BID-ASK SPREAD COMPONENTS: EVIDENCE FROM PFTS (FIRST UKRAINIAN TRADING SYSTEM)

by

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Abstract

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The bid–ask spread is often considered as a cost that an investor pays for a round trip trade. Therefore its magnitude is one of the major factors of the stock market development.

In late October, 2007 PFTS introduced market-makers for several securities in order to provide more liquidity and decrease spreads in the Ukrainian stock market. In these conditions it was interesting to explore the components and the dynamics of spreads just prior to the introduction of the so-called "liquidity providers". One or two years from now on there would be completely different picture of the Ukrainian stock market.

The model of the bid–ask spread designed for one market microstructure has shown a generally good performance in another market microstructure conditions. While the inventory holding cost component of the spread originates from the activity of market makers the model tested on the Ukrainian stock market before they were introduced provided statistically and economically significant results.

In this thesis I also aimed to get adequate estimates for the scope of informed trading on the domestic stock market. The obtained results suggest that there

were only two components of the spread: order proceeding and adverse selection. At the same time the estimates of the adverse-selection component seem to be lower than the true level.

The model was applied to analyse an intraday and intraweek trading volumes, posted and traded spreads development for years 2005 and 2006. No strong patterns of their dynamics were observed. However certain features of the prices, spreads and trade volume are similar to those of developed markets are present. One important conclusion is that spreads declined through 2005- 2006. In my opinion this can be explained primarily by a general improvement of the information flows in Ukrainian stock market.

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GLOSSARY

Ask price. Price at which a dealer is ready to sell a security.

Bid price. Price at which a dealer is ready to buy a security.

Effective bid-ask spread. The difference between a transaction security price and quote midpoint at a specific moment in time.

Free float. The ratio of freely circulating stocks of a given company to the number of shares outstanding (charter fund).

Inside quote. Any price between bid and ask prices.

Market makers (Liquidity providers). The participants of a trading system that are obliged to permanently post bid and/or ask quotes for a specific list of companies and obliged to fulfill trade orders from the public. Market makers' quotations are subject to certain restrictions (usually there their spreads are bounded by the Exchange authorities)

Posted bid-ask spread. The difference between the ask security price and the bid security price at a specific moment in time.

Quote midpoint. The half of the sum of best bid and best ask quotes

Relative bid-ask spread. The relation of the posted bid-ask spread to the quote midpoint

Traded bid-ask spread. The difference between the price at which a dealer sells a security at a moment t and the price at which he/she bought it at a moment t-1.

Chapter 1

INTRODUCTION

The necessity in the correct estimation of the bid-ask spread and its components has been evident for investors, financial authorities and researchers for a long time. Indeed, bid-ask spread is one of the main components of trading costs faced by traders in any stock market. Higher spreads for a given stock imply higher expected price (risk) of a round trip trade – process of buying of the stock and its further reselling. Naturally, an investor or trader that acts optimally will, ceteris paribus, chose stocks with lower spreads since in this case he will loose less when liquidating its inventory position. On the other hand, national securities issuers, ceteris paribus, could also choose a foreign trade floor on which order processing costs are lower. As a result, the size of the bid-ask spread significantly impacts actual stock market trade volumes and trade dynamics. In other words, resources that can be allocated through the stock market (they can enhance economic growth) are widely influenced by the magnitude of spreads.

Although empirical evidence of the bid-ask spread and its components has been interesting for practitioners and theoreticians for a long time, developing capital markets are still poorly studied in this field. Up to now there has been no scientific work presenting a study of the bid-ask spread on Ukrainian stock market.

To fill the gap, in this thesis I propose to execute a decomposition of the bid-ask spread into three components using a model of the trade indicator similar to that developed in Hanousek and Podpiera (2003) for the case of Czech equity market.

1.1 Ukrainian context

There are currently ten different stock exchanges and one trading information system in Ukraine. The PFTS, "Persha Fondova Torgova Systema", is an advanced electronic trade system which covers 97 % of the organized Ukrainian stock market. Since summer 2004 the Ukrainian Stock Market, which stagnated for a long time after the financial crisis of 1998, has started so powerfully, that at the end of 2006 it ranked among the world leaders by rate of growth. Since 2004 PFTS index added a lot to recover from below 100 points to a historical peak of 843 points in March 2007. The overall market turnover has been doubling each year since 2002 and grew up to UAH 403.76 bn in 2005. Remaining very susceptible to external factors the Ukrainian stock markets has recently started to show a dynamics that is different from the Russian RTS index.

Nonetheless, about 95% of the Ukrainian stock market is non-organized, the national stock market lacks liquidity, capital supply and smaller spreads. According to Kaminsky et al. (2000), these are key problems of all emerging markets, and Ukraine is not an exception. The importance of this issue for the domestic economy is rising with the tendency that more and more companies begin to search better markets abroad to be traded in or to make an Initial Placement Offer (IPO). They often chose London AIM with less restrictive legal terms of trade and high chances to attract foreign investors or large and more liquid Russian RTS (nowadays the stock market capitalization to GNP ratio is only 35 % in Ukraine whereas in Russia it goes up to 85%). Anecdotic evidence tells that Ukrainian Stock Market would be ruined if a dozen of the largest domestic companies or groups such as SCM, Privat or Interpipe leave it. Generally small free floats (about 8-10% on average) of companies listed on PFTS will be transferred abroad. When their stocks start to being traded on foreign trade floors, capital flight will dramatically increase. Evidently, the underdeveloped banking sector will not be able to provide the needed capital at reasonable prices which are already rather high. No doubt, that will badly hurt the fragile growth of the national economy which could even transform into recession.

What is of primary importance for Ukrainian financial authorities now is a clear understanding that in the context of rapidly developing global telecommunications and a growing availability and ease of access of foreign stock issuers and investors to mature foreign stock markets, Ukrainian stock market can in one instance lose its dynamic growth, be absorbed or monopolized by more developed neighbor stock markets (e.g. Austrian companies are traded on Frankfurt Stock Exchange). If during some time there will be no significant improvement in companies' transparency and a consequent trading activity growth, the low liquid domestic stock market could become not interesting for stock issuers that search cheap financing, for traders and investors who seek for justified risks and finally for the government that has been announcing its plans to privatize state-owned plants on foreign markets that are more likely to price a business more fairly and pay for it a fair price.

Chapter 2

LITERATURE REVIEW

It is worth noting that a theory of a bid-ask spread is a theory of the posted bid-ask spread. It is quite straightforward: no reason to study the traded bid-ask spread because in this case an investor freely chooses the time (and therefore, the price) of a purchase and then he chooses the time (and the price) of a sale. The latter choice is very subjective and personal.

Modern financial literature lists the following three components of bid-ask spread:

•order processing costs component, which compensates market makers for different types of order execution cost (labor, equipment costs etc.);

•inventory holding costs component, which compensates market makers for taking undesired inventory positions;

•adverse selection cost component that compensates market makers for trading with informed traders.

Since the seminal work by Demsetz (1968), many researchers tried to model the components of the posted bid-ask spread. While order processing component of the spread was the first to attract attention of researchers on the spread, namely in papers by Demsetz (1968) and Tinic (1972), more recent researchers concentrate mostly on the remaining two components. (It is worthwhile to mention that later researchers also do recognize the importance of order processing costs.) Inventory holding component of the bid-ask spread are studied in great detail in Stoll (1978), Amihud and Mendelson (1980) and Ho and Stoll

(1981). The role of adverse information costs, that a dealer faces, is studied in Copeland and Galai (1983), Glosten and Milgrom (1985) and Easley and O'Hara (1987).

Inventory cost and adverse information cost models predict that the posted spread for a security is greater than the traded spread [Stoll (1976), (1985)]. The inventory cost model explains such inequality with a dealer's incentive to diminish (increase) both bid and ask prices after a he/ she buys (sells) in order to initiate order flow of such sign and magnitude that his inventory level will be at optimum. According to the adverse information cost model, bid and ask prices are expected to react in a similar way. The logic is simple: if one assumes that some traders are better informed than others, and, therefore, transactions bear information, then dealers will diminish (increase) both bid and ask prices after a he/ she buys (sells) since they will interpret a buy (sell) order for a security as a signal that its posted price is higher (lower) that the true price. It is easy to see, that quotes react to trades in the same manner under both inventory and adverse information motives. Therefore, it is difficult and even impossible to distinguish between these motives in the two-way decomposition models [Huang & Stoll (1997)].

It is worth noting that some researches like George et al. (1991) reject the assumption that there should be inventory holding costs component. Hanousek and Podpiera (2003) also argue that this component exists but in extreme situation of a general trading pressure. I will discuss this point later below in this work.

Empirical studies of the bid-ask spread can be divided into two classes of models: covariance-based models and trade indicator models. The first class of models originates from the paper by Roll (1984). Roll showed that one can estimate the traded spread in an efficient market (he considered stocks traded at NYSE) with help of covariance of transaction returns. His assumptions that dealers face only order-processing cost were quite strong. For that reason his mode is often called a naive order processing cost model of the posted spread. Although Roll did not propose a model of a relation between the posted and the traded spread, he found out that the former is greater than the latter, as noted above. Other covariance-based models were developed in Choi et al. (1988), Stoll (1989), and George et al. (1991).

Stoll's (1989) model is of particular interest since it gives a way to estimate all three components of the spread. In this sense the model is "full". The author estimates the spread components in two stages. Stoll calculates an estimate of traded spread with help of estimates of the covariance of price changes and the covariance of quote changes. Adverse selection component is then calculated by subtracting the posted spread from traded spread. The latter is be decomposed into the order processing and the inventory holding components, which are combinations of estimated probability of trade reversal and the magnitude of a price change as a spread portion.

George et al. (1991) also use two stages. Firstly, they compute the serial covariances, and then they regress these serial covariances on posted spread.

George et al. (1991) decomposed the bid-ask spread into the order processing cost and the adverse selection cost. They also showed that the spread estimates provided in Stoll (1989), as well as those in Roll (1984), suffer from a downward bias since they do not account for the fact that expected returns vary with time. To fight the problem they propose "a new approach", measuring spread on the basis of serial covariance of the difference between transaction returns and returns at bid prices.

The second class of models, where spread components are estimated by running price changes on a trade indicator variable which is assigned +1 if a trade is buyer-initiated and -1,if it is seller-initiated, was pioneered by Glosten and Harris (1988). The authors tried to model the relation between the posted and traded bid-ask spreads (of NYSE stocks) in a more explicit way than Roll did and attempted to estimate the order processing and adverse selection components of the spread. Interesting is that they considered these components as linear combinations of trade size, supposing by this that spread depends on the trade size. They found that in the best model specification order processing component is constant while the adverse selection component is positively related to the trade size. This finding is consistent with the presence of informed traders which trade larger quantities optimizing the return of their private information, evidence shown in Easley and O'Hara (1987). Unfortunately, Glosten and Harris had some problems with estimating components of the spread since they were short of posted spreads data.

Other two-way decomposition models of estimation order processing and adverse selection costs are those of Hasbrouck (1988), Lin et al. (1995), Madhavan et al. (1997) and Huang and Stoll (1994). Lin et al. (1995) estimate the effect of trade size on the adverse information component of the spread. Their model is special due to use of the effective spread. Their model adds such parameter as the extent of order persistence to mention above probability of trade reversal and the magnitude of a price change. They are estimated via non-simultaneous estimation of 3 equations (list the purpose that these equations serve). In Madhavan et al. (1996) spread is decomposed into a permanent component due to adverse information and a transitory component. They estimate also three additional parameters: the probability a transaction takes place inside the spread, the probability of trade continuation and the first-order autocorrelation of the trade initiation variable. Huang and Stoll (1994) show that short-run security price changes of are influenced, among others, by microstructure factors.

Finally, I come to Huang and Stoll's (1997) model within which all previous models are "reconciled". Showing that in the two-way decomposition models, the first parameter represents a mix of the adverse selection and inventory holding costs, while the second parameter stands for the order processing cost, they proposed and tested two extensions of their basic model to separate the two effects. They accomplished further decomposition of the first parameter with help of the probability of trade reversal. Being a three-way decomposition model, the model is "full", like that of Stoll (1989). Other key features of Huang and Stoll's (1997) models are: simplicity, possibility to be implemented easily with a one-step regression procedure and flexible framework for examining a number of microstructure problems like trade size role in forming components of the bid-ask spread, variability of spreads and their components during different time intervals, the asymmetry in the price effect of block trades (the authors confirmed results of previous researchers that the spread components depend on the trade size).

It is worthwhile that transaction prices covariances models assume efficiency of markets, which is not appropriate for the Ukrainian stock market presumed to show weak form inefficiency, or at least the joint hypothesis of weak form inefficiency found by Nikulyak (2002). The fact that trade indicator models are not based on covariances of stock prices and the mentioned above strong advantages of Huang and Stoll's (1997) model speak loudly in favor of this model to be applied to the Ukrainian stock market. But their model needs some modifications due to the following reasoning.

As mentioned above, when inventory of liquidity suppliers is imbalanced and they want to induce inventory equilibrating order flow they post higher bid and ask quotes (correspondingly, the midpoint moves in the same direction). That is a prediction conventional inventory theories of the spread and the Huang and Stoll's (1997) model. Meanwhile, not all researchers, for example, Hanousek and Podpiera (2003), agree with that approach. In their study they executed a decomposition of the bid-ask spread into three components using a modification of Huang and Stoll's (1997) model for the case of the most liquid companies traded on SPAD, a segment of the Prague Stock Exchange. The authors were the first to say that the traditional assertion only holds true when there is a single market maker or dealer like the specialist at NYSE. They assert that in competitive dealer systems (like NASDAQ, SPAD in Prague) markets behave differently from a single dealer system. Hanousek and Podpiera (2003) argue that quotes revisions due to inventory considerations are rather weak. First, the same risk of undertaking undesired inventory is shared by a larger number of dealers, which makes the reaction to inventory weaker. Second, the reaction to inventory is weakened by the behavior of dealers. In fact, dealers with extreme inventory positions are more likely to post the inside quote in order to reverse their inventory positions. Market makers with the best quotes who got the imbalanced inventory would also post the inside quotes. Meanwhile, dealers who posted the second-best quotes would not be affected by the change in inventory but only by the adverse information contained in the trade. The same holds true for other dealers.

Hanousek and Podpiera (2003) assert that normally quotes are very rarely adjusted due to inventory reasons. They say that dealers with the best quotes actually want the inventory and there is no reason to expect pressure from trading between dealers. Periods of serious selling or buying pressure are quite unusual. During these periods trade between dealers increases sharply – some dealers use inter-dealer trade to balance their inventory. In such cases, those who are not directly affected by the current trade are more likely to revise their quotes due to inventory reasons. In order to incorporate the above arguments in the model, they create a dummy variable "PRESS" reflects the presence of selling or buying pressure.

SPAD is a computer-based system multiple-dealer system (like PFTS) which unites a big number of competing dealers that can observe all quotes and trades. The informational efficiency of the Czech Stock Market in 2002 was weak. These similarities speak for our choice of their version of the original trade indicator Huang and Stoll's (1997) model in this Thesis.

C h a p t e r 3

METHODOLOGY AND ESTIMATION RESULTS

3.1 Main Hypotheses

During our sample period there were no market makers on the Ukrainian stock market. They were introduced on the PFTS only in late October, 2006.

Any particular dealer was forced to permanently post quotations in order to support liquidity in the market. This means that all quotations posted by dealers and all deals executed by them were desirable. Unlike market makers they could keep themselves from buying or selling stocks in case they did not wanted so. This automatically means that an argument that risk of undesirable inventories should be rewarded to the dealer is nonsense for the Ukrainian stock market.

Thus a first and main hypothesis tested in this thesis is a hypothesis of no inventory holding cost component.

The second hypothesis concerns a statistical and economic significance of the adverse selection cost component. Several methodologies of decomposing the bid-ask spread reported statistically significant negative values for the averse selection cost component

The third hypothesis would be about the size of informed trading as measured by the magnitude of adverse selection cost component. We expect it to be high enough since as people whose daily job is trading say that the insider trading is unfortunately a permanent feature of the Ukrainian stock market.

And fourth, we expect that there is a negative relation between the magnitude of the adverse-selection cost component and a trade size as Huang and Stoll(1997) showed. The explanation for this is large trades seem to be prenegotiated such that the trade price already bears the information content of the trade.

3.2 Data description

Data on individual trades from PFTS trading terminal have been publicly available since the beginning of 1997. Our sample period covers 22 months from January 1, 2005 to November 28, 2006. For this period I have information about each trade and quote in PFTS. The dataset consists of a security identification (PFTS ticker), transaction price, number of shares sold, time when the trade was concluded and a history of best bid and best ask quote prices with the corresponding number of shares proposed for sell or to buy.

It is worth noting that number of deals, average prices, spreads and trading volumes presented in this thesis are calculated from trades registered during open phase of trading on PFTS. This is common practice for studies on the bid-ask spread decomposition. Omission of the trades registered before the open (11:00) and after the close (17:00) reduces the number of observations and approximately by 35% (see Table B1). Naturally, recalculated annual and daily trading volumes are significantly underreported. From now on Iwill refer to the number of deals (annual and daily), average prices, spreads and trading volumes (annual and daily) as to those calculated from trades registered during open phase of trading.

In this thesis, I examine ten most actively traded stocks (see Table A1) which are also largest by market capitalization and trade volumes. A majority of them are included in the PFTS-14 index. Despite these stocks are most liquid on PFTS there are significant differences among them. Descriptive statistics on the securities are presented in Appendix B.

First of all, the considered companies are of different size and the gap in market capitalization of them is considerable. Out of ten selected companies five are comparatively large. They had an average market capitalization (in 2005-2006) greater than UAH 5000,000 mn while the capitalization of others was significantly lower. For the sake of comparison, an average capitalization of DTRZ was UAH 404mn while it amounted UAH 15,530mn for UTEL.

Average transaction prices, posted and traded half-spreads (in absolute terms) varied significantly across companies. Their dynamics was unrelated to the companies' size. The reason for this is huge differences in stocks par values. Prices ranged from a very low of UAH 0.45 for BAVL to enormous UAH 381.88 for DNEN. Posted half-spreads in absolute terms turned to be extreme for the same companies – UAH 0.02 and UAH 19.21. At the same time, average relative posted half-spreads were less different for our companies ranging from UAH 2.28 to UAH 9.03.

A relationship between relative posted spreads and market capitalization is observed in the majority of cases. Companies with higher capitalization are often those that have smaller posted relative spreads. That can be explained by the fact that smaller companies are more risky due to lower level of their transparency. They are also paid less attention by investors and analysts. That result in less fair companies' value estimations.

As was expected posted spreads were higher than the estimated traded spreads (see Table B2). This is consistent with the idea that some trades are being executed at the inside quote which is evidently less attractive for the dealer. This can happen when dealers compete for trade orders. In such conditions they either decrease spreads (which is not always reasonable) or negotiate a specific price with an investor or other dealer and agree on the inside quote price. Traded spreads were estimated using Equation 1 for each time period (hourly/daily) over 2005, 2006 and for both.

Trading activity and trading volumes were also far from a uniform type. It can be clearly seen that companies with higher capitalization tend to be traded more frequently. The number of trades for the sample period varied from 222 for DNEN to 948 for UTEL (difference of about 4.5 times). The same statement is true in the daily context. At the same time average daily trading volumes were not connected with a company capitalization. This can be explained by different free floats for different companies and the fact that I do not report trades registered out of the open phase of PFTS. Lower volume of freely circulating securities of a given company imposes physical restrictions on daily turnovers. Lower free float of UTEL might explain the fact that a company with the highest capitalization and the highest frequency of trades has the lowest average daily trading volume. While another large company, BAVL, had the largest average daily trading volume.

Studies on developed stock markets say that both hourly posted spreads and hourly trading volumes exhibit a U-shaped pattern (see Madhavan et al., 1996). The reasoning behind this is as follows. A downward trend of spreads during the first half of the day reflects the fact that inventory holding motives are rather weak while a degree of information asymmetry decreases due to information frictions. At the end of the day information asymmetry continues to decrease but inventory holding costs increase since with each incoming sell order inventories of market makers risk to be transferred overnight. This make the curve to bent up in the second part of the day. As can be seen from Fig. 1, the dynamics of posted and traded half-spreads over a trading day and over a week did not exhibit any clear pattern. What can one see from our graphs is that there is no clear U-shape form. Instead, in the majority of cases one can observe spreads peaks in the midday and they are more pronounced that spreads drops. One possible explanation of the increased spreads in the noon is that dealers might accumulate important (insider) information near the lunch time when they could meet each other. As predicted by the theory posted spreads moved together with trading volumes. This can be explained by the fact that informed traders prefer to trade large amounts of a specific stock obtaining immediately the full effect of their private information.

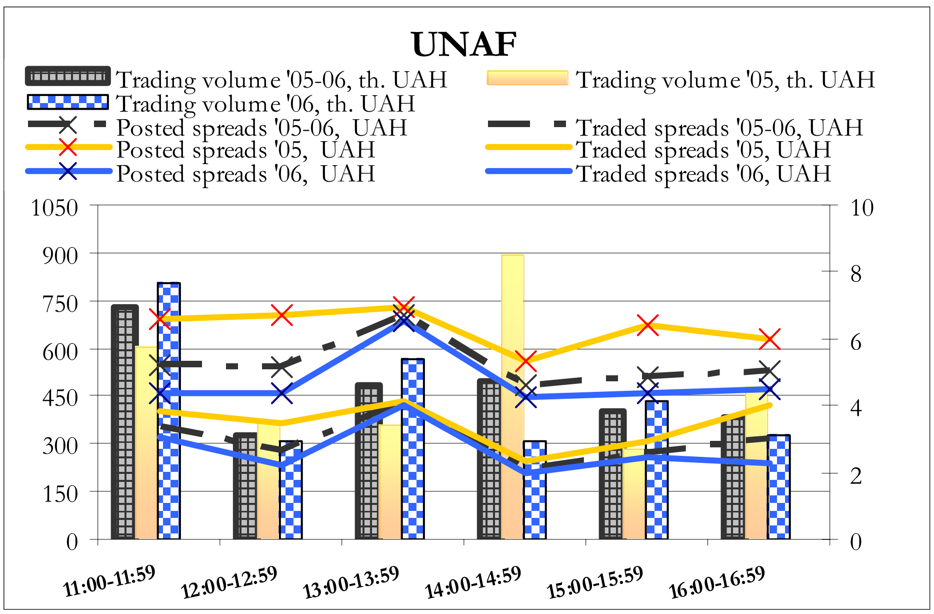

Fig.1. Intraday dynamics of trading volumes, posted and traded spreads in 2005 and 2006.

One can also remark that posted and traded spreads were almost unchanged for larger companies in 2005 and 2006 (see Fig. 2). At the same time, both posted and traded half-spreads for companies with smaller capitalization were higher and decreased through time (from 2005 to 2006). This signals primarily about information improvement of the Ukrainian Stock Market and not about an increase in the competition between dealers on it. The latter would have caused a decrease in spreads for all companies (in 2006 comparatively to 2005) but this was not observed. Instead, information transparency can explain this fact that spreads for some companies remain stable while for others decreases. When a company is said to be transparent there is a possibility to learn quickly about the company's recent performance. One would say there is no way to improve further the openness of UTEL or BAVL. At the same time if a company with relatively low transparency starts to improve it (e.g. in order attract cheaper loans or make an IPO), an increase in the frequency of publishing reports may

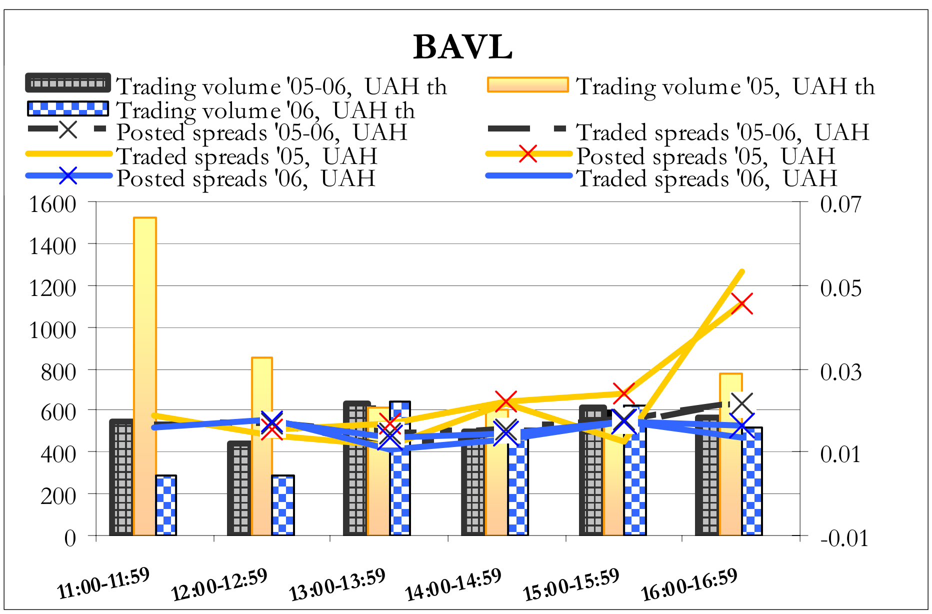

Fig. 2. Intraday dynamics of trade volumes, posted and traded half-spreads in 2005 and 2006

contribute to its more adequate pricing, thus decreasing risks of trading in its securities and spreads. The latter is often the case of low capitalized companies. From recently one can observe a tendency that annual and quarterly reports of are being published at free government web-sites and almost immediately they are issued.

In order to report results on the bid-ask spread decomposition comparable to those for developed stock markets Hanousek and Podpiera (2003), authors of a modification of Huang and Stoll's (1997) model applied to the Czech stock market compare different characteristics of their stocks with the correspondent ones of stocks chosen by other researchers who studied developed stock markets. In spite trade activity, market capitalization of companies and trade volumes of an emerging and a mature stock market differ wildly the authors found that Easley et al. (1996) and Stoll (1989) considered among others stocks traded on NYSE and NASDAQ with characteristics similar to those of the stocks used by Hanousek and Podpiera. I will follow this logic and compare characteristics of stocks in my sample.

The average market capitalization of a company in Hanousek and Podpiera (2003) sample of 10 most liquid companies was USD 800mn which is even lower than the average market capitalization of a company in our sample (USD 1,143mn). Relative bid-ask spreads are also comparable. Our stocks are traded with a average spread of 4.41% versus 1.9% in their study. Nevertheless, the average daily trading volume of a company in Hanousek and Podpiera (2003) is USD 1,87mn which is considerably higher than the average daily trading volume of a company in our sample (USD 0.12mn). The same is true for the average daily number of deals. While stocks in Hanousek and Podpiera (2003) are traded on average 28 times a day our stocks are significantly less actively traded (1.6 trades per day). Overall, this brief comparison show that one should be careful when directly comparing our estimation results on the bid–ask spread components since the characteristics of our stocks differ much from those in the study by Hanousek and Podpiera .

3.2 Model Specification

For the reasons of market inefficiency noticed above, I use a model of the trade indicator type. Namely, a modification of the original Huang and Stoll's (1997) model applied later on to the Czech stock market by Hanousek and Podpiera (2003). Let us start from the general model of Huang and Stoll (1997).

Consider a market for a risky stock which true price is unobservable and time variant. Let us use the subscript *t* to indicate three successive events. The unobservable true price in absence of transaction costs, Vt, is determined just before the dealers post their quotations at time *t*. Bid and ask quotes that prevail just before a transaction permit to to calculate the quote midpoint, Mt. Transaction happens at time *t* at a price Pt. Let us denote the buy-sell trade indicator as Qt to be variable for the transaction price, Pt. This trade indicator variable takes on 3 values: +1 if the transaction is buyer initiated ($Pt>Mt$), -1 if the transaction is seller initiated ($Pt<Mt$), and 0 if the transaction occurs at the midpoint ($Pt=Mt$). The logic behind determining a trade as "buy" (buyer initiated) or a "sell" (seller initiated) is quite straightforward. When the transaction is initiated by a buyer it is natural to reason that the transaction price will be relatively better for the counterpart (seller) since the latter possesses a relatively higher bargaining power. This will be reflected in a price above the midpoint. The same way of thinking is leads to a conclusion that the most probable price if the trade is initiated by a seller is that below the midpoint.

Assume that the traded spread is constant. Then the unobservable fundamental stock price, Vt, can be modeled as follows:

$$V_t = V_{t-1} + \alpha \frac{S}{2} Q_{t-1} + \varepsilon_t , \tag{1}$$

where S is the constant spread, α is the fraction of the half-spread due to adverse selection and *εt* is the serially uncorrelated public information shock. Equation (1) tells that the change in *Vt* happens due to new information which is divided into private information revealed by the most recent trade, $\alpha \frac{S}{2} Q_{t-1}$, and public information captured by ε_t.

In contrast to the unobservable *Vt* I can observe the quote midpoint, *Mt*. As inventory theories of the spread say, market makers allow the midpoint differing from the fundamental value due to inventory reasons, i.e. when they want to change their inventory position. According to Ho and Stoll (1981) market makers can make their inventories more balanced when doing so. Inventory theories model the quote midpoint as follows:

$$M_t = V_t + \beta \frac{S}{2} \sum_{t=1}^{t-1} Q_t , \tag{2}$$

where trades are assumed to have a normal size of one, β is a fraction of the half-spread attributable to inventory holding costs. Here the sum of trade indicators from the initial inventory for the day until the current *Qt* reflects the amount of accumulated inventories.

Equations (1) and (2) imply that if inventory holding costs were zero, the true fundamental price should be equal (and could be learned) from the quote midpoint. However, if there were no information asymmetry then the true fundamental price could only in expectations be equal to the previous true fundamental price.

After taking first difference of Equation (2) and plugging in Vt from the Equation (1) Iobtain the following result:

$$\Delta M_t = (\alpha + \beta)\frac{S}{2}Q_{t-1} + \varepsilon_t , \tag{3}$$

Equation (3) tells that quote midpoints are revised in response to new information that contained in the last trade and its inventory cost.

The following Equation incorporates the constant spread assumption:

$$P_t - M_t = \frac{S}{2}Q_t + \eta_t , \tag{4}$$

where ηt is a deviation of the observed half-spread, Pt-Mt, from the constant half-spread, $S/2$. Error term ηt incorporates among other rounding errors.

The spread estimated using Equation (4) is a called traded half-spread. As mentioned above, posted half-spread is generally greater than traded half-spread. This happen due to situations when a market maker agrees to trade at any price between the midpoint and the quote (ask or bid).

Equations (3) and (4) can be used to get the regression equation for the estimation of the traded half-spread, $S/2$ and a combined weight of both adverse selection and inventory holding cost components ($\lambda = \alpha+\beta$)

$$\Delta P_t = \frac{S}{2}(Q_t - Q_{t-1}) + \lambda\frac{S}{2}Q_{t-1} + e_t , \tag{5}$$

where $et = \varepsilon t + \eta t$. Equation (5) is nonlinear in parameters. It represents a general Huang and Stoll's (1997) trade indicator model with the only regressor - trade indicator variable Qt. As mentioned above Huang and Stoll's (1997) general model (5) incorporates a majority of existing price covariance and trade indicator models.

By using Equation (5) it is impossible to decompose the bid-ask spread into thee components based on this equation since it pools together adverse selection and inventory holding cost components. The only component that can be estimated is order processing cost component, 1-λ.

In order to estimate the remaining two components of the bid-ask spread Huang and Stoll (1997) again came to inventory models. Namely, they used a fact that there is a relationship between current changes in quotes and future order flows. After a market maker buys (sell) a stock from other traders he decides to decrease the bid (increase the ask) in order to increase the probability of an order of the opposite direction to equilibrate his inventories. The compensation for the dealer for inventory risk arises due to the fact that midpoint change is positive if he has bought and negative if he has bought. This implies that the probability of a trade reversal is greater than 0.5 just after a any given trade. This suggests a presence of negative serial covariance in trades. Trade reversals invoke quotes reversals. This results in the possibility to identify the inventory component.

Iwill not consider in detail Huang and Stoll's (1997) model of correlations in trade flows but Iwould rather pass to another extension of their general model which is based on trading pressure the idea of which was applied by Hanousek and Podpiera (2003).

Huang and Stoll (1997) recalled the fact that (contrarily to the security specific adverse selection reasons) quote revisions originate not just from inventory changes in a specific stock but also from inventory changes in other stocks held by a market maker. This idea encouraged them to elaborate the second extension to their general model which allows them estimating separately all three bid-ask spread components.

The arguments for the trading pressure approach are as follows. Being driven by hedging reasons a market maker who has just purchased a stock j will not only decrease his quotation prices for this stock j, but will also decrease them for of other correlated stocks. Sales of the latter will help him to hedge his increased inventory position in stock j. At the same time, if other stocks are under buying pressure, a market maker may wish to decrease his quotations of stock j in order to sell j while buying other stocks. The portfolio approach suggests that the quotes revisions in stock j differ from those invoked solely by the adverse information and/or inventory motives of trades in stock j. In particular, selling (buying) pressure in other stocks will produce quote changes in the stock j as the liquidity suppliers attempt to keep their overall portfolios in balance.

Huang and Stoll (1997) have rewritten Equation (2) as follows:

$$M^k{}_t = V^k{}_t + \beta \frac{S^k}{2} \sum_{t=1}^{t-1} Q^*{}_t \, , \qquad (6)$$

where *k* stands for a specific security and *Qt** is an aggregate trade indicator which equals 1 when inventories of stocks from a portfolio accumulated at time *t* exceed zero. *Qt** equals -1 when inventories of stocks from a portfolio accumulated at time *t* are below zero. *Qt** is zero otherwise.

This trading pressure approach but in a modified way was used by Hanousek and Podpiera (2003). They also paid attention to trading pressure but for a specific stock. They found that in quote-driven market system which is Prague SPAD dealers monitor changes in order flows (and inventories) of a particular stock separately rater than changes in order flows (and inventories) to a bundle of chosen stocks (portfolio). First of all, there is an open question on the choice of portfolio of stocks used to monitor for trading pressure. Huang and Stoll themselves were in doubts and pay relatively much attention to the serial correlation in trade flows. Moreover, the issue of different trading systems is in play. The authors considered stocks traded on NYSE which is single single specialist dealer system while Prague SPAD (as well as Ukrainian PFTS) are competitive dealer systems. Above I discussed differences in behavior of market makers in these systems. In competitive dealer systems market makers may react significantly weaker to general trading pressure rather than to trading pressure on a particular stock since general trading pressure falls not on a single specialist but is instead dispersed among a larger capital base of multiple cometing dealers. Hanousek and Podpiera (2003) assert that normally quotes are very rarely adjusted due to inventory reasons. Only during periods of serious selling or buying trade pressure the role of inventory holding arguments sharply increases. In such cases (which are generally rather rare) those dealers who initially were not directly affected by a specific trade are more likely to revise their quotes in order to protect themselves from a risk of large stock movement from the affected market makers.

Hanousek and Podpiera (2003) have proposed their version of equation (2) that incorporates the fact that not each trade matters for the quote revision:

$$M_t = V_t + \beta \frac{S}{2} \sum_{t=0}^{t-1} Q_t PRESS_i \tag{7}$$

where PRESS is a dummy variable indicating whether there was a buying or selling pressure on a particular stock. It takes on value +1 if last four trades were either buyer or seller initiated, and 0 otherwise.

I should be mentioned that Hanousek and Podpiera (2003) also added to the right-hand side of Equation (1) a dummy variable *CROSS* with a coefficient δ. This variable takes on value +1 when there is a "cross trade" (transaction between a dealer and his client). The authors extended the Huang and Stoll (1996) version of equation (1) with *CROSS* variable for the reason that information on cross-trades can be a signal of the order flow to the market. They pointed out that ex ante it is not clear whether the coefficient δ will be significant or not. Cross trades can bear important information and be viewed by the market as indicators of stronger order flow. In this case they will affect the market. But it is equally possible that cross trades are not important for the market participants.

Our database does not allow distinguishing transactions between a dealer and his clients. So I drop this variable and use equation (1). This modification might be of low importance since Hanousek and Podpiera (2003) showed that *CROSS"* variable war significant in unique cases (for two out of 10 companies). That means that the Czech stock market did not consider information on cross trades as important signals in 2002. Isuppose that the Ukrainian Stock Market in 2005-2006 was even more underdeveloped and more inefficient than the Czech Stock Market at the time and reacted to the cross trades information rather weakly.

Taking first derivatives from Equation (7) and plugging *Vt* from Equation (1) Iget Hanousek and Podpiera's (2003) model which is able to decompose the bid-ask spreads into three components:

$$\Delta M_t = \alpha \frac{S}{2} Q_{t-1} + \beta \frac{S}{2} Q_{t-1} PRESS_{t-1} + \varepsilon_t , \qquad (8)$$

Equations (4) and (8) together represent a model of a three way bid-ask spread decomposition. They yield estimates of all parameters we are interested in: the two bid-ask spread components α and β and the traded half spreads S/2. Order processing cost can be obtained as $1-\alpha-\beta$.

3.4 Estimation Procedure and Results

First of all, I split all my trades on three groups by trade size in order to explore the effect of trade size on the estimates of adverse-selection and on inventory holding cost components. I learned that brokers in Ukraine consider trades to be large if their amount exceeds UAH 1mn. These are also called block trades. Then I decided to modify and approach of Huang and Stoll (1997) when they split trades on three groups by the number of shares traded. Since prices vary in dozens of times across the selected stocks it would be more appropriate to split stocks by trade size in money terms. Small size trades are those amounting up to UAH 0.1mn, medium size trades are those ranging from UAH 0.1mn to UAH 1mn and large trades are those greater than UAH 1mn. Table represents the trade structure based on my classification. It can be seen that an average share of small trades in the total number of trades was about 63%, share of medium trades was about 26%, the remainder being large ones. It is worth noting that due to the low frequency of trades it can be harmful to split significant number of trades omitting observations that could significantly distort the construction of the *PRESS* variable. So I decided allow distorting estimates as low as possible with trading size by running regressions not on each trade size category but on only small trades subset (a loss of "only" 37% of trades on average) and the whole dataset which include all trade sizes.

Equations (4) and (8) are nonlinear in parameters. They should be estimated simultaneously to obtain the estimates of the two bid-ask spread components α and β and the traded half spreads S/2. They can be estimated by ML method, SUR and GMM.

Glosten and Harris (1988) exercised ML approach but found significant practical difficulties when applying it. For the sake of comparison I decided to run both GMM and SUR routines in TSP 5.0.

A reason for doing SUR was that error terms in both equations might be contemporaneously correlated. Indeed if prices are constantly increasing if relatively to the quote midpoint then it would be possible for a dealer to increase both bid and asks (and the quote midpoint will rise automatically) and sell at higher prices.

At the same time GMM approach while accounting for the possibility that error terms in both equations might be contemporaneously correlated needs very weak distributional assumptions and allows me to account for possible problems of heteroscedasticity of unknown form and serial correlation in the residuals. GMM is generally adopted in studies on the bid-ask spread decomposition. As instruments for the GMM I used first lags of the regressors of both equations. It was important that TSP package can operate GMM estimation of nonlinear systems.

The results of estimations are presented in Tables C1-C2. As can be seen the results in general confirm the hypotheses stated above.

First, there are almost no econometric evidence of inventory holding costs. That means that the trade indicator model used in this thesis perform well also in conditions when there are no market makers. Almost unique exclusions are the estimates obtained by using SUR for PGOK. Moreover, it can be seen that SUR never makes coefficients statistically insignificant if they were significant in GMM. Instead, in some cases it makes statistically significant those parameters that were they were insignificant in GMM. SUR also imposes higher values for almost all parameters. In my opinion we can ignore these few significant parameter estimates due to possible problem with autocorrelation. Generally, we should rely more on the GMM estimates.

The only statistically significant inventory holding cost components obtained by GMM were those for UNAF and ZAEN for small trade size sample. However, as we discussed above the splitting of successive trades lead to a priori incorrect estimates.

What about the adverse-selection cost component estimates? They turned to be statistically significant for five companies out of ten if we look at the more reliable part of the output (namely at the GMM for "all trades" sample). These companies were the four largest by market capitalization companies (AZST, BAVL, UNAF and UTEL) and one minor (MZVM). It is seen from Table B1 that these five companies are those with the largest number of observations. That gives a positive outlook on the insignificant adverse-selection cost component estimates for the remaining companies that probably "just lacked" another one-two hundreds of observations to improve the performance of GMM.

Moreover, there were no significant negative adverse-selection cost component estimates. Thus I think that the second hypothesis about statistic and economic significance of adverse-selection cost component is also confirmed.

Adverse-selection cost component estimates ranged from a low 5.9% of the half-spread for AZST to a high 16.3% for MZVM. As expected the risk of informed trading increases with the diminishing of the company size (which is presumably related to lower transparency). This component estimate averages about 10%. The remaining 90% are of order processing costs. Effectively, such value for the information asymmetry on the Ukrainian stock market is too low. Hanousek and Podpiera (2003) also found that an average adverse-selection cost component of

17% for the Prague Stock Exchange was also inadequate to the scope of informed trading..

One way to explain this is to recall a suspiciously large number of trades registered out of the PFTS trading session. In other words they are likely to be concluded several days before they were registered in order not to shock the market immediately. It also happen that an important trade is not shown at all in PFTS registry. For this reason our dataset could be too refined from really informed trades.

As expected the relation between the trade size and the adverse selection was negative. According to Huang and Stoll (1997) large trades seem to be prenegotiated such that the trade price already bears the information content of the trade.

The traded spreads were statistically significant at 5% level for both GMM and SUR estimates of both trade size samples. They ranged from a low UAH 0.1 to a high 7.091 for DTRZ. As expected they are lower than the correspondent posted spreads.

Chapter 4

CONCLUSIONS

In this Thesis I tested the model of Hanousek and Podpiera (2003) on the sample of ten most liquid and actively traded stocks listed in PFTS, Ukrainian largest stock exchange. The authors adjusted the original model of Huang and Stoll (1997) to the case of a competitive dealer system (which is PFTS). This important correction as well as the fact that the model is of the trade indicator type (which is important for markets with low information efficiency) determined the choice of their model.

It turned out that the model of the bid–ask spread designed for a market microstructure with market makers also fits quite well in market microstructure without market makers (my case). When there are no market makers (which are the only subject of inventory holding costs) the same model says that the correspondent coefficient on the inventory holding costs is statistically insignificant when we use a more reliable GMM approach and do not cluster trades by trade size. The latter leads to a wrong construction of the variable being a multiplier for the inventory holding cost component.

The estimates of the scope of informed trading on the domestic stock market are statistically significant in a half of cases and but their values seem to be lower than the true level. The adverse selection cost component was comparable to those of developed stock markets (10%).

The model was applied to analyse an intraday and intraweek trading volumes, posted and traded spreads development for years 2005 and 2006. No strong pattern of their dynamics were observed. However certain features of transaction prices, spreads and trade volume are similar to those of developed markets are present. One important conclusion is that spreads declined through 2005- 2006. In my opinion this can be explained primarily by a general improvement of the information flows in Ukrainian stock market.

A full explanation of the relationship between informed trading and the adverse-selection component in emerging markets remains a topic for further research and would require evidence from multiple markets.

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APPENDIX A

Table A1. Sample of securities

Company Name	Identification (PFTS ticker)
Azovstal	AZST
Raiffeisen Bank Aval	BAVL
Dniproblenergo	DNEN
Dnipropetrovsk Pipe	DTRZ
Mariupil heavy machines	MZVM
Poltava OMEP	PGOK
Sumy NVO Frunze	SMASH
Ukrnafta	UNAF
Ukrtelecom	UTEL
Zakhidenergo	ZAEN

Table A2. Trade structure

Company	**Small trades**	**Medium trades**	**Large trades**
UTEL	76.00%	21.00%	3.00%
UNAF	47.30%	34.80%	17.90%
AZST	75.80%	19.50%	4.70%
BAVL	60.10%	22.10%	17.80%
PGOK	47.70%	32.80%	19.50%
ZAEN	72.50%	18.80%	8.70%
DNEN	55.10%	29.50%	15.40%
SMASH	68.90%	24.20%	6.90%
MZVM	68.10%	23.30%	8.60%
DTRZ	56.10%	36.30%	7.60%
Average	**0.63**	**0.26**	**0.11**

APPENDIX B

Table B1. Securities characteristics and trading activity

Company	Industry	Average Capitalisation (UAH mn)	Gross # of Trades*	# of Trades	# of Trading Days	Daily # of Trades		
						Mean	Min	Max
UTEL	Telecoms	15,530	1620	948	449	2.11	0.00	20.00
				(725)	(449)	(1.61)	(0)	(17)
UNAF	Oil & Gas	13,786	1133	665	450	1.48	0.00	14.00
				(317)	(450)	(0.70)	(0)	(8)
AZST	Iron & Steel	9,639	857	544	447	1.22	0.00	11.00
				(42)	(447)	(0.93)	(0)	(11)
BAVL	Banking	7,243	721	519	428	1.21	0.00	22.00
				(315)	(428)	(0.74)	(0)	(22)
PGOK	Ore mining & enrichment	5,528	509	297	416	0.71	0.00	9.00
				(144)	(416)	(0.35)	(0)	(5)
ZAEN	Electric Utilities	1,926	556	377	443	0.85	0.00	17.00
				(277)	(443)	(0.63)	(0)	(16)
DNEN	Electric Utilities	1,518	340	222	446	0.50	0.00	7.00
				(125)	(446)	(0.28)	(0)	(5)
SMASH	Engineering	1,317	642	442	424	1.04	0.00	17.00
				(308)	(424)	(0.73)	(0)	(15)
MZVM	Engineering	880	625	459	374	1.23	0.00	18.00
				(316)	(37)	(0.85)	(0)	(16)
DTRZ	Piping	404	504	323	292	1.11	0.00	8.00
				(184)	(292)	(0.63)	(0)	(7)
Average		**5,776.88**	**750.70**	**479.60**	**416.90**	**1.15**	**0.00**	**14.30**

Gross # of Trades* is calculated as a total number of trades made in PFTS irrespectively of whether they were registered at the open phase of the Exchange trading. Other columns are calculated on the basis of entries in the registry made during the open phase and trading activity)

APPENDIX B

Table B2. Securities prices and posted half-spreads

Company	Price (UAH)				Posted half-spread (UAH)				Posted half-Spread (%)			
	Mean	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**
UTEL	0.90	0.15	0.60	1.23	0.02	0.02	0	0.12	2.44	1.72	0	16
	(0.89)	(0.15)	(0.6)	(1.23)	(0.02)	(0.02)	(0)	(0.12)	(2.43)	(1.76)	(0)	(16)
UNAF	262.26	70.39	135.50	355.50	5.15	3.81	0.4	36.5	2.28	2.03	0.13	13.45
	(272.63)	(67.96)	(135.5)	(355)	(4.97)	(3.28)	(0.4)	(20)	(2.06)	(1.59)	(0.13)	(7.85)
AZST	2.58	0.60	1.42	4.27	0.12	0.08	0.02	0.6	4.43	2.86	0.68	19.81
	(2.50)	(0.58)	(1.42)	(4.27)	(0.15)	(0.08)	(0.02)	(0.6)	(4.49)	(2.98)	(0.77)	(19.81)
BAVL	0.45	0.09	0.20	0.75	0.02	0.03	0	0.6	4.1	4.3	0	63.16
	(0.46)	(0.08)	(0.22)	(0.75)	(0.02)	(0.04)	(0)	(0.6)	(3.87)	(4.37)	(0)	(63.16)
PGOK	47.05	14.60	14.00	82.82	3.69	3.36	0.35	23.45	9.03	8.88	0.49	47.75
	(47.54)	(14.23)	(14.5)	(77)	(3.85)	(3.61)	(0.35)	(23.45)	(8.64)	(7.92)	(0.49)	(42.33)
ZAEN	145.37	18.10	110.00	203.00	4.01	2.81	0.5	18.25	2.86	2.16	0.32	14.57
	(145.33)	(17.06)	(110)	(200)	(3.88)	(2.75)	(0.5)	(14.5)	(2.78)	(2.12)	(0.32)	(11.65)
DNEN	381.88	47.04	270.00	530.00	19.21	11.53	2.5	74	5.23	3.45	0.61	22.7
	(379.13)	(45.33)	(273.46)	(520)	(19)	(11.38)	(3.45)	(67.5)	(5.18)	(3.32)	(0.84)	(15.97)
SMASH	16.94	3.74	9.95	28.00	0.92	1.16	0.01	7.7	5.13	5.54	0.04	30.61
	(16.39)	(3.09)	(9.95)	(28)	(0.78)	(1.05)	(0.01)	(7.6)	(4.63)	(5.59)	(0.04)	(30.62)
MZVM	53.47	9.28	27.00	75.00	2.16	1.3	0.14	7	4.04	2.52	0.28	25
	(54.42)	(8.23)	(35.9)	(75)	(2.14)	(1.35)	(0.14)	(6.25)	(3.81)	(2.24)	(0.28)	(11.11)
DTRZ	309.77	96.32	138.00	436.32	11.63	9.72	0.9	62.5	4.51	4.19	0.23	22.19
	(313.71)	(95.02)	(138)	(429.25)	(11.6)	(10.67)	(0.9)	(62.5)	(4.4)	(4.3)	(0.23)	(22.19)
Average	**122.07**				**4.69**				**4.41**			

APPENDIX B

Table B 3 Annual and daily trading volumes

Company	**Gross annual trading volume (UAH mn) ***	**Annual trading volume (UAH mn)**	**Daily Trading Volume (UAH th)**			
			Mean	**Std.Dev.**	**Min**	**Max**
UTEL	105.40	50.35	102.79	212.35	2.63	3860.00
			(45.4)	(24.56)	(2.63)	(99.30)
UNAF	328.10	175.23	483.08	2208.00	10.98	52480.00
			(44.87)	(23.24)	(10.98)	(99.69)
AZST	54.42	33.49	112.86	289.82	1.35	4065.00
			(36.65)	(23.39)	(1.35)	(99.00)
BAVL	267.12	159.95	537.40	1428.00	1.80	10240.00
			(32.72)	(20.38)	(1.8)	(99.8)
PGOK	154.09	73.66	420.34	1308.00	2.39	16250.00
			(44.26)	(23.77)	(2.394)	(98.75)
ZAEN	84.34	38.49	184.28	461.44	10.01	4216.00
			(40.90)	(23.96)	(10.01)	(99.23)
DNEN	93.43	50.11	410.13	1059.00	9.50	8383.00
			(48.50)	(21.85)	(9.5)	(98.8)
SMASH	65.60	41.44	161.94	428.86	1.50	5542.00
			(39.40)	(24.54)	(1.5)	(98.15)
MZVM	100.65	58.46	194.07	524.50	2.24	5394.00
			(41.10)	(21.70)	(3)	(98.00)
DTRZ	84.07	50.12	184.60	398.92	5.28	4040.00
			(48.36)	(21.63)	(5.28)	(99.25)
Average	**133.72**	**73.13**	**279.15**			

Gross annual trading volume * is calculated as a total annual trading volume observed in PFTS irrespectively of whether they were registered at the open phase of the Exchange trading. Other columns are calculated on the basis of entries in the registry made during the open phase.

APPENDIX C

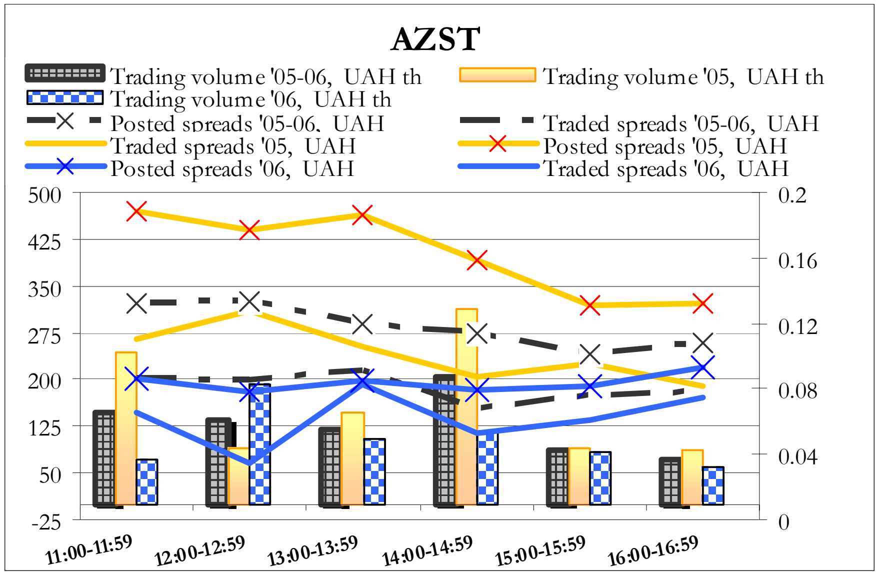
Table C1. GMM and SUR estimation results of model parameters

Trade size	Estimated value	AZST		BAVL		DNEN		DTRZ		MZVM	
		GMM	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**
All trades	S/2	0.106**	0.080**	0.018**	0.014**	9.065**	9.441**	7.091**	5.039**	1.158**	1.289**
		(0.008)	(0.003)	(0.001)	(0.001)	(2.149)	(0.619)	(1.341)	(0.317)	(0.173)	(0.05)
	Alfa	0.059*	0.106**	0.111*	0.304**	0.068	0.103	0.066	0.145*	0.163**	0.172**
		(0.035)	(0.045)	(0.064)	(0.139)	(0.089)	(0.086)	(0.048)	(0.086)	(0.055)	(0.042)
	Beta	0.112	0.114	-0.017	0.211	0.435	0.276*	0.124	0.138	-0.014	-0.032
	R-sq.Eq.(1)	0.522	.522	0.217	.548	0.514	0.513	**0.433**	0.432	0.583	0.583
	R-sq.(Eq.2)	0.27	026	0.003	0.003	0.034	0.035	**0.041**	0.014	0.054	0.053
		GMM	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**
Small trades		(0.077)	(0.076)	(0.102)	(0.245)	(0.299)	(0.161)	(0.127)	(0.171)	(0.113)	(0.078)
	S/2	0.112**	0.084**	0.016**	0.014**	8.080**	11.318**	5.304**	4.942**	1.232**	1.299**
		(0.01)	(0.004)	(0.002)	(0.002)	(2.385)	(0.923)	(1.243)	(0.431)	(0.259)	(0.059)
	Alfa	0.087*	0.137**	0.258*	0.448*	0.409	0.268*	0.296*	0.363**	0.165**	0.133**
		(0.049)	(0.055)	(0.14)	(0.234)	(0.276)	(0.137)	(0.177)	(0.136)	(0.073)	(0.056)
	Beta	0.084	0.115	0.056	0.131	0.073	0.099	-0.237	-0.312	0.013	0.02
		(0.108)	(0.092)	(0.199)	(0.384)	(0.375)	(0.226)	(0.405)	(0.263)	(0.152)	(0.11)
	R-sq.Eq.(1)	0.527	0.527	0.165	.165	0.539	0.538	0..419	0.419	0.593	0.593
	R-sq.(Eq.2)	0.034	0.034	0.018	.017	0.064	0.063	0.039	0.039	0.032	0.032

APPENDIX C

Table C2. GMM and SUR estimation results of model parameters. Continued

Trade size	Estimated value	PGOK		SMASH		UNAF		UTEL		ZAEN	
		GMM	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**
All trades	S/2	2.989**	1.933**	0.784**	0.494**	3.304**	2.956**	0.021**	0.018**	1.861**	2.345**
		(0.809)	(0.157)	(0.211)	(0.04)	(0.575)	(0.172)	(0.001)	(0)	(0.499)	(0.12)
	Alfa	0.04	0.081	0.046	0.098	0.107**	0.127**	0.106**	0.133**	-0.003	0.01
		(0.051)	(0.087)	(0.049)	(0.071)	(0.04)	(0.04)	(0.031)	(0.027)	(0.08)	(0.056)
	Beta	0.259	0.480**	0.107	0.177	0.120	0.120	0.038	0.02	0.278	0.147
		(0.232)	(0.183)	(0.142)	(0.146)	(0.081)	(0.076)	(0.072)	(0.054)	(0.21)	(0.118)
	R-sq.Eq.(1)	0.36	0.36	0.263	0.262	0.309	0.309	0.634	0.634	0.502	0.502
	R-sq.(Eq.2)	0.03	0.030	0.01	0.010	0.042	0.042	0.035	0.036	0.004	0.004
		GMM	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**	**GMM**	**SUR**
Small trades	S/2	4.109**	2.459**	0.825**	0.494**	4.262**	3.296**	0.023**	0.019**	3.212**	2.440**
		(1.187)	(0.262)	(0.238)	(0.049)	(0.755)	(0.318)	(0.002)	(0.001)	(0.443)	(0.144)
	Alfa	0.118*	0.201	0.065	0.08	0.096*	0.187**	0.110**	0.151**	-0.004	-0.01
		(0.066)	(0.131)	(0.045)	(0.086)	(0.056)	(0.076)	(0.037)	(0.036)	(0.068)	(0.077)
	Beta	-0.096	0.028	0.06	0.189	0.204*	0.073	0.116	0.028	0.316**	0.237
		(0.191)	(0.272)	(0.124)	(0.168)	(0.111)	(0.131)	(0.079)	(0.073)	(0.138)	(0.149)
	R-sq.Eq.(1)	0.342	0.341	0.247	0.247	0.257	0.257	0.632	0.631	0.496	0.651
	R-sq.(Eq.2)	0.016	0.017	0.011	0.011	0.037	0.042	0.034	0.0363	0.009	0.002



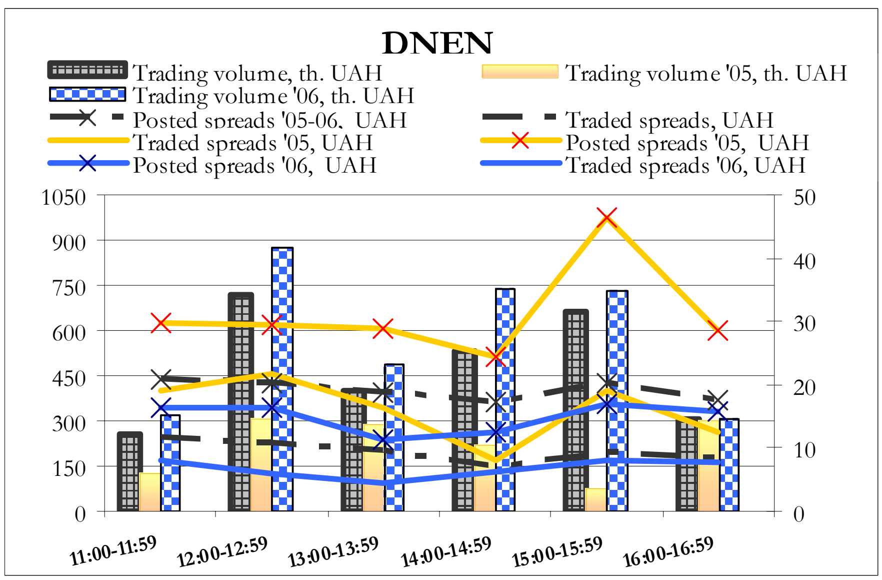
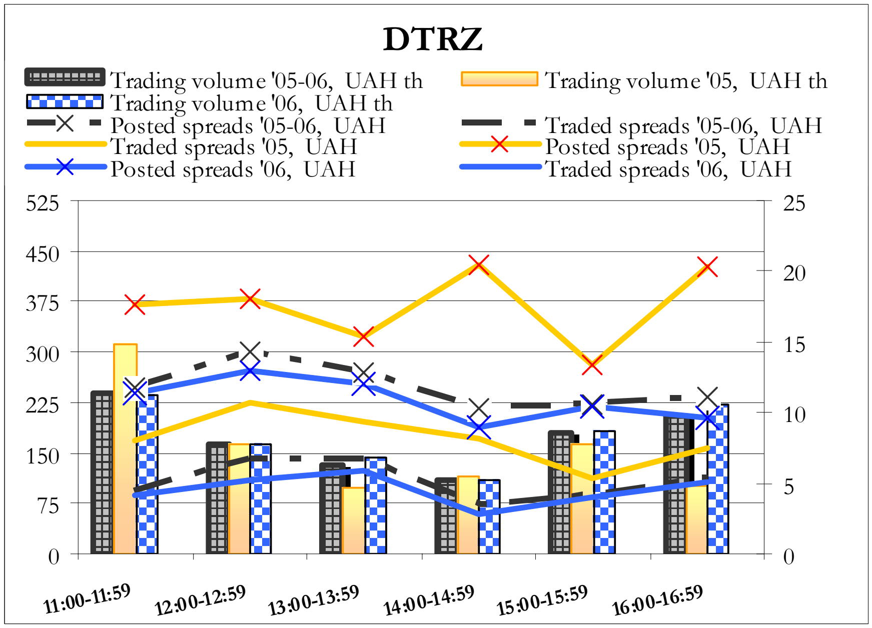


Fig. 3. Intraday dynamics of trade volumes, posted and traded half-spreads.



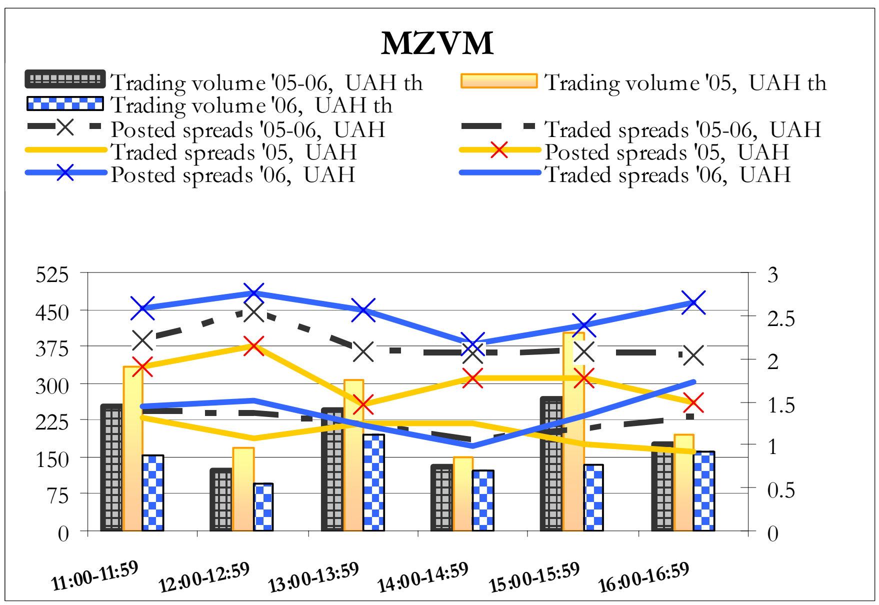
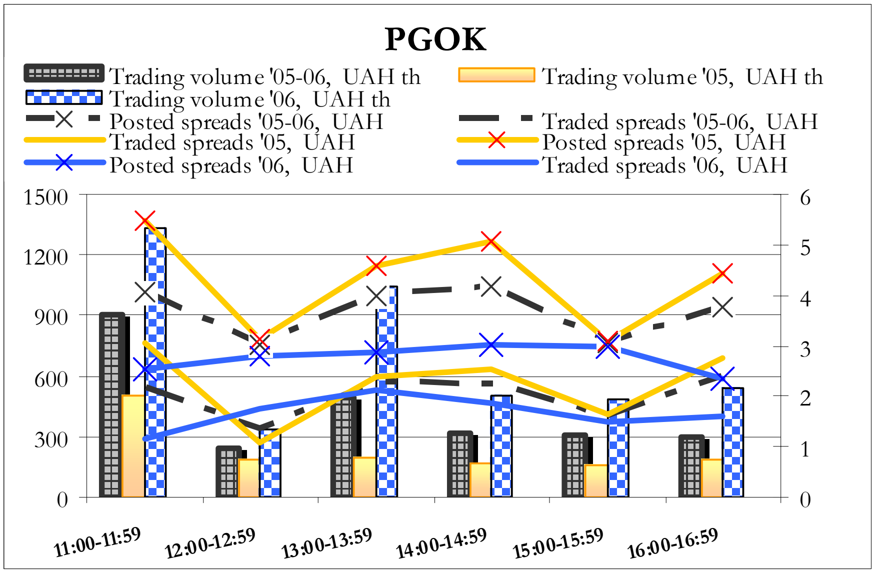


Fig. 3. Continued



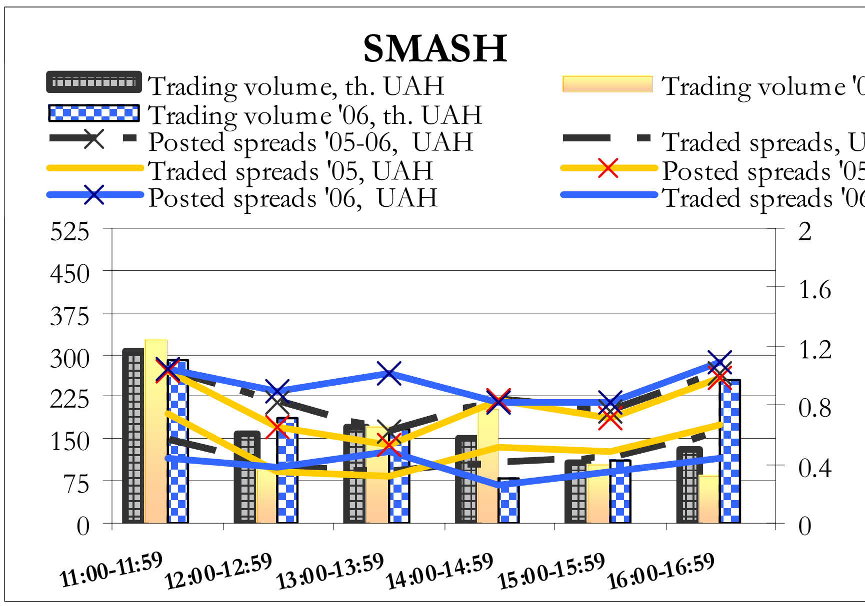
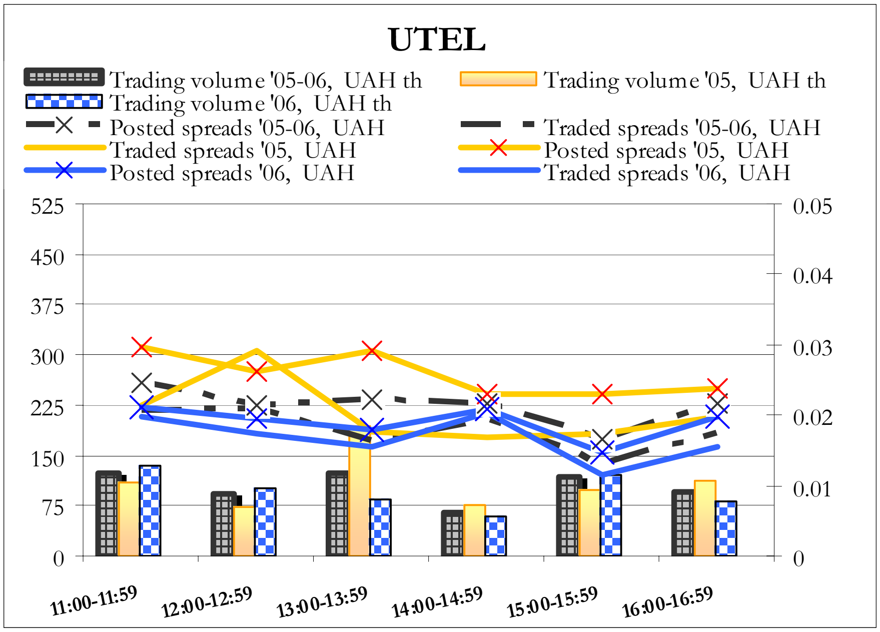


Fig. 3. Continued



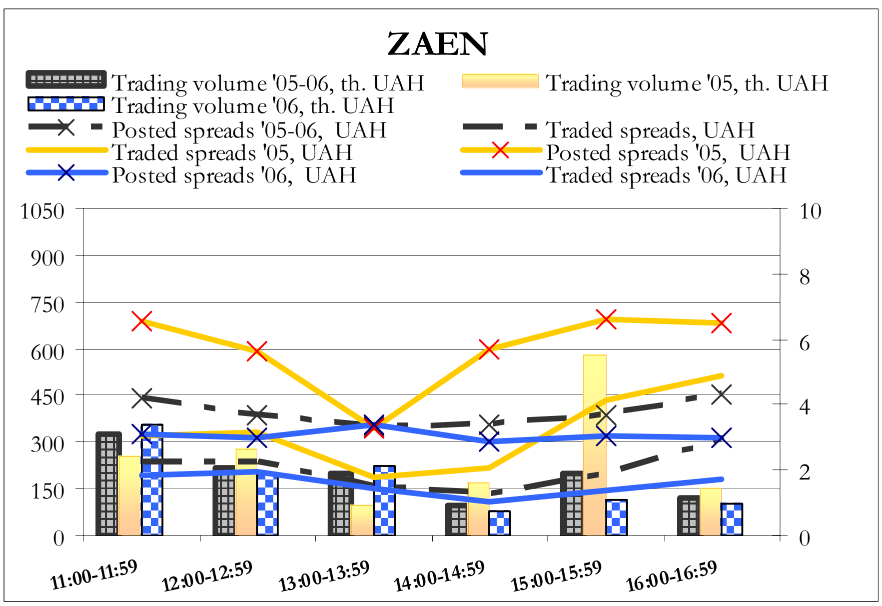


Fig. 3. Continued