as four hours.
- 5 This is a kind of call auction procedure which guarantees the collection of orders before the session openings in a non-transparent environment. It is different from the fixing of Euronext in the sense that there exist the multiple-price rule and no pre-opening transparency on the ISE.
- 6 For our sample period, 1311 trade-initiating orders match 2885 waiting orders everyday on average.
- 7 The volume exchanged by diskette orders is less than 1% of the daily volume during this three-month period. The inclusion of these orders within the dataset is not of interest considering that they provide very marginal information and deteriorate the usual path of the time series. However, studies with newer datasets would require taking these orders into account, since off-hours orders have reached a significant level with the

advances in new technologies.

- 8 This exclusion does not cause a problem for the essential aim of the study; we just lose an observation out of 65.
- 9 In this study liquidity is measured ex-post, namely via transaction data. Seeking pre-trade liquidity, however, necessitates investigating orders and orderbook, which has not been possible yet in the case of Istanbul Stock Exchange due to the unavailability of data. Even so, using transaction data is still intuitive. We admit that for transaction level to be high, so should have been liquidity.
- 10 Tick levels varied between 1% and 2.5% of stock prices until recently. As of April 14, 2003, these levels were decreased to 0.4-1% by the market authorities with the purpose of improving liquidity.
- 11 $PCAP_1$ and $PCVWAP_1$ of the first observation day are taken zero for convenience, since the earlier day's AP_{48} and $VWAP_{48}$ are not available.
- 12 Jarque-Bera test rejects the normality of intradaily averages of V , $\%V$, NT , $\%NT$, NIT , $\%NIT$, NBT , $\%NBT$, VTS , $PCAP$, $PCVWAP$ and SAR at the 5% level of significance and fails to reject only for ATS , VP , $VWVP$, and $AART$.
- 13 Among many statistics textbooks, the reader can refer to Freund (1999) for the details of these tests.
- 14 See Küçükkocaoğlu (2003).
- 15 For brevity, results from sensitivity analyses are just mentioned in the paper; they are available upon request.
- 16 The first two parts of the investigation were repeated without statistical tests with 17 big stocks (included in the ISE30 index) and 19 medium-sized stocks (included in the ISE100 index but not in the ISE50 index) by forming 5-min and 15-min intervals,

respectively. Results reveal that the smooth liquidity patterns disappear as the company size (in terms of market capitalization or total amount exchanged) reduces. In any case, even more apparent in smaller stocks, the last interval is the most active period of the day. Overnight returns are apparent and significant for both groups of companies. One particular aspect of smaller companies is that negative returns are observed in the last interval of the day. Nevertheless, we should be cautious as for the validity of these results since number of trades considerably decreases in small stocks.

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Table 1

Liquidity Variables

Variable	Symbol	Formula
Volume in interval t	V_t	$\sum_{i=1}^{NT_t} TS_{ti}$
Percentage Volume of interval t within the day	$\%V_t$	$\frac{V_t}{\sum_{j=1}^{48} V_j}$
Number of Trades in interval t	NT_t	
Percentage Number of Trades of interval t within the day	$\%NT_t$	$\frac{NT_t}{\sum_{j=1}^{48} NT_j}$
Number of Instant Trades in interval t	NIT_t	Number of D_{ti} such that $D_{ti} \leq 2$ seconds
Percentage Number of Instant Trades of interval t within the day	$\%NIT_t$	$\frac{NIT_t}{\sum_{j=1}^{48} NIT_j}$
Number of Big Trades in interval t	NBT_t	NT_t such that $TS_{ti} > 5000$ lots
Percentage Number of Big Trades of interval t within the day	$\%NBT_t$	$\frac{NBT_t}{\sum_{j=1}^{48} NBT_j}$
Average Trade Size in interval t	ATS_t	$\frac{\sum_{i=1}^{NT_t} TS_{ti}}{NT_t}$
Variance of Trade Size in interval t	VTS_t	$\frac{\sum_{i=1}^{NT_t} (TS_{ti} - ATS_t)^2}{NT_t}$
<p>where $t=1..48$ are the 5-min intervals, TS_{ti} is size of trade i in interval t, NT_t is the number of trades in interval t, D_{ti} is time (duration) in seconds between transactions $i+1$ and i in interval t,</p>		

Table 2

Return Variables

Variable	Symbol	Formula
Percentage Change in Average Price in interval t	PCAP _t	$\frac{AP_{t+1} - AP_t}{AP_t}$
Percentage Change in Volume-Weighted Average Price in interval t	PCVWAP _t	$\frac{VWAP_{t+1} - VWAP_t}{VWAP_t}$
<p>where $t=1..48$ are the 5-min intervals, AP_t and $VWAP_t$ are average price and volume-weighted average price in interval t, i.e.,</p> $AP_t = \frac{\sum_{i=1}^{NT_t} P_{ti}}{NT_t} \text{ and } AP_0 \text{ equals previous day's } AP_{48};$ $VWAP_t = \frac{\sum_{i=1}^{NT_t} P_{ti} \cdot TS_{ti}}{\sum_{i=1}^{NT_t} TS_{ti}} \text{ and } VWAP_0 \text{ equals previous day's } VWAP_{48},$ <p>P_{ti} and TS_{ti} being price and trade size for trade i in interval t, respectively¹¹.</p>		

Table 3

Volatility Variables

Variable	Symbol	Formula
Variance of Price in interval t	VP _t	$\frac{\sum_{i=1}^{NT_t} (P_{ti} - AP_t)^2}{NT_t}$
Volume-Weighted Variation in Price in interval t	VWVP _t	$\frac{\sum_{i=1}^{NT_t} (P_{ti} - VWAP_t)^2 \cdot TS_{ti}}{\sum_{i=1}^{NT_t} TS_{ti}}$
Sum of Absolute Returns in interval t	SAR _t	$\sum_{i=1}^{NT_t} AR_i$
Average Absolute Returns per Trade in interval t	AART _t	$\frac{\sum_{i=1}^{NT_t} AR_i}{NT_t}$
<p>where $t=1..48$ are the 5-min intervals, AP_t and $VWAP_t$ are average and volume-weighted average prices for interval t, AR_i is the absolute value of percentage change in price between transactions $i+1$ and i.</p>		

Table 4

Hypotheses and Tests

		Set of Hypotheses		
		H_{I3}	H_{JE}	H_S
Variable	V	T, SR, U	F, H	
	%V	T, SR, U	F, H	
	NT	T, SR, U	F, H	
	%NT	T, SR, U	F, H	
	NIT	T, SR, U	F, H	
	%NIT	T, SR, U	F, H	
	NBT	T, SR, U	F, H	
	%NBT	T, SR, U	F, H	
	ATS	T, SR, U	F, H	
	VTS	T, SR, U	F, H	
	PCAP	T, SR, U	F, H	T, SR
	PCVWAP	T, SR, U	F, H	T, SR
	VP	T, SR, U	F, H	
	VWVP	T, SR, U	F, H	
	SAR	T, SR, U	F, H	T, SR
AART	T, SR, U	F, H	T, SR	
<p>Equality of each interval to the 13th interval (H_{I3}):</p> <p>1. $H_0: \mu_i = \mu_{13}$ for $i=1..48$ and $i \neq 13$ $H_1: \mu_i \neq \mu_{13}$</p> <p>2. $H_0: \mu_i = \mu_{13}$ for $i=1..48$ and $i \neq 13$ $H_1: \mu_i > \mu_{13}$</p> <p>3. $H_0: \mu_i = \mu_{13}$ for $i=1..48$ and $i \neq 13$ $H_1: \mu_i < \mu_{13}$</p> <p>Joint equality of 48 intervals (H_{JE}):</p> <p>4. $H_0: \mu_i = \mu_j$ for all $i=1..48, j=1..48$ and $i \neq j$ $H_1: \mu_i \neq \mu_j$ for at least one i such that $i=1..48, j=1..48$ and $i \neq j$</p> <p>Significance (H_S):</p> <p>5. $H_0: \mu_i = 0$ for $i=1..48$ $H_1: \mu_i \neq 0$</p> <p>6. $H_0: \mu_i = 0$ for $i=1..48$ $H_1: \mu_i > 0$</p> <p>7. $H_0: \mu_i = 0$ for $i=1..48$ $H_1: \mu_i < 0$</p>				

Table 5
Volume (V), Percentage Volume (%V), Number of Trades (NT) and Percentage Number of Trades (%NT)

Int	Volume (V)				Percentage Volume (%V)				Number of Trades (NT)				Percentage Number of Trades (%NT)						
	T	1-T	2-T	SR	T	1-T	2-T	SR	T	1-T	2-T	SR	T	1-T	2-T	SR			
1	4.10	**	**	**	5.08	**	**	-5.59	**	-7.05	**	-7.82	**	12.32	**	-6.77	**	-8.58	**
2	3.02	**	**	**	3.09	**	**	-4.07	**	-5.63	**	-5.76	**	8.09	**	-5.07	**	-7.10	**
3	2.66	**	**	**	3.23	**	**	-3.75	**	-4.63	**	-4.61	**	5.72	**	-4.42	**	-5.79	**
4	4.23	**	**	**	4.11	**	**	-4.99	**	-5.57	**	-4.64	**	5.41	**	-5.50	**	-5.95	**
5	1.78	**	**	**	2.18	**	**	-2.63	**	-3.32	**	-2.85	**	3.39	**	-3.11	**	-3.87	**
6	0.70	**	**	**	0.65	**	**	-0.96	**	-1.59	**	-1.34	**	1.55	**	0.12	**	-2.26	**
7	1.10	**	**	**	1.14	**	**	-1.97	**	-1.45	**	-0.58	**	0.97	**	0.86	**	-1.30	**
8	0.99	**	**	**	1.32	**	**	-0.79	**	-0.74	**	-0.96	**	1.42	**	-0.26	**	-1.40	**
9	1.09	**	**	**	0.76	**	**	-0.64	**	-1.02	**	-0.39	**	0.70	**	0.19	**	-0.47	**
10	2.31	**	**	**	2.10	**	**	-1.85	**	-1.35	**	-0.75	**	1.62	**	0.52	**	-1.19	**
11	0.40	**	**	**	0.41	**	**	-0.71	**	-0.60	**	-0.14	**	0.44	**	0.41	**	-0.51	**
12	0.80	**	**	**	0.53	**	**	-0.73	**	-0.03	**	-0.20	**	-0.19	**	-0.35	**	-0.25	**
13	0.04	**	**	**	-0.32	**	**	-0.24	**	-0.57	**	-0.63	**	0.64	**	0.18	**	-0.72	**
14	1.37	**	**	**	1.24	**	**	-0.54	**	-0.14	**	-0.30	**	0.62	**	0.62	**	-0.61	**
15	-0.32	**	**	**	-0.56	**	**	-1.08	**	-1.06	**	-1.42	**	-1.46	**	-1.95	**	-1.74	**
16	0.35	**	**	**	0.38	**	**	-0.76	**	-1.04	**	-1.81	**	-1.81	**	-1.89	**	-1.65	**
17	-0.58	**	**	**	-0.46	**	**	-0.65	**	-0.33	**	-1.28	**	-2.09	**	-1.34	**	-1.38	**
18	-0.42	**	**	**	-0.82	**	**	-0.21	**	-0.51	**	-1.18	**	-2.05	**	-1.87	**	-1.49	**
19	0.24	**	**	**	0.77	**	**	-0.45	**	-0.42	**	-0.34	**	-0.82	**	-0.78	**	-0.70	**
20	-0.52	**	**	**	-0.50	**	**	-0.96	**	-1.21	**	-0.90	**	-0.43	**	-0.83	**	-1.18	**
21	0.56	**	**	**	0.41	**	**	-0.54	**	-0.52	**	-1.54	**	-1.66	**	-1.41	**	-1.40	**
22	-0.85	**	**	**	-1.32	**	**	-1.03	**	-0.78	**	-0.82	**	-1.66	**	-1.08	**	-0.85	**
23	-0.51	**	**	**	-0.65	**	**	-0.65	**	-1.03	**	-0.82	**	-1.66	**	-1.08	**	-0.85	**
24	1.68	**	**	**	2.01	**	**	-2.28	**	-3.35	**	-0.33	**	0.65	**	-0.05	**	-0.46	**
25	2.31	**	**	**	3.07	**	**	-4.59	**	-5.89	**	-6.71	**	12.49	**	-6.63	**	-8.59	**
26	3.21	**	**	**	2.89	**	**	-3.60	**	-4.35	**	-5.11	**	5.92	**	-4.83	**	-6.35	**
27	2.90	**	**	**	3.19	**	**	-2.89	**	-4.37	**	-4.37	**	4.97	**	-3.99	**	-5.46	**
28	1.60	**	**	**	2.05	**	**	-2.70	**	-2.99	**	-2.68	**	2.38	**	-0.63	**	-3.09	**
29	1.76	**	**	**	1.80	**	**	-2.16	**	-2.60	**	-2.26	**	2.47	**	-0.77	**	-2.83	**
30	1.66	**	**	**	1.64	**	**	-2.19	**	-1.80	**	-1.74	**	1.76	**	-1.06	**	-2.54	**
31	0.68	**	**	**	0.77	**	**	-1.45	**	-1.45	**	-1.17	**	1.08	**	0.10	**	-1.78	**
32	0.79	**	**	**	1.18	**	**	-0.21	**	-0.01	**	-0.74	**	1.17	**	-0.47	**	-0.81	**
33	0.04	**	**	**	0.56	**	**	-0.80	**	-1.12	**	-1.29	**	1.06	**	-0.13	**	-1.45	**
34	0.43	**	**	**	0.59	**	**	-0.80	**	-0.83	**	-0.99	**	0.59	**	-0.42	**	-0.01	**
35	1.74	**	**	**	1.79	**	**	-1.23	**	-0.83	**	-0.32	**	1.05	**	0.75	**	-0.43	**
36	1.62	**	**	**	1.45	**	**	-1.45	**	-0.91	**	-0.51	**	0.75	**	-0.02	**	-0.42	**
37	1.29	**	**	**	1.31	**	**	-1.16	**	-1.06	**	-1.80	**	1.52	**	0.86	**	-1.27	**
38	0.70	**	**	**	0.60	**	**	-1.15	**	-1.32	**	-1.34	**	1.72	**	-0.87	**	-2.46	**
39	1.09	**	**	**	0.87	**	**	-1.09	**	-1.33	**	-1.34	**	1.80	**	-1.25	**	-1.81	**
40	1.18	**	**	**	1.48	**	**	-1.28	**	-1.41	**	-1.49	**	1.48	**	0.31	**	-1.84	**
41	0.71	**	**	**	0.48	**	**	-0.69	**	-2.11	**	-1.55	**	1.30	**	0.99	**	-1.93	**
42	1.45	**	**	**	0.93	**	**	-1.35	**	-2.28	**	-1.73	**	1.48	**	-0.36	**	-2.12	**
43	1.47	**	**	**	0.89	**	**	-1.84	**	-2.00	**	-2.40	**	2.50	**	-2.46	**	-3.35	**
44	1.90	**	**	**	1.97	**	**	-2.09	**	-3.18	**	-3.59	**	3.82	**	-3.85	**	-4.54	**
45	2.27	**	**	**	2.15	**	**	-3.23	**	-3.39	**	-4.57	**	4.56	**	-1.99	**	-5.47	**
46	2.21	**	**	**	2.11	**	**	-2.74	**	-4.03	**	-5.62	**	6.30	**	-5.12	**	-6.79	**
47	2.71	**	**	**	3.12	**	**	-3.99	**	-5.75	**	-7.44	**	9.75	**	-6.47	**	-8.47	**
48	6.33	**	**	**	6.81	**	**	-5.91	**	-8.05	**	-9.14	**	16.63	**	-6.90	**	-9.45	**
F	3.02	**	**	**	4.22	**	**	-519.77	**	-468.97	**	-700.38	**	33.46	**	-977.32	**	-977.32	**

Notes:
The "Int" column shows the 5-min intervals. The line below the 24th interval indicates the lunch break. 1-T (2-T) stands for 1-tailed (2-tailed) test. Student (T), Signed-Rank (SR) and Wilcoxon-Mann-Whitney (U) test both the equality and superiority (inferiority) of each 5-min intervals' mean to the 19th intervals. Fisher (F) and Kruskal-Wallis (H) test the joint equality of forty eight periods (5-min intervals). Under the null, T-statistics are distributed as T(63), SR- and U-statistics as Z(63), F- and H-statistics as F(47,3024) and H-statistics as $\chi^2(47)$ for alphas equaling .05 and .01. (*), (**), (***) and (-) show the rejection of the null at the 5% (1%) level of significance.

Table 6

Int	Number of Instant Trades (MIT), Percentage Number of Instant Trades (%MIT), Number of Big Trades (MBT), Percentage Number of Big Trades (%MBT)																										
	Number of Instant Trades (MIT)				Percentage Number of Instant Trades (%MIT)				Number of Big Trades (MBT)				Percentage Number of Big Trades (%MBT)														
	T	I-T	2-T	SR	T	I-T	2-T	SR	T	I-T	2-T	SR	T	I-T	2-T	SR											
1	5.43	**	**	-5.16	**	**	7.23	**	**	8.79	**	**	-5.30	**	**	4.07	**	**	4.54	**	**	4.88	**	**	4.88	**	**
2	3.94	**	**	-1.93	**	**	-4.78	**	**	5.13	**	**	-1.67	**	**	2.55	**	**	2.54	**	**	2.23	**	**	2.32	**	**
3	3.42	**	**	-2.43	**	**	-4.47	**	**	3.80	**	**	-2.50	**	**	2.27	**	**	2.46	**	**	2.44	**	**	2.61	**	**
4	4.23	**	**	-3.77	**	**	-4.01	**	**	3.80	**	**	-3.95	**	**	3.73	**	**	3.98	**	**	3.40	**	**	4.08	**	**
5	2.40	*	*	1.14	*	*	-3.05	**	**	2.50	*	*	1.23	*	*	1.64	*	*	1.51	*	*	1.94	*	*	1.65	*	*
6	1.42	*	*	1.46	*	*	-0.65	*	*	0.48	*	*	1.04	*	*	-0.30	*	*	-0.31	*	*	-0.37	*	*	-0.21	*	*
7	1.61	*	*	1.14	*	*	-0.39	*	*	0.64	*	*	0.84	*	*	0.59	*	*	0.50	*	*	0.72	*	*	0.73	*	*
8	1.17	*	*	1.14	*	*	-0.58	*	*	0.98	*	*	0.69	*	*	0.20	*	*	0.10	*	*	0.84	*	*	0.21	*	*
9	0.67	*	*	0.06	*	*	-0.03	*	*	0.53	*	*	0.00	*	*	0.51	*	*	0.15	*	*	0.54	*	*	0.01	*	*
10	1.73	*	*	1.53	*	*	-1.02	**	**	1.64	*	*	1.51	*	*	2.03	*	*	1.74	*	*	1.84	*	*	1.43	*	*
11	0.92	*	*	0.52	*	*	-0.21	*	*	0.42	*	*	0.61	*	*	0.13	*	*	0.43	*	*	-0.03	*	*	0.16	*	*
12	0.33	*	*	0.37	*	*	-0.39	*	*	0.00	*	*	0.08	*	*	-0.11	*	*	-0.45	*	*	-0.27	*	*	-0.41	*	*
13																											
14	0.82	*	*	1.39	*	*	-0.57	*	*	0.10	*	*	0.80	*	*	-0.33	*	*	-0.43	*	*	-0.32	*	*	-0.75	*	*
15	0.55	*	*	1.15	*	*	-0.44	*	*	0.18	*	*	0.66	*	*	0.69	*	*	0.62	*	*	0.70	*	*	0.04	*	*
16	-0.82	*	*	-1.15	*	*	-1.58	*	*	-0.94	*	*	-1.72	*	*	-0.76	*	*	-1.12	*	*	-1.22	*	*	-1.38	*	*
17	0.02	*	*	-0.68	*	*	-1.29	*	*	-1.32	*	*	-1.00	*	*	-0.20	*	*	-0.39	*	*	-0.56	*	*	-0.54	*	*
18	-1.02	*	*	-0.48	*	*	-1.38	*	*	-1.56	*	*	-1.15	*	*	-0.57	*	*	-0.64	*	*	-0.91	*	*	-1.13	*	*
19	-0.78	*	*	-1.56	*	*	-1.49	*	*	-1.94	*	*	-1.94	*	*	-1.48	*	*	-1.19	*	*	-2.30	*	*	-2.13	*	*
20	-0.53	*	*	-0.48	*	*	-0.51	*	*	-1.11	*	*	-0.67	*	*	-0.12	*	*	-0.31	*	*	0.14	*	*	0.17	*	*
21	0.30	*	*	-0.10	*	*	-0.49	*	*	-0.25	*	*	-0.35	*	*	-0.47	*	*	-0.63	*	*	-0.86	*	*	-0.86	*	*
22	-0.19	*	*	-1.10	*	*	-1.60	*	*	-1.27	*	*	-1.38	*	*	0.00	*	*	-0.15	*	*	-0.50	*	*	-0.50	*	*
23	-0.97	*	*	-0.77	*	*	-1.15	*	*	-1.66	*	*	-1.67	*	*	-1.49	*	*	-1.48	*	*	-2.02	*	*	-1.81	*	*
24	1.23	*	*	1.65	*	*	-1.16	*	*	1.13	*	*	1.42	*	*	1.50	*	*	1.42	*	*	1.53	*	*	1.57	*	*
25	5.27	**	**	-5.59	**	**	-7.33	**	**	7.62	**	**	-5.60	**	**	2.46	**	**	2.73	**	**	2.32	**	**	2.31	**	**
26	3.83	**	**	-2.32	**	**	-4.01	**	**	3.58	**	**	-2.77	**	**	2.50	**	**	2.27	**	**	2.26	**	**	1.92	**	**
27	2.97	**	**	-3.50	**	**	-3.50	**	**	2.89	**	**	0.45	**	**	2.77	**	**	2.75	**	**	2.76	**	**	2.63	**	**
28	1.17	**	**	1.87	**	**	-2.03	**	**	1.55	**	**	1.93	**	**	0.67	**	**	0.86	**	**	1.34	**	**	1.15	**	**
29	1.60	**	**	1.95	**	**	-1.72	**	**	1.50	**	**	2.29	**	**	1.46	**	**	1.45	**	**	1.43	**	**	1.18	**	**
30	1.51	**	**	2.18	**	**	-1.28	**	**	1.00	**	**	1.77	**	**	1.02	**	**	1.20	**	**	1.13	**	**	0.87	**	**
31	0.83	**	**	0.93	**	**	-1.08	**	**	0.80	**	**	1.33	**	**	0.22	**	**	0.15	**	**	0.05	**	**	-0.12	**	**
32	0.69	**	**	0.21	**	**	-0.52	**	**	1.20	**	**	0.53	**	**	0.87	**	**	-0.03	**	**	1.09	**	**	0.11	**	**
33	0.12	**	**	0.67	**	**	-0.48	**	**	0.30	**	**	0.28	**	**	-0.40	**	**	-0.87	**	**	0.00	**	**	-0.30	**	**
34	0.71	**	**	-0.84	**	**	0.00	**	**	0.80	**	**	-0.44	**	**	1.26	**	**	1.49	**	**	1.62	**	**	1.37	**	**
35	1.37	**	**	1.15	**	**	-0.25	**	**	1.14	**	**	0.99	**	**	1.10	**	**	0.70	**	**	0.89	**	**	0.40	**	**
36	0.85	**	**	0.51	**	**	-0.39	**	**	0.69	**	**	0.58	**	**	0.87	**	**	0.71	**	**	0.87	**	**	0.46	**	**
37	1.61	**	**	1.01	**	**	-0.82	**	**	1.67	**	**	1.14	**	**	0.50	**	**	-0.08	**	**	0.24	**	**	-0.37	**	**
38	0.85	**	**	1.42	**	**	-1.61	**	**	0.84	**	**	1.58	**	**	1.10	**	**	0.66	**	**	0.44	**	**	0.41	**	**
39	1.46	**	**	1.50	**	**	-1.57	**	**	1.27	**	**	1.68	**	**	0.87	**	**	0.73	**	**	0.34	**	**	-0.08	**	**
40	0.56	**	**	0.56	**	**	-0.87	**	**	0.85	**	**	0.73	**	**	-0.09	**	**	0.08	**	**	-0.47	**	**	-1.08	**	**
41	0.43	**	**	0.36	**	**	-0.32	**	**	0.91	**	**	0.92	**	**	0.36	**	**	-0.86	**	**	0.75	**	**	-0.22	**	**
42	0.55	**	**	0.91	**	**	-1.06	**	**	0.75	**	**	0.96	**	**	0.48	**	**	0.39	**	**	0.22	**	**	-0.29	**	**
43	1.77	**	**	2.13	**	**	-1.72	**	**	1.36	**	**	1.86	**	**	1.24	**	**	1.04	**	**	1.81	**	**	1.52	**	**
44	2.32	**	**	0.79	**	**	-3.50	**	**	2.63	**	**	0.52	**	**	0.89	**	**	0.71	**	**	0.44	**	**	0.46	**	**
45	2.79	**	**	-1.70	**	**	-3.68	**	**	2.99	**	**	-1.52	**	**	0.50	**	**	0.68	**	**	0.24	**	**	-0.37	**	**
46	3.67	**	**	-1.22	**	**	-4.47	**	**	3.86	**	**	-1.26	**	**	1.55	**	**	1.47	**	**	1.84	**	**	1.02	**	**
47	4.56	**	**	-4.59	**	**	-7.03	**	**	5.71	**	**	-4.56	**	**	2.13	**	**	2.19	**	**	2.00	**	**	2.04	**	**
48	8.39	**	**	-6.93	**	**	-8.95	**	**	10.81	**	**	-6.78	**	**	5.42	**	**	-1.80	**	**	5.28	**	**	-1.76	**	**
E	10.92	**	**	567.80	**	**				20.29	**	**	728.33	**	**	3.53	**	**	208.98	**	**	4.85	**	**	218.94	**	**

Notes: The "Int" column shows the 5-min intervals. The line below the 24th interval indicates the lunch break. I-T (2-T) stands for I-tailed (2-tailed) test. Student (T), Signed-Rank (SR) and Wilcoxon-Mann-Whitney (U) test both the equality and superiority / inferiority of each 5-min interval's mean to the 10th intervals. Fisher (F) and Kruskal-Wallis (H) test the joint equality of fourty eight periods (5-min intervals). Under the null, T-statistics are distributed as T(63), SR- and U-statistics as Z(63), F-statistics as F(47, 3024) and H-statistics as $\chi^2(47)$ for alphas equaling .05 and .01. *, (**), + (++) and - (--) show the rejection of the null at the 5% (1%) level of significance.

Table 7
Average Trade Size (ATS) and Variance of Trade Size (VTS)

Int	Average trade Size (ATS)						Variance of Trade Size (VTS)											
	T	1-T	2-T	SR	1-T	2-T	U	1-T	2-T	T	1-T	2-T	SR	1-T	2-T	U	1-T	2-T
1	2,35	*	*	-4,07	**	**	-5,68	**	**	0,11			-3,62	**	**	-6,09	**	**
2	1,89			-3,50	**	**	-4,22	**	**	0,79			-3,35	**	**	-4,23	**	**
3	2,24	*	*	-2,93	**	**	-4,09	**	**	1,66			-2,67	**	**	-3,83	**	**
4	3,52	**	**	-4,64	**	**	-4,80	**	**	2,10	*	*	-4,39	**	**	-4,63	**	**
5	1,08			-1,93		*	-2,66	**	**	0,07			-1,60			-2,06	*	*
6	0,53			-0,43			-1,13			0,80			-0,31			-1,01		
7	0,54			-1,19			-1,65		*	0,40			-1,63			-1,47		
8	0,72			-0,03			-0,72			0,46			-0,89			-0,64		
9	0,50			-0,55			-0,66			0,85			-0,43			-0,30		
10	1,75		*	-1,82		*	-0,91			1,33			-1,43			-0,82		
11	0,71			-0,69			-0,54			0,92			-0,82			-0,60		
12	0,74			-0,30			-0,23			0,94			-0,11			-0,09		
13																		
14	-0,88			-0,30			-0,17			-0,60			-0,53			-0,09		
15	1,54			-0,58			-0,42			1,57			-0,46			-0,60		
16	0,07			-0,51			-0,29			0,62			-0,73			-0,91		
17	0,63			-0,46			-0,25			0,96			-0,54			-0,48		
18	-0,18			-0,04			-0,24			-0,84			0,00			-0,04		
19	0,17			-0,28			-0,08			0,59			-0,26			-0,19		
20	0,91			-1,06			-1,09			0,77			-0,90			-0,93		
21	-0,43			-0,22			-0,62			-0,41			-0,57			-1,02		
22	0,48			-0,03			-0,27			0,83			-0,21			-0,46		
23	-0,02			-1,30			-0,58			0,32			-1,53			-1,08		
24	2,00		*	-2,15	*	*	-3,36	**	**	0,93			-2,57	*	**	-3,40	**	**
25	1,39			-3,00	**	**	-3,41	**	**	1,01			-3,72	**	**	-3,86	**	**
26	2,42	*	**	-2,24	*	*	-2,55	*	**	1,93		*	-2,34	*	**	-2,73	**	**
27	2,91	**	**	-2,74	**	**	-3,27	**	**	2,24	*	*	-3,16	**	**	-2,84	**	**
28	1,85		*	-2,58	**	**	-2,68	**	**	1,86		*	-2,58	**	**	-2,60	**	**
29	1,56			-1,73		*	-2,25	*	*	1,06			-1,42			-2,33	*	*
30	1,32			-1,61			-1,18			1,22			-1,89	*		-1,18		
31	1,03			-0,25			-1,21			0,70			-0,03			-0,77		
32	0,52			-1,03			-0,02			0,25			-0,80			-0,26		
33	-0,25			-0,31			-0,96			-0,17			-0,33			-0,91		
34	0,12			-0,04			0,00			0,57			-0,19			-0,20		
35	1,38			-1,15			-0,98			1,20			-1,08			-0,82		
36	1,53			-1,18			-1,07			1,31			-1,38			-1,39		
37	1,10			-1,00			-0,60			0,95			-0,87			-0,80		
38	0,22			-0,33			-1,17			0,40			-0,22			-1,12		
39	0,49			-0,84			-1,21			0,19			-1,04			-0,89		
40	1,25			-0,91			-1,02			1,50			-0,91			-1,05		
41	0,64			-0,10			-1,51			0,40			-0,05			-1,51		
42	1,55			-1,44			-1,69		*	1,64			-1,50			-2,06	*	*
43	0,64			-0,14			-0,50		*	0,83			-0,84			-0,73		
44	1,31			-1,19			-1,68		*	1,11			-1,31			-1,68		*
45	1,55			-2,43	*	**	-1,67		*	1,50			-2,84	**	**	-1,96	*	*
46	0,42			-1,87		*	-2,06	*	*	0,30			-1,89		*	-2,24	*	*
47	1,16		**	-2,21	*	*	-4,18	**	**	1,17			-3,02	**	**	-4,23	**	**
48	3,56	**	**	-4,51	**	**	-6,69	**	**	1,19			-4,29	**	**	-6,69	**	**
	E			H						E			H					
	1,43	*		295,10	**					0,77			306,07	**				

Notes :

The "Int" column shows the 5-min intervals. The line below the 24th interval indicates the lunch break. 1-T (2-T) stands for 1-tailed (2-tailed) test. Student (T), Signed-Rank (SR) and Wilcoxon-Mann-Whitney (U) test both the equality and superiority / inferiority of each 5-min interval's mean to the 13th interval's. Fisher (F) and Kruskal-Wallis (H) test the joint equality of forty eight periods (5-min intervals). Under the null, T-statistics are distributed as T(63), SR- and U-statistics as Z(63), F-statistics as F(47,3024) and H-statistics as $\chi^2(47)$ for alphas equaling .05 and .01. * (**), + (**+) and - (--) show the rejection of the null at the 5% (1%) level of significance.

Table 8 Percentage Change in Average Price (PCAP) and Percentage Change in Volume-Weighted Average Price (PCVWAP)

Int	Percentage Change in Average Price (PCAP)				Percentage Change in Volume-Weighted Average Price (PCVWAP)															
	T	1-T	2-T	SR	U	1-T	2-T	SR	T	1-T	2-T	U	1-T	2-T	SR	T	1-T	2-T	SR	
1	3.80	**	**	-3.82	**	3.56	**	-3.49	**	2.61	**	-2.41	**	-2.65	**	2.36	**	-2.85	**	-1.99
2	-0.45			-0.42		-1.74		-1.30		-0.08		-0.13		-0.86		-0.91		-0.86		-0.23
3	1.81	*	*	-1.91	*	1.22	*	-1.54	*	2.24	*	-2.08	*	-2.19	*	2.13	*	-2.19	*	-1.34
4	1.00			-0.35		0.14		-0.94		0.90		-0.86		-0.86		0.15		-0.86		-0.01
5	2.16	*	*	-1.59	*	1.70	*	-0.94	*	2.09	*	-1.66	*	-2.08	*	1.78	*	-2.08	*	-1.39
6	1.13			-0.82		0.26		-0.08		0.57		-0.38		-0.80		-0.26		-0.80		-0.41
7	0.24			-0.12		-0.74		-0.15		0.46		-0.54		-0.71		-0.50		-0.56		0.17
8	0.90			-0.57		-0.09		-0.15		0.46		-0.54		-0.71		-0.50		-0.71		-0.50
9	0.05			-0.53		-1.35		-1.11		0.88		-0.54		-0.70		0.14		-0.70		-0.36
10	0.35			-0.14		-0.98		-0.68		-0.93		-1.46		-0.77		-2.29		-2.29		-2.21
11	1.50			-1.82		0.77		-0.93		1.16		-1.13		-1.50		0.50		-1.50		-0.46
12	0.78			-0.19		-0.29		-0.47		1.64		-1.48		-1.59		1.17		-1.59		-0.68
13						-1.34		-0.72							1.15				-1.34	
14	1.03			-0.77		0.01		-0.52		0.65		-0.62		-1.27		-0.24		-1.27		-0.24
15	0.83			-0.91		0.25		-0.11		0.72		-0.56		-1.14		-0.03		-1.14		-0.03
16	0.31			-0.45		-0.89		-1.45		-0.04		-0.01		-0.45		-0.95		-0.45		-0.73
17	0.59			-0.47		-0.48		-0.20		0.87		-1.16		-1.11		0.20		-1.11		0.16
18	0.82			-0.02		-0.26		-0.39		0.15		-0.37		-0.32		-0.71		-0.32		-0.68
19	0.84			-0.23		-0.23		0.15		0.19		-0.29		-0.32		-0.89		-0.32		-1.35
20	0.25			-0.08		-1.00		-0.68		0.43		-0.71		-1.20		-0.50		-1.20		-0.27
21	0.76			-0.54		-0.36		-0.47		1.02		-1.02		-0.96		0.32		-0.96		0.01
22	0.51			-0.48		-0.63		-0.47		-0.39		-0.36		-0.42		-1.49		-0.42		-1.56
23	0.95			-0.98		-0.10		0.10		2.02	*	-2.05	*	-1.95	*	1.71	*	-1.95	*	-1.22
24	1.46			-1.15		0.65		-0.61		0.12		-0.18		-0.61		-0.99		-0.61		-0.68
25	-0.78			-1.11		-1.87		-2.07	*	-0.44		-0.41		-0.32		-1.34		-0.32		-1.57
26	0.55			-0.62		-0.65		-1.11		1.52		-1.49		-1.11		1.00		-1.49		1.00
27	2.29	*	*	-1.99	*	1.88	*	-1.75	*	1.51		-1.52	*	-2.13	*	1.01		-2.13	*	-1.44
28	2.25	*	*	-1.46	*	1.81	*	-1.39	*	1.02		-0.83	*	-1.33	*	0.37		-1.33	*	-0.43
29	1.11			-1.04		0.36		-0.49		0.97		-0.92		-1.38		0.34		-1.38		-0.59
30	0.50			-0.05		-0.63		-0.84		0.60		-0.54		-1.03		-0.25		-1.03		-0.09
31	2.11	*	*	-2.07	*	1.64	*	-1.42	*	2.81	**	-2.27	**	-2.98	**	2.79	**	-2.98	**	-2.05
32	0.20			-0.47		-1.08		-1.36		-0.26		-0.22		-0.14		-1.33		-0.14		-1.33
33	0.67			-0.09		-0.52		-0.83		0.37		-0.40		-0.62		-0.55		-0.62		-0.54
34	0.81			-0.45		-0.22		-0.40		0.70		-0.96		-1.36		0.07		-1.36		-0.45
35	0.87			-0.72		-0.09		-0.33		0.80		-0.57		-1.28		-0.16		-1.28		-0.20
36	1.21	**	**	-1.06	**	0.31	**	-0.39	**	0.80		-0.74	**	-1.09	**	0.03	**	-1.09	**	-0.13
37	3.43	**	**	-2.95	**	3.89	**	-3.38	**	3.14	**	-2.64	**	-3.18	**	3.34	**	-3.18	**	-3.11
38	1.19			-0.72		0.41		-0.25		0.82		-1.00		-0.50		0.16		-0.50		-0.22
39	-0.35			-0.49		-1.94		-1.67		-0.06		-0.35		-0.18		-1.03		-0.18		-1.14
40	1.20			-0.34		0.37		-0.12		0.72		-0.82		-1.09		-0.12		-1.09		-0.11
41	0.53			-0.26		-0.76		-0.45		0.59		-0.42		-0.59		-0.20		-0.59		-0.55
42	-0.39			-0.18		-1.77		-1.65		0.02		-0.43		-0.79		-1.13		-0.79		-0.49
43	1.35			-1.24		0.55		-0.70		-0.40		-0.09		-0.09		-1.54		-0.09		-1.20
44	0.60			-0.56		-0.51		-0.43		0.98		-1.26		-1.43		0.29		-1.43		-0.56
45	0.00			-1.22		-1.33		-1.50		0.33		-0.17		-0.34		-0.83		-0.34		-0.83
46	-0.40			-0.76		-2.17	*	-2.05	*	-0.43		-0.58		-0.63		-1.71	*	-0.63	*	-2.01
47	0.56			-0.32		-0.88		-1.27		0.66		-0.43		-0.67		-0.36		-0.67		-0.82
48	1.17			-0.88		0.32		-0.23		2.27	*	-2.32	*	-2.53	*	2.01	*	-2.32	*	-2.06
F	3.33	**	**	-78.24	**					1.75	**	63.27	**							

Notes: The "Int" column shows the 5-min intervals. The line below the 24th interval indicates the lunch break. 1-T (2-T) stands for 1-tailed (2-tailed) test. Student (T), Signed-Rank (SR) and Wilcoxon-Mann-Whitney (U) test both the equality and superiority / inferiority of each 5-min intervals' mean to the 13th intervals'. Fisher (F) and Kruskal-Wallis (H) test the joint equality of fourty eight periods (5-min intervals). The last two columns in italics show the results of significance test. Under the null, T-statistics are distributed as T(63), SR- and U-statistics as Z(63), F-statistics as F(47,3024) and H-statistics as $\chi^2(47)$ for alphas equaling .05 and .01. * [**], + [++] and - [--] show the rejection of the null at the 5% [1%] level of significance.

Table 9
Variance of Price (VP) and Volume-Weighted Variation in Price (VwVP)

Int	Variance of Parice (VP)						Volume-Weighted Variation in Price											
	T	1-T	2-T	SR	1-T	2-T	U	1-T	2-T	T	1-T	2-T	SR	1-T	2-T	U	1-T	2-T
1	2,15	*	*	-1,71	*	*	-1,69	*	*	0,03			-0,89			-0,10		
2	-1,23			-1,29			-1,25			-1,11			-1,20			-1,03		
3	-0,89			-0,75			-0,49			-1,37			-1,29			-1,34		
4	-0,45			-0,43			-0,55			-1,70			-1,92			-1,58		
5	-1,19			-1,28			-1,28			-0,84			-0,71			-0,66		
6	0,45			0,20			-0,02			-0,33			-0,12			-0,12		
7	0,38			0,41			-0,36			-0,56			-0,38			-0,43		
8	-0,21			-0,54			-0,11			0,49			-0,38			-0,45		
9	0,06			-0,30			-0,29			0,45			-0,72			-0,52		
10	-0,10			-0,38			-0,16			1,05			-0,36			-0,90		
11	0,15			0,21			-0,45			-0,89			-0,83			-0,94		
12	-1,08			-0,97			-0,84			-0,34			-0,50			-0,56		
13																		
14	0,41			-0,35			-0,46			0,53			-0,47			-0,57		
15	-0,80			-0,78			-1,02			-0,26			-0,26			-0,32		
16	-0,07			-0,13			-0,18			0,59			0,27			-0,55		
17	-0,48			-0,50			-0,54			-1,60			-1,32			-1,65		
18	-1,07			-0,95			-1,27			-0,24			-0,03			-0,54		
19	0,55			-0,68			-0,75			0,64			-0,68			-0,71		
20	-0,46			-0,31			-0,25			0,45			-0,07			-0,17		
21	-0,14			-0,24			-0,19			0,37			-0,17			-0,36		
22	-0,80			-0,87			-0,71			-0,55			-0,56			-0,41		
23	0,25			-0,23			-0,14			0,16			-0,07			-0,34		
24	0,15			0,13			-0,61			-1,55			-1,68			-1,50		
25	0,39			-0,30			-0,10			-0,11			-0,23			-0,04		
26	-0,25			-0,41			-0,53			-1,07			-1,10			-0,88		
27	0,36			-0,02			-0,25			-1,18			-1,60			-1,03		
28	0,63			0,32			-0,70			-0,62			-0,58			-0,50		
29	0,89			0,56			-1,07			0,58			-0,14			-0,60		
30	0,21			0,00			-0,14			-0,27			-0,31			-0,14		
31	-0,19			-0,29			-0,64			0,00			-0,10			-0,04		
32	0,14			-0,30			-0,15			0,64			-0,62			-0,80		
33	2,16	*	*	-1,85	*	*	-1,77	*	*	0,77			-0,61			-0,87		
34	-0,09			-0,02			-0,20			0,32			0,20			-0,21		
35	-0,32			-0,23			-0,16			-0,10			-0,14			-0,43		
36	0,34			-0,01			-0,04			-0,59			-0,53			-0,46		
37	-0,17			-0,40			-0,24			0,75			-0,41			-0,59		
38	1,01			-0,91			-0,49			0,37			-0,39			-0,73		
39	0,49			0,37			-0,57			0,42			0,03			-0,46		
40	0,11			-0,27			-0,11			0,39			-0,32			-0,55		
41	1,08			0,39			-1,13			0,61			-0,21			-0,64		
42	1,08			-1,07			-0,84			0,33			-0,22			-0,47		
43	1,90	*	*	-2,05	*	*	-2,05	*	*	1,11			-1,11			-1,28		
44	1,29			-1,16			-1,33			0,42			-0,62			-0,69		
45	-0,33			-0,17			-0,47			0,17			-0,07			-0,12		
46	0,08			0,06			-0,23			0,23			-0,27			-0,20		
47	-0,66			-0,77			-0,79			-1,14			-0,90			-0,92		
48	1,50			-0,92			-0,42			0,74			-0,80			-0,87		
	E			H						E			H					
	1,28			53,47						1,04			48,84					

Notes :

The "Int" column shows the 5-min intervals. The line below the 24th interval indicates the lunch break. 1-T (2-T) stands for 1-tailed (2-tailed) test. Student (T), Signed-Rank (SR) and Wilcoxon-Mann-Whitney (U) test both the equality and superiority / inferiority of each 5-min interval's mean to the 13th interval's. Fisher (F) and Kruskal-Wallis (H) test the joint equality of forty eight periods (5-min intervals). Under the null, T-statistics are distributed as T(63), SR- and U-statistics as Z(63), F-statistics as F(47,3024) and H-statistics as $\chi^2(47)$ for alphas equaling .05 and .01. * (**), + (**+) and - (-) show the rejection of the null at the 5% (1%) level of significance.

Table 11

Some Results from the Sensitivity Analysis

Variable	Comparison of the test results using 5-min intervals and 15-min intervals
<i>%NT</i>	SR and U statistics are more sensitive with 15-min intervals in the second half of the morning session.
<i>NIT</i>	SR and U statistics are more sensitive with 15-min intervals in the second half of the morning session.
<i>NBT</i>	SR statistics are more sensitive with 15-min intervals.
<i>%NBT</i>	U statistics are more sensitive with 15-min intervals.
<i>ATS-VTS</i>	T and SR statistics are less sensitive with 15-min intervals.
<i>PCAP</i>	SR statistics are more sensitive with 15-min intervals. T test does not find any significantly different interval from the 13 th , although F test rejects the null at the 1% level of significance.
<i>PCVWAP</i>	T statistics are less sensitive with 15-min intervals.
<i>AART</i>	AART in the 14:15-14:30 interval is significantly lower than the 11:00-11:15 interval by all the tests with 15-min intervals, which is not the case with 5-min intervals. F and H tests reject the null with 15-min intervals while they do not with 5-min intervals.

Figure 1

Averages of V, NT, %V and %NT

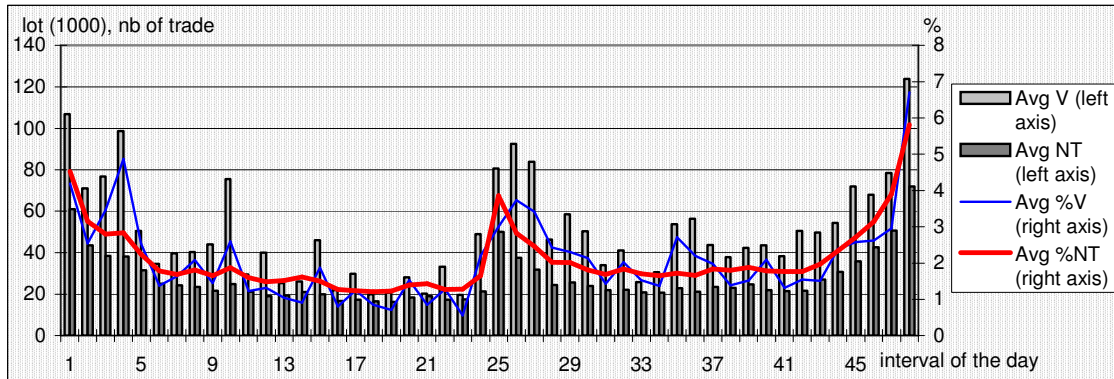


Figure 2

Averages of NIT, NBT, %NIT and %NBT

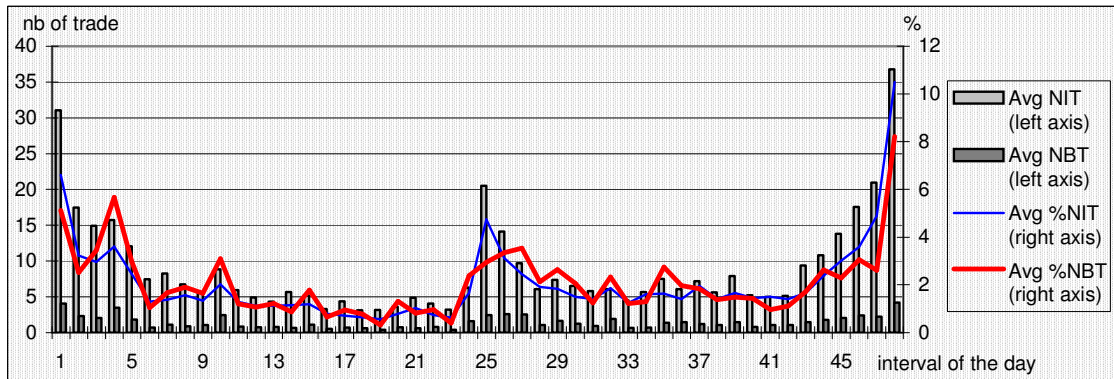


Figure 3

Averages of ATS and VTS

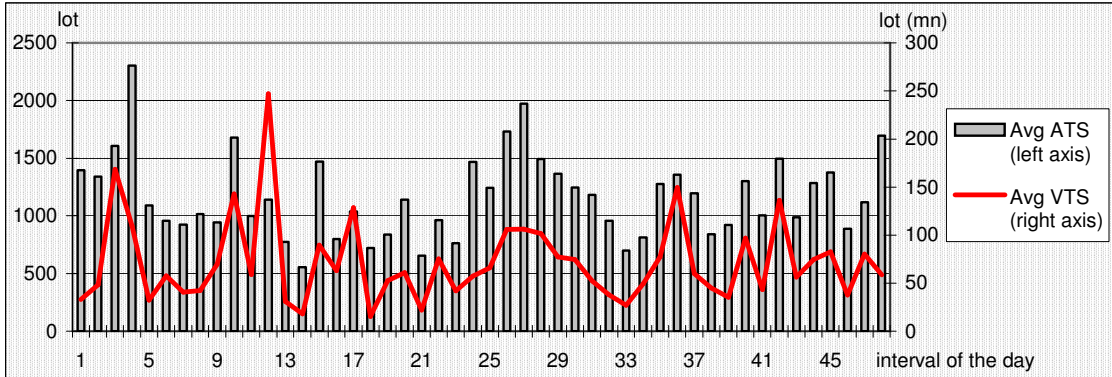


Figure 4

Averages of PCAP and PCVWAP

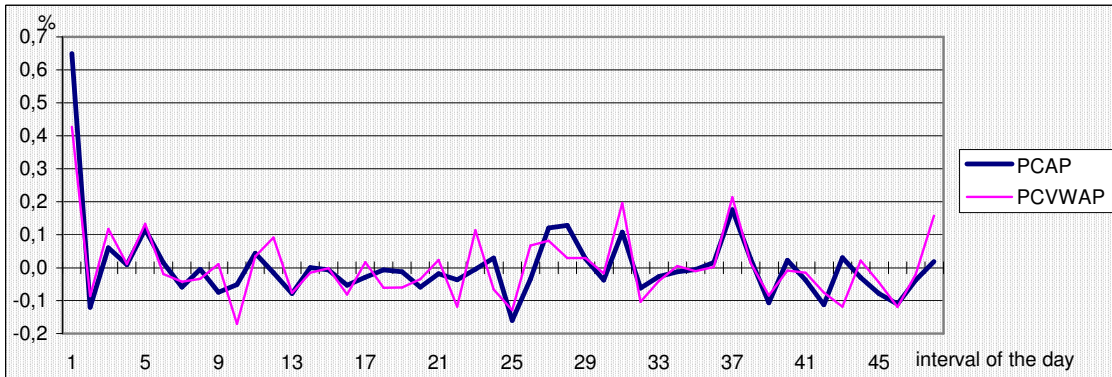


Figure 5

Averages of VP and VWVP

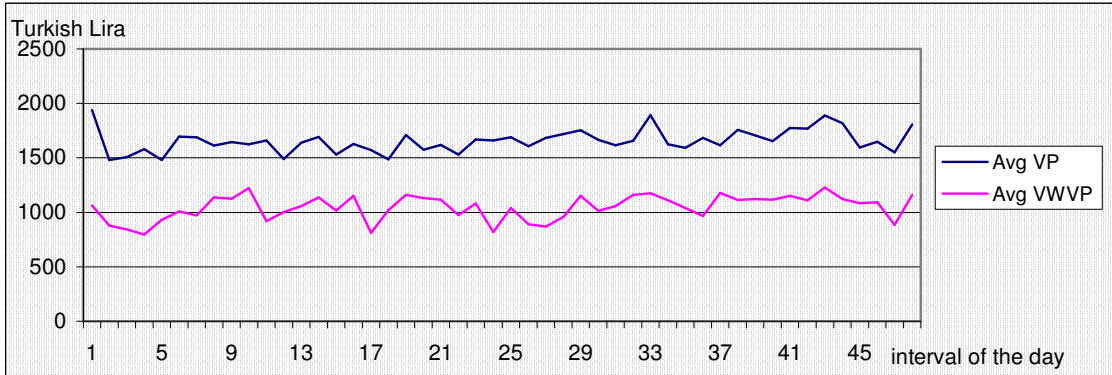


Figure 6

Averages of SAR and AART

