Informed Trading and the Bid-Ask Spread: Evidence from an Emerging Market

Jan Hanousek and Richard Podpiera **

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Jan Hanousek
CERGE-EI,
P.O. Box 882
Politických vězňů 7
111 21 Prague
Czech Republic

Richard Podpiera
International Monetary Fund
700 19th Street, N.W.
Washington, D.C. 20431
USA

Correspondence to: Richard Podpiera, International Monetary Fund, 700 19th Street N.W., Washington, D.C., 20814, USA, e-mail: rpodpiera@imf.org

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** Jan Hanousek currently fills the Citibank Chair in Financial Markets at CERGE-EI, a joint workplace of Charles University and the Academy of Sciences of the Czech Republic. Richard Podpiera is with the International Monetary Fund; this paper was prepared prior to joining the staff of the International Monetary Fund and does not necessarily reflect the views or policies of the IMF. This research was supported by the National Science Foundation of the United States (grant number SPR-9712336) and by the PHARE/ACE Research Program of the European Union (grant number P97-8118-R). We would like to thank Libor Němeček, Randall K. Filer, Barbara Forbes, and Jan Kmenta for their suggestions and comments.

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Abstract: Bid-ask spread is a major determinant of trading costs and therefore significantly affects the performance of financial markets. We explore the impact of informed trading on the composition of the bid-ask spread in high frequency data from the Czech equity market. This market has been plagued by informed trading due to insufficient regulation and missing institutions. We modify an earlier approach to estimating the components of the bid-ask spread to suit the setup of this market. Our estimates suggest that the Czech market-maker based trading system is efficient in dealing with informed trading. Only 17 percent of the bid-ask spread is explained by informed trading, which roughly corresponds to the share of the adverse-selection component in developed markets. An explanation based on the difference between posted and traded spread is offered.

Keywords: trading systems, market microstructure, informed trading, emerging markets

JEL Classification: G14, G15, P34, P59

1. Introduction

Since the bid-ask spread is an important determinant of trading costs and thus significantly impacts the performance of financial markets, the link between informed trading (adverse selection of traders) and the bid-ask spread has been the focus of plentiful research.[1] Some authors have suggested that if informed trading is common, it might lead to market shutdown as the spread would simply be too wide for investors to participate in trading.

Historically, the bid-ask spread has been regarded as a function of order processing and inventory costs, but more recent research has brought adverse selection and informed trading into the picture. In this view, the market maker (as a provider of liquidity who always quotes prices for buying and selling) faces the possibility of trading with agents who have superior information. The market maker will lose money when trading with such individuals, so he sets a spread between the bid and ask price in order to compensate for this adverse-selection problem. Glosten and Milgrom (1985) were the first to show formally that, with informed trading, a bid-ask spread would exist even if there were no order processing or inventory costs. The current literature thus distinguishes three components of the bid-ask spread, that is, inventory, order processing and adverse-selection components.

Despite the fact that a number of empirical studies have tried to estimate the components of the bid-ask spread, the problem of the size of the adverse-selection component has never been fully resolved. Earlier studies suggested that the share of the adverse-selection component is large. For instance Stoll (1989), who used a sample of NASDAQ stocks, reported that 43 percent

[1] "Bid-ask spread" is defined as the difference between the price at which the market maker is willing to sell and the price at which he is willing to buy.

of the quoted spread is due to adverse selection. On the other hand George, Kaul and Nimalendran (1991) estimate a much smaller share of adverse selection costs. For a sample of NYSE, AMEX and NASDAQ stocks, they put this share in the range of 8 to13 percent. Huang and Stoll (1997) estimate a general model and offer two ways of decomposing the spread. They also estimate two values of this share, 9.6 percent and 21.5 percent. It is difficult to explain the differences of the estimated shares due to adverse selection since the cited studies differ both in the data and the estimation methodology they use. Generally, recent studies suggest that the share of the adverse-selection component is rather low in developed markets.

The current paper investigates the bid-ask spread components of the Czech stock market, with a focus on the adverse-selection component. Our study uses high frequency data as evidence for the composition of the bid-ask spread from an emerging market. Previous studies have dealt almost exclusively with U.S. markets and, except for the most recent studies, have used only daily and weekly data. In estimating the adverse-selection component, we combine recent findings of the inventory literature with older methods of estimation. In previous literature, the distinction between competitive market makers and a single specialist was largely ignored, perhaps due to the use of less detailed data. Our analysis offers an insight into the magnitude of the adverse-selection component in a market known for being seriously plagued by insider trading.

From the outset, the Czech equity market developed very rapidly, since many companies were floated as a result of coupon privatization. Market regulation, however, lagged significantly. Insider trading, price manipulation, fraud in the investment funds industry, and abuses of minority shareholder rights eroded investor confidence. In recent years regulation has

improved, but enforcement continues to appear rather weak.[2] The Czech market still offers wide latitude for informed and inside traders to trade on non-public information. Besides abundant anecdotal evidence, Hanousek and Podpiera (2002) formally estimated the extent of informed trading and their results suggest that informed trading is indeed considerably higher than in developed markets.

Besides being an example of lax regulation and insufficient institutions, the Czech equity market offers a good opportunity for investigating the bid-ask spread thanks to the setup of its trading system. Its key component, the SPAD trading system, is based on market makers, who are obliged to quote prices on selected stocks. The setup corresponds in several ways to the theoretical models used for analyzing the bid-ask spread. For instance, the trading lots are rather large, so in most trades only one lot changes hands, which allows us to abstract from the trade size. Also, there are a number of market makers for each stock which compete for order flow.

[2] The perception of the Czech equity market by the international investor community can be illustrated by articles in the press and assessments by international organizations. *The Economist* (April 1996) and the *Wall Street Journal* (May 1996) reported on "dealing in Prague as a losers' guide to investment," and characterized the Czech capital market as "a muddy market" and as "anarchy to the outsider, sweet profit to those in the know." More recently, *The Economist* (March 1997) quoted an investor as saying "…[the government should] fight the perception that the Prague stock exchange is just a vehicle for select insiders to enrich themselves at the expense of the ordinary shareholder." In its 1999 Country Study, the World Bank argued that "The capital market needs to be further strengthened to recover credibility and to be a real source of corporate financing" (Summary Report, page 17). It is also illustrative that the Prague Stock Exchange had been unable to become a member of the Federation of European Stock Exchanges until mid-2001, even though both Budapest and Warsaw Stock Exchanges became associate members of this federation years earlier.

Only the most liquid Czech stocks are included in the system, but these are medium-sized by international standards.[3]

In the next section, we describe the trading system and the data. In Section 3 we describe the models used to investigate the components of the spread. Initially, we examine the basic characteristics of market maker behavior based on the findings of inventory models. Then we present our strategy for estimating the adverse-selection component of the spread and review the Huang and Stoll (1997) approach, which we later use for comparative purposes. Section 4 presents the estimation results. Section 5 summarizes our findings and draws conclusions.

2. Trading System and Data Description

2.1. Trading System

The SPAD system was created in 1998 for the most liquid Czech stocks. This segment of the Prague Stock Exchange (PSE) is formed by market makers who are obliged to quote prices for sale and purchase. The whole system is computer-based, and all the market makers and members of the PSE are able to see all the quotes and trades. Members of the PSE who apply and are approved serve as market makers in the SPAD system. The system, launched with the aim of improving liquidity and increasing transparency of the Czech market, was successful in attracting order flow from the OTC market segment.

[3] Thus, we do not face the problem that our sample is formed by large companies which tend to have a lower spread in absolute terms and, as shown by Easley et al. (1996b), also tend to have a lower adverse- selection component of the spread. For a more detailed discussion of the sample selection and comparison with developed markets, see the next section (Trading System and Data Description).

During our sample period, which starts in March 1999 and ends in December 2001, six stocks were traded without any significant interruption. These include two telecommunication companies (SPT Telecom[4] and České radiokomunikace), two banks (Česká spořitelna and Komerční banka), a petrochemical company (Unipetrol), and an electricity generator (ČEZ). In addition, an investment fund (RIF), a construction company (IPS), another bank (IPB) and a cigarette producer (Tabák) were either added to the SPAD system after our sample period started or removed before the end of 2001.[5] Altogether, we have data on ten stocks. More information about the companies is provided in the Data Description section and Table 1 below.

The number of market makers varied during the sample period, but not dramatically. Each of the ten stocks had, on average, nine market makers quoting it. The SPAD rules stipulate that there must be at least three market makers for each stock for it to be traded in the system. In reality, the number of market makers for each stock was considerably higher than the required minimum.

Individual market makers are allowed to quote different ask and bid prices, but the maximum spread for each of them is limited. A committee of the PSE sets the exact limits depending on a number of factors, but we can say that it amounted to roughly 2.5 percent of the stock's price during our sample period. Depending on the development of the stock's price the maximum spread is irregularly changed. The system operates in two phases, closed and open.

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[4] During the sample period, SPT Telecom was renamed Český Telecom (Czech Telecom) and Tabák's name was changed to Philip Morris ČR.

[5] RIF was removed from the SPAD system due to its conversion to an open ended fund, IPB shares were suspended from trading after it was put under forced administration, IPS shares were delisted after a takeover by a major foreign investor and Tabák was introduced to the SPAD system only in October 2000.

The closed phase is a technical device that allows market makers to clear the trades that they did not manage to conduct during the open phase and is not important for our purposes. The actual trading occurs during the open phase of the system, which lasts from 9.30 a.m. to 4.00 p.m. each trading day and during which the market makers quote firm prices for a fixed number of shares of each stock.

During the sample period, the size of trading lots varied from 200 shares for Tabák (Philip Morris ČR) to 20,000 shares for Unipetrol or ČEZ. Although the size of the lots occasionally changed depending on price development of the stock, the trading lots were nevertheless rather large, compared to both the overall trading volume and the capital base of some of the market makers.[6]

The quotes in the system are firm in the sense that if the quote is the best one available on the market and if another party reacts to it by entering an instruction for a trade, the market maker is obliged to enter his instruction so that the trade can be executed. Blocks of shares that differ in size from the trading lot can be settled through the system as well, but these trades are negotiated in advance over the phone and are not very frequent.

In order to limit the risk of default, there exists a standard settlement procedure and a guarantee fund into which market makers must insert a deposit, and there are procedures that come into play if one side of the trade defaults. Overall, trading in SPAD appears to be safe, since no serious problems of default have been reported since its inception.

[6] The market value of one trading lot ranged from 0.5 mn CZK to 5.3 mn CZK during the sample period and averaged slightly below 2.0 mn CZK.

2.2. Data Description

Data on individual trades from SPAD have been publicly available since early 1999. For our 34-months-sample period (March 1999 – December 2001) we have information about each trade conducted in the SPAD system. Our database carries a stock identification, transaction price, number of shares, time the trade was concluded, and the best bid and ask quotes at the time the transaction took place. Also, we are able to identify so-called cross trades, that is, to distinguish trades that are conducted between the inventory of a market maker and the market maker's clients, since these must be reported in the system as well.

Table 1 depicts the basic characteristics of all ten stocks included in our sample. Even though these stocks represent the most liquid equities on the Czech market, there are substantial differences among them. They can be roughly split into two groups: actively traded stocks that tend to have larger market capitalization, and less actively traded stocks that tend to be smaller. The first group consists of all six stocks that were traded during the whole sample period, with an average of nearly 40 trades a day and a market capitalization of 43 bn CZK. Each of the remaining four stocks had just 9 trades a day and their market capitalization was considerably lower, below 10 bn CZK on average.

<INSERT TABLE 1>

A higher number of trading days and more active trading point up large differences in the number of trades between the two groups. While our sample includes more than 26,000 trades, on average, for each of the stocks in the first group, the average stock in the second group has only slightly more than 2,000 trades.

The size of the spread appears to change in connection with the size and trading activity of the stocks. SPT Telecom, the largest and most actively traded stock, has the lowest spread (0.9%) and then the spread generally increases in the first group with lower market capitalization and less active trading. Stocks in the second group exhibit considerably higher spreads, with RIF the only notable exception. This could be related to the fact that RIF is the only investment fund in our sample. The development of the posted spread over time does not exhibit any strong trend: the average spread across all stocks decreased in the first half of the sample period and increases in the second half.

The average daily trading volume in SPAD amounts to 700 mn CZK (approximately 19 mn USD) during the sample period.[7] Basic characteristics of volumes and prices for individual stocks can be found in Table 2.

<INSERT TABLE 2>

Not surprisingly, trading volumes are also considerably higher for stocks in the first group, where the average daily volume exceeds 100 mn CZK (2.7 mn. USD). Based on the variation coefficient, trading volume is considerably more volatile than prices, which is also in line with expectations. Stocks in the first group exhibit a greater volatility of prices and lower volatility of volume compared to stocks in the second group.

For illustration, Figure 1 depicts the development of prices and volumes of the ten stocks during our sample period. There is no pattern in price development, and the profile of volumes

[7] At the same time, the share of the SPAD system in the whole PSE trading volume (in equities) was rather high in 1999-2001, at 96%, as it was successful in attracting order flow from the direct trades segment.

also differs substantially across the stocks. The only common feature is a significant increase of trading volume in early 2000 among the six stocks in the first group.

<INSERT FIGURE 1>

A brief comparison of the stocks in our sample with those used in previous studies of informed trading and the components of the bid-ask spread appears to be in order. Naturally, the volumes and market capitalization of SPAD stocks are remarkably smaller than those of the most liquid U.S. stocks. The average trading volume of the stocks in our sample just about equals the average trading volume of the fifth decile stocks from the NYSE included in Easley et al. (1996b). Huang and Stoll (1997) examined 1992 data for the twenty stocks in the Major Market Index. For these stocks, the mean percentage posted spread hovered between 20 and 70 basis points. The NASDAQ stocks used by Stoll (1989) are comparable in both volume and posted percentage spread, and even the reported average number of thirteen to fourteen market makers corresponds to the number of market makers in SPAD.

Overall, our stocks are less frequently traded and have larger posted spreads than the blue chips from the U.S. The differences are not so dramatic, however, as to prevent us from comparing our results with those of previous studies. In fact, the opposite is true, since our stocks are comparable to an average U.S. stock used in previous studies. It is important to note that the average absolute value of the posted spread of our stocks is comparable to the spread of average U.S. stocks used in the previous studies.

2.3. Intraday Development of Volume and Spread

The transaction data allows us to explore the development of spreads and volumes during the trading day. Figure 2 depicts the trading volume, as well as posted and traded spreads for each of the ten stocks in 15 minute intervals.[8]

<INSERT FIGURE 2>

The intraday pattern of volumes is U-shaped, very clearly for the six actively traded stocks and to a lesser extent for the remaining four stocks, with peaks at the open and close.[9] This is consistent with the findings of several previous papers for NYSE stocks (see for instance Jain and Joh, 1988 and Foster and Viswanathan, 1993.

The intraday development of the spreads is different, however. Previous papers–Chan et al. (1995) among the more recent–found that the spread of NYSE stocks follows a U-shaped pattern, with the spread widest after the open and prior to the close. In contrast, for all ten stocks traded in the SPAD system, both posted and traded spreads decline gradually during the trading day (9:30 a.m. through 4:00 p.m.). The decline is smoother for the more actively traded stocks, but still apparent in all of them. The difference between the posted and traded spreads is rather stable during the day.

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[8] Posted spread is simply the difference between best ask and best bid quotes. Traded spread, in addition, accounts for the fact that investors are sometimes able to obtain better prices from the market makers, and thus the effective spread is lower. The traded spread in the graphs in Figure 2 were obtained by estimating equation (1) described in section 3.1. at 15 minute intervals.

[9] Please note that the period of active trading (open phase) starts at 9:30 a.m. and ends at 4:00 p.m. Trades recorded outside this time period are only settled through the system and the information about the spread is therefore not very relevant (the spread does not change after the market closes).

There exist market microstructure models, like that posed in Madhavan (1992), in which the gradual resolution of asymmetric information leads to a declining bid-ask spread during the day. This might be the case in SPAD, but its differing market structure from that of the NYSE is likely to play a role as well, especially at the end of the trading day. As opposed to NYSE, where the specialist increases the spread with higher trading volume and order imbalances before the close, in SPAD the inventory component of the spread may decrease before the close. The competitive market makers try to unload undesired inventory positions before the market closes, improving the quotes from both bid and ask sides and thus narrowing the spread.

3. Adverse-Selection Component: Models and Estimation Method

Several different approaches to estimating the components of the bid-ask spread exist in the literature, including an approach based on Roll (1984) and developed by Stoll (1989) and George et al. (1991). We find their approaches less suitable in an emerging market setting, as they use the covariance of transaction prices or quotes to infer the effective spread and its components and require strong assumptions about other, non-adverse selection, factors affecting the bid-ask spread. We thus prefer another class of models: those that use the trade indicator to analyze the bid-ask spread.[10]

[10] The trade indicator is usually defined as equal to 1 if the trade is a buy, -1 for a sell and 0 if the type of trade is unclear, for instance, if the trade was executed exactly at the midpoint between bid and ask quotes. Some studies do not use 0 and classify all the trades as buys or sells by using additional characteristics of the order flow, for instance, the direction of previous trades.

3.1. The Adverse-Selection Component of the Bid-Ask Spread: Our Model

We decompose the bid-ask spread into three components. The first is called the order processing component and is caused by the costs market makers incur when they provide market-making services. These costs include various items including the rent of office space and the salaries of traders. Order processing does not change with short-term fluctuations of the order flow and is assumed to be constant; a safe assumption because our sample period includes only a couple of months. The second component, inventory, exists because market makers run the risk of taking on undesired inventory when quoting firm prices. The market maker's inventory position, however, can change with order flow. This flow results in quote and price revisions, since the market maker changes the quotes and thus increases the probability of reversing his inventory position. The third component of the spread, adverse-selection, occurs because the market maker faces the risk of trading with an agent who has private information about the value of an asset. The market makers will inevitably lose when trading with such informed agents and so must set a spread between their bid and ask quotes which compensates for this expected loss. We should point out that there is a difference between the posted (quoted) spread, which is simply the difference between the bid and ask quotes, and the traded (effective) spread. The traded spread takes into account the fact that some trades are conducted within the inside quote, that is, at better prices than best bid or best ask.[11]

The most serious problem in estimating all three components of the bid-ask spread is the distinction between the adverse-selection and inventory components. They both lead to the same revision after a trade. On the other hand, an incoming buy order lowers the market maker's

[11] The inside quote is formed by the best bid and best ask quotes.

inventory, compelling him to increase quotes in order to raise the probability of a sell order which would balance his inventory position. Similarly, a buy order in an environment with nonzero probability of informed trading increases the market maker's beliefs about the value of the asset and leads to an upward revision of quotes. Buy orders thus lead to quote increases and sell quotes to quote decreases due to both adverse-selection and inventory effects; it is difficult to distinguish these two effects empirically.

This situation only holds true, however, if there is a single market maker or dealer like a specialist at NYSE. In the case of a competitive dealer system (for instance NASDAQ, SEAQ in London, or SPAD in Prague), market reaction to inventory reasons will be different, a point not recognized in earlier papers. For instance, Stoll (1989) argues that the NASDAQ can be treated as a one-dealer market: "Competition among dealers, the desire of investors to trade with the dealer at the 'inside', knowledge by all dealers of quotes of other dealers, and the knowledge of transaction prices causes the inside quote [best bid and best offer] and transaction prices to behave as if there were one dealer" (Stoll, 1989, p. 123).

We disagree. Quote revisions behave differently when there are multiple dealers as opposed to only one specialist. In the first scenario, the same inventory risk is spread among a larger number of market makers and thus also across a broader capital base, which itself would make the inventory induced reaction weaker. That, and the behavior of dealers lowers the reaction to inventory.[12] First, dealers with extreme inventory positions tend to form the inside quote since they want their positions to be reversed. Second, even if they had the best quotes and took an undesired inventory, they would revise the quote and thus cease to have the best quotes.

[12] The risk-sharing feature of multiple dealer systems is also recognized in Affleck-Graves et al. (1994). We assume that dealers do not view the undesired inventory of other dealers as their own.

The second-best quote, however, would not be affected by the change in inventory but would change only by the information content of the trade, assuming all market makers observed all trades.

Thus, even if the market makers with the best quotes do not like the inventory change, only the affected market makers would revise their quotes for inventory reasons. All other dealers would revise quotes only due to adverse selection, that is, a change in the expected fair value of the stock. They do not obtain any undesired inventory position. An argument might be made that the remaining dealers would revise quotes because they expect the dealer with an undesired inventory position to try to get rid of it. Yet it would not be rational for them to revise their quotes other than in line with the new expected fundamental price. Of course, if a dealer knows there is a seller, the dealer might be tempted to lower the price further and pick up the stock more cheaply, but competition among market makers should prevent this.

The view that dealers set quotes according to their relative inventory positions appears in the literature, although it has not been used in the estimation of the bid-ask spread components. The first authors to deal with the issue of quote setting by competitive market makers were Ho and Stoll (1983). Their model implies that inventory position will affect the placement of competing quotes, with the market makers at the inside quote having extreme inventory positions.[13] Lack of detailed data, however, made empirical testing of this prediction impossible for almost 15 years. Only recently two papers, Reiss and Werner (1998) and Hansch et al. (1998) tested the crucial predictions of this and other inventory models explicitly. These two papers use

[13] In fact, Ho and Stoll solve the model only for two dealers. Also, the best quotes are not the reservation prices of dealers with extreme positions, but rather those equal to the second-best positions (or only marginally better). This does not affect our analysis here, though.

data from the London Stock Exchange, a multiple dealer market, to test the hypothesis that the positioning of quotes by one market maker relative to that of other market makers is a function of their inventories. Hansch et al. (1998) found that changes in quotes and inventories are strongly correlated and that standardized and relative inventories are mean reverting. They also report that market makers who post competitive quotes execute a significantly larger proportion of public trades (the data they use distinguish between interdealer and public trades), so competitive quoting attracts more trade flow. This supports the view that dealers with the best quotes are those with extreme inventory positions. Further evidence in Hansch et al. (1998) and a paper by Reiss and Werner (1998) suggest that dealers engage in interdealer trading primarily when their inventory positions become extreme. This strengthens the view that a dealer with an undesired inventory position has two options: to make his quotes the best on the market and wait for a client order (which is more profitable, but uncertain) or to accept a worse price, but unwind the position quickly in an interdealer trade. When the undesired position becomes large, it is too risky to wait for a public order.

In fact, this weak inventory induced response of the competitive dealer system might explain the results of Stoll (1989), who used NASDAQ data and found only a small inventory component (10% of the spread). This finding was also one of the arguments George et al. (1991) used to defend their assumption that the inventory component of the spread does not exist (they use this assumption for NYSE stocks as well). Such an assumption is inappropriate if the competitive dealer system response to inventory pressure is different from that of a specialist system.

Our approach to the inventory component of the spread assumes that under normal circumstances the revision of quotes due to inventory reasons in response to a trade is

negligible, since those who have the best quotes actually want the inventory and there is no reason to expect pressure from interdealer trading. If, however, the circumstances are not normal and there is substantial selling or buying pressure, several dealers accumulate undesired inventory and use interdealer trades to unwind their positions. In that case, inventory reasons for quote revision might also become important for those who are not directly affected by the current trade. We thus create a binary variable (denoted as PRESS) to indicate whether a particular trade happened in a period of selling or buying pressure. We take a moving window of ten trades prior to the particular trade and, given the number of sells and buys, determine whether there was trading pressure. We have chosen three different levels for this variable; we require the cumulative variable to exceed four, six and eight sells or buys, which selects approximately 50 percent, 20–30 percent, and 10 percent of all trades, as being conducted under selling or buying pressure.[14] These frequencies do not fully correspond to the frequencies we would expect if the trades came from an independent binomial distribution with equal probability of buy and sell, which would be 51 percent, 9 percent, and 0.2 percent, but this discrepancy is explained by the fact that our "draws" are not independent and by our expectation that trades in a similar direction are clustered under trading pressure. This expectation is borne out, since the frequencies in our data are higher than the theoretical frequencies.

Further, we assume that the traded spread is constant and therefore,

[14] This method is similar to that of Huang and Stoll (1997), who also use a three-way decomposition of the spread based on portfolio trading pressure. They use an aggregate (cumulative) sell-buy indicator. Their approach is used solely for NYSE stocks, however, so it is difficult to argue that the specialist should react to inventory changes only when there is overall selling and buying pressure. Also, the selection of stocks that should be indicative of trading pressure is questionable, and Huang and Stoll do not support this approach very strongly.

$$P_t - M_t = S/2*Q_t + \eta_t, \qquad (1)$$

where S is the constant traded spread, P_t is the transaction price at time t, M_t is the quote midpoint (average between best bid and ask quotes at the time of trade) at time t, and Q_t is the trade indicator variable, which equals 1 if the trade is a buy, -1 if it is a sell, and 0 if it occurs exactly at the midpoint. We assume that the error term **η** has zero mean conditional on Q.

The key part we estimate is based on the model of Huang and Stoll (1997), and hence we use the same notation as in their paper. First, the unobservable fundamental value of the security at time t, $V_{t,}$ is driven by new information in the most recent trade (from time t-1) as indicated by the trade indicator variable Q_t and by several additional characteristics of the trade:

$$V_t = V_{t-1} + \alpha*S/2* Q_{t-1} + \delta*CROSS_t + \varepsilon_t .$$

The variable CROSS indicates whether the trade was a so-called cross trade, that is, a trade between the dealer's own accounting book and that of his client. Such trades naturally do not originate in the SPAD system, but they must be reported so that the market is aware of the order flow. The rationale for including this variable in the model is that such trades might be viewed by the market as having a different information value from normal trades. It is not clear, however, what sign the coefficient δ should have, since the market might view cross trades as transactions that will not affect the market (then cross trades would have lower information value) or as an indication of stronger order flow (then the information value would be higher). We assume that the error term ε has zero mean conditional on the right-hand side variables.

The actual quotes that we observe are influenced by inventory effects as discussed above. We assume that inventory matters only when there is significant buying or selling pressure.[15] Thus, the quote midpoint M_t is given by

$$M_t = V_t + \sum_{i=0}^{t-1} \beta \frac{S}{2} Q_i PRESS_i$$

.

Taking first differences and substituting for V_t yields

$$\Delta M_t = \alpha * S/2 * Q_{t-1} + \beta * S/2 * Q_{t-1} * PRESS_{t-1} + \delta * CROSS_t + \varepsilon_t. \quad (2)$$

We estimate equations (1) and (2) simultaneously to obtain the estimates of α, β, δ, and S/2. We choose the generalized method of moments since it imposes very weak distributional assumptions and allows us to account for autocorrelation and heteroscedasticity.[16] We estimate the model for each stock using all available data and then use a two-month moving window for the six stocks traded during the whole sample period to examine the stability of the estimates. We only use trades recorded during the active phase of trading (9:30 a.m. to 4:00 p.m.).[17]

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[15] The treatment of the inventory component is what mainly distinguishes our model from that of Huang and Stoll (1997). It is important, since it allows us to use a rather simple estimation technique. Our estimation results and our comparison with the results of the Huang and Stoll (1997) approach appear to support our method.

[16] We use the GMM routine in the TSP 4.5 package.

[17] We were able to obtain more detailed data for two months, September and October 1999, and estimated a slightly extended model for that time period. For these two months, our data also identifies the buyer and the seller. We have identified the most active market makers and created a new variable called ACTIVE. This variable equals 1 if the trade was a buy initiated by one of the most active market makers, -1 if it was a sell initiated by one of the most active market makers and 0 otherwise. A buy (sell) was initiated by an active market maker if this market maker was on the buy (sell) side of the trade. We consider the top five market makers, who account for nearly 50% of trading

3.2. Huang and Stoll (1997) Model

For the sake of comparison, we estimate one of the two models of a three-way decomposition of the spread presented in Huang and Stoll (1997). We retain most of the notation from our model presented above. Huang and Stoll (1997) base their model on three equations. First, the unobservable fundamental value of the stock V_t develops according to

$$V_t = V_{t-1} + \alpha*S/2* Q_{t-1} + \varepsilon_t \, . \qquad (3)$$

Second, they assume that every trade affects the inventory position of the market maker (they use NYSE data, so apparently they have the specialist in mind). Thus, the position of the quote midpoint in relation to the current fundamental value of the stock is

$$M_t = V_t + \sum_{i=0}^{t-1} \beta \frac{S}{2} Q_i . \qquad (4)$$

Third, they assume the spread to be constant, with the random factor in the following equation reflecting the deviation of the observed spread from its constant value:

$$P_t - M_t = S/2*Q_t + \eta_t \qquad (5)$$

Combining equations (3), (4) and (5) and taking first differences yields the basic regression model

$$\Delta P_t = S/2*(Q_t - Q_{t-1}) + \lambda*S/2*Q_{t-1} + e_t \qquad (6)$$

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volume, as being the most active. We include this variable because a trade initiated by the most active market makers might have a higher information value for other market participants. Equation (2) then has the following form:

$\Delta M_t = \alpha*S/2* Q_{t-1} + \beta*S/2* Q_{t-1}*PRESS_{t-1} + \delta*CROSS_t + \theta*ACTIVE_t + \varepsilon_t$

where $\lambda = \alpha + \beta$ and thus the combined inventory and adverse-selection component of the model is estimated.

Huang and Stoll offer two ways of fully decomposing the spread, or two ways of separating the inventory and adverse-selection components. First, they use serial correlation in trade flows. Second, they use the concept of portfolio trading pressure that we discussed above, and which is similar to our approach. Since portfolio trading pressure as described by Huang and Stoll is disputable, especially as far as the specialist trading model is concerned, we have chosen to estimate the first model, which is based on the serial correlation of trade flows.

This way of differentiating between adverse-selection and inventory components is based on the observation that, given past order flow, the market forms an expectation about the next order. The conditional expectation of the trade indicator at time t-1 given Q_{t-2} is

$$E(Q_{t-1}|Q_{t-2}) = (1-2\pi)\, Q_{t-2} \qquad (7)$$

where π is the probability of trade reversal, i.e., the probability that the sign of the next trade will be opposite. If we assume that the market knows equation (7), it will take this expectation into account and the development of the fundamental value will be driven by

$$\Delta V_t = \alpha*S/2*Q_{t-1} - \alpha*S/2*(1-2\pi)\, Q_{t-2} + \varepsilon_t . \qquad (8)$$

Combining this with equation (4), which describes the impact of inventory on the position of the midquote, yields

$$\Delta M_t = (\alpha + \beta)*S/2*Q_{t-1} - \alpha*S/2*(1-2\pi)\, Q_{t-2} + \varepsilon_t . \qquad (9)$$

Furthermore, adding the constant spread assumption yields the final expression

$$\Delta P_t = S/2*Q_t + (\alpha + \beta - 1)*S/2*Q_{t-1} - \alpha*S/2*(1-2\pi)\, Q_{t-2} + e_t. \qquad (10)$$

For the purposes of estimation, equation (7) can be rewritten as

$$Q_{t-1} = (1-2\pi)\, Q_{t-2} + \xi_t \qquad (11)$$

and we assume that the error term ξ has zero mean conditional on Q_{t-2}.

By estimating equations (10) and (11) we are able to distinguish between the adverse-selection (α) and the inventory component of the spread (β). We estimate these equations simultaneously, again using the generalized method of moments (GMM routine of the TSP 4.5), as did Huang and Stoll (1997). We only use trades recorded during the active trading phase.

4. Adverse-Selection Component: Results of Estimation

4.1. The Adverse-Selection Component of the Bid-Ask Spread: Our Model

We report the results for the middle choice of the variable PRESS, that is, the case in which we require the cumulative trade indicator to exceed the value of six, in Table 3. The estimates for the other two choices of the PRESS variable are not substantially different (except for the coefficient of the inventory variable itself) and can be found in the Appendix.

<INSERT TABLE 3>

All estimates of alpha, the adverse-selection component, are statistically significant at the 1 percent level and average at 17% – a surprisingly low value given the widespread informed trading on the Czech market. There is virtually no difference in average alpha between the two groups. The estimates in the first group are more concentrated around the average (they range from 15% for Unipetrol to 18% for SPT Telecom), while there is slightly more variation in the second group – there, the estimates vary from 13% for IPB to 22% for RIF. There does not

appear to be any strong correlation between trading volume and the size of the adverse-selection component.

As for the inventory component, β, the results suggest that our assumptions on inventory impact were justified. The component increases from the least strict choice (PRESS 4), which counts almost half of all trades as occurring under trading pressure, to the strictest choice (PRESS 8), which classifies only approximately 10 percent of trades in this way. Moreover, statistical significance (t-statistics) increases in this direction as well.

All estimates of the inventory component, except for IPB and Tabák, are statistically significant at the 1 percent level. There exists a relation between trading volume and the size of the inventory component, the estimates of β range from 4% for the most liquid SPT Telecom to 13% for the least liquid IPS. This is in line with expectations as market makers demand a higher premium for holding inventory of less liquid stocks. Overall, the inventory component is rather small, amounting to only 6% on average. Combined with the 17% share of the adverse-selection component, this implies that the 77 % major part of the spread in the SPAD system is formed by the order-processing component. The coefficient at the CROSS variable is rarely significant, so evidently the market does not find it important that a trade is of the cross type.[18]

We also estimated our model for 17 two-month windows in order to examine the development of the adverse-selection component over time (for the six stocks with full sample data). The estimates of α and the interval of ± 2 standard errors are depicted in Figure 3. There is

[18] In the extended model with the ACTIVE variable, estimated for September and October 1999, we found that for several of the most liquid stocks (including SPT Telecom, ČEZ and Komerční banka) it matters whether the trade is initiated by an active market maker. The significant coefficients (θ) are positive, which implies that a trade initiated by a major market maker is viewed to have higher information value than other trades.

no single pattern to the development of the adverse selection share, as it slightly increases in some cases (ČEZ or Komerční banka), yet decreases or stays stable in others (Česká spořitelna). While there is some fluctuation in the bi-monthly estimates, all are reasonably close to the average and the standard errors are relatively low.

<INSERT FIGURE 3>

As expected, the traded spread is smaller than the posted one. While the best quotes of market makers imply an average spread of 2.1% for all stocks in our sample, the spread that was actually paid amounted to only 1.3% on average. Therefore, more than one third of the posted spread was waived by the market makers since they were willing to offer their counterparties better prices than the posted best bid and ask quotes. Information about individual stocks, which is depicted in Table 4, reveals that the ratio of traded to posted spread is rather uniform across the stocks in our sample. It is interesting that the gap between the posted and traded spread actually widened during our sample period. While at the beginning of our sample, traded spread stood at 70-80% of the posted spread, this ratio decreased toward the 60% mark at the end of the sample (average for the six stocks traded during the whole sample period).[19]

<INSERT TABLE 4>

The rather large and persistent difference between the posted and traded spread might help explain the surprisingly low share of the adverse-selection component we found. It might be a

[19] Judging from the estimates reported by Huang and Stoll (1997), the difference between the posted and traded spread for their stocks was lower than in our sample. In their case, the difference was likely affected by price/quote discreteness since it was approximately equal to one tick. Price discreeteness is a much less important problem in the SPAD system since prices and quotes can be entered up to hellers (100ths of a crown), which allows a very small tick size even for stocks with the lowest prices.

result of the mechanism that market makers use to protect themselves against unknown, potentially informed traders or counterparties they suspect of having and using non-public information. Any investor can come to the market and trade at the posted quotes, best bid and ask prices "officially" available. The market makers can, and apparently do, offer better prices to some investors, presumably to those they believe (based, for instance, on previous experience) do not have better information. The traded spread is then effectively a weighted average of wider spreads offered to unknown or suspicious counterparties and narrower spreads (i.e., trades inside the best bid and best ask price interval) offered at the market makers' discretion to trusted counterparties. The ability of market makers to screen counterparties and offer a lower spread to liquidity investors would then help overcome some problems caused by informed trading. While this is clearly very difficult in practice, longer-term experience and the limited size of the Czech market might enable the market makers to perform a limited screening role. Overall, it appears that the SPAD system is efficient in dealing with informed trading, which is in contrast to the growing literature on market inefficiency and lack of informed risk arbitrage in emerging markets (see for instance Morck et al., 2000).

4.2. Huang and Stoll (1997) Model

The results of estimating the Huang and Stoll (1997) model are depicted in the following table.

<INSERT TABLE 5>

The estimates of the combined share of adverse-selection and inventory components ($\alpha + \beta$) are virtually identical to the estimates obtained from our model above and range from 19% for IPB to 31% for RIF. Nevertheless, the Huang and Stoll (1997) model assigns a considerably

lower share to the adverse-selection component (α) than does our model, ranging from 2% for SPT Telecom to 14% for Tabák, on average only 7%. On the other hand, the inventory component (β) is considerably higher, at 18%, and does not exhibit any dependence on the stock's trading volume. It is worth noting that virtually all coefficients are statistically significant at the 1% level.

Overall, the results of the Huang and Stoll (1997) model confirm that the share of the adverse-selection component is rather small in the SPAD system. Since our model is designed to suit the competitive market maker setting in SPAD, we believe it provides more reliable estimates of the adverse-selection component than the Huang and Stoll (1997) model.

5. Conclusion

Abundant literature links informed trading with the size of the bid-ask spread. Some papers express the concern that a large amount of informed trading might substantially limit the liquidity of the market or even lead to its shutdown. Although the current literature is not settled on the issue of the relative importance of the three components (adverse-selection, inventory, and order processing) of the bid-ask spread, and we provide evidence on this issue, with a focus on the adverse-selection component, from a market in which lax regulation and insufficient institutions have allowed informed and insider trading to become widespread.

In order to estimate the components of the bid-ask spread, we use recent findings that test the inventory behavior of dealers in multiple-dealer trading systems to modify the general Huang and Stoll (1997) model. Earlier studies treated the systems of market makers as single-dealer systems. However, there is a substantial difference between the inventory impact in a single-dealer (specialist) system and a multiple-dealer system. First, multiple dealers have a higher capital base and a higher risk-taking capacity than does a single dealer. Second, the positioning of quotes relative to other dealers depends on the current inventory level, which means that many trades (even though not initiated by the market maker) do not bring undesired inventory, but instead bring the inventory to the desired level. In our model, therefore, inventory impacts quotes only under trading pressure, and our results further indicate that even in times of trading pressure inventory is of rather low importance.

While the absolute value of the spread in our sample is comparable to that of average U.S. stocks used in previous studies, our estimates of the bid-ask spread components suggest that the adverse-selection component amounts to only 17 percent, on average, which is rather low and in

line with recent estimates from developed markets. 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. We offer one plausible explanation for the surprisingly low adverse-selection component on the Czech market, based on the significant gap between the posted and traded spread we observed. The limited size of the market and growing experience might have allowed the market makers to discriminate among counterparties and thus lower the expected loss caused by informed trading. Overall, it appears that the SPAD trading system, which consists of competitive market makers, is efficient in dealing with the problem of informed trading.

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Table 1: Basic characteristics of the stocks in our sample (3/99 – 12/01)

Company	Sector	Average market cap. (mn CZK)	Total number of trades	Number of trading days	Daily number of trades	Avg. spread* (CZK)	Avg. spread* (percent)	Number of market makers**
Group 1								
SPT (ČESKÝ) TELECOM	Telecoms	124,333	47,448	712	67	5.0	0.9%	12
ČEZ	Utilities	54,481	28,922	710	41	1.1	1.1%	12
Č. RADIOKOMUNIKACE	Telecoms	40,380	28,157	710	40	16.9	1.3%	10
KOMERČNÍ BANKA	Banking	16,776	28,001	712	39	11.8	1.3%	11
ČESKÁ SPOŘITELNA	Banking	13,392	14,726	700	21	3.5	1.7%	11
UNIPETROL	Chemicals	10,488	13,885	697	20	1.2	2.0%	11
Average		**43,308**	**26,857**	**707**	**38**	**7**	**1.4%**	**11.2**
Group 2								
RIF	Inv. fund	13,100	2,221	339	7	10.0	0.7%	7
IPB	Banking	12,198	1,206	133	9	4.8	5.3%	7
TABÁK (PHILIP MORRIS ČR)	Tobacco	12,039	2,074	271	8	124.0	2.0%	7
IPS	Construction	2,033	3,245	311	10	4.0	2.7%	8
Average		**9,843**	**2,187**	**264**	**9**	**36**	**2.7%**	**7.3**
Average of all 10 stocks	**n.a.**	**29,922**	**16,989**	**530**	**26**	**18.2**	**1.9%**	**9.4**

Source: Prague Stock Exchange and authors' calculation. The average exchange rate during the sample period amounted to 37.4 CZK/USD.

**This is the posted spread, that is, the difference between best bid and best ask prices. **Simple average of the number of market makers at the beginning and at the end of the sample period.*

Table 2: Prices and volumes: basic descriptive statistics (3/99 – 12/01)

Company	Price (CZK)					Volume (mn CZK)				
	Average	Std. dev.	Var. coeff.	Min	Max	Average	Std. dev.	Var. coeff.	Min	Max
Group 1										
SPT (ČESKÝ) TELECOM	529	171	0.32	174	975	269.0	259.0	0.96	7.9	2,440.7
ČEZ	92	20	0.22	44	137	93.7	81.1	0.87	5.5	911.4
Č. RADIOKOMUNIKACE	1,313	532	0.41	222	2,322	68.8	82.8	1.20	1.0	614.8
KOMERČNÍ BANKA	883	167	0.19	259	1,275	119.7	116.3	0.97	0.05	1,466.4
ČESKÁ SPOŘITELNA	207	43	0.21	76	314	57.1	58.8	1.03	0.5	615.6
UNIPETROL	58	9	0.16	38	76	35.3	40.1	1.14	0.3	250.4
Average	**514**	**157**	**0.31**	**136**	**850**	**107**	**106**	**0.99**	**3**	**1050**
Group 2										
RIF	1,366	134	0.10	1,037	1,546	21.0	28.6	1.36	0.2	205.3
IPB	91	12	0.13	56	133	9.5	11.4	1.20	0.3	57.1
TABAK (PHILIP MORRIS ČR)	6,291	621	0.10	5,250	8,320	17.0	19.8	1.16	0.1	130.4
IPS	147	26	0.18	72	202	9.7	12.5	1.29	0.01	107.4
Average	**1,974**	**198**	**0.10**	**1,604**	**2,550**	**14**	**18**	**1.29**	**0.2**	**125**
Average of all 10 stocks	**1,098**	**174**	**0.16**	**723**	**1,530**	**70**	**71**	**1.01**	**2**	**680**

Source: Prague Stock Exchange and authors' calculation. The average exchange rate during the sample period amounted to 37.4 CZK/USD.

Table 3: Results of estimation (for PRESS 6)

Company	S/2	α	β	δ (Cross)	NOB	R^2 (eq. 1)	R^2 (eq. 2)
Group 1							
SPT (ČESKÝ) TELECOM	1.90 [a] (0.01)	0.18 [a] (0.003)	0.04 [a] (0.01)	-0.01 (0.01)	45,421	0.69	0.10
ČEZ	0.36 [a] (0.003)	0.16 [a] (0.004)	0.05 [a] (0.01)	-0.001 (0.002)	27,510	0.64	0.08
Č. RADIOKOMUNIKACE	6.06 [a] (0.05)	0.17 [a] (0.004)	0.06 [a] (0.01)	0.02 (0.06)	26,937	0.68	0.07
KOMERČNÍ BANKA	4.18 [a] (0.03)	0.17 [a] (0.004)	0.06 [a] (0.01)	0.06 [c] (0.03)	26,112	0.71	0.08
ČESKÁ SPOŘITELNA	1.13 [a] (0.01)	0.16 [a] (0.01)	0.05 [a] (0.01)	-0.002 (0.01)	13,816	0.66	0.08
UNIPETROL	0.41 [a] (0.004)	0.15 [a] (0.01)	0.06 [a] (0.01)	-0.02 [a] (0.004)	13,141	0.69	0.09
Average	**n.m.**	**0.17**	**0.05**	**0.01**	**25,490**	**0.68**	**0.08**
Group 2							
RIF	3.46 [a] (0.08)	0.22 [a] (0.02)	0.12 [a] (0.03)	0.08 (0.16)	2,069	0.70	0.12
IPB	1.49 [a] (0.05)	0.13 [a] (0.02)	0.02 (0.04)	0.05 (0.07)	1,156	0.67	0.04
TABÁK (PHILIP MORRIS ČR)	32.78 [a] (1.12)	0.18 [a] (0.03)	0.01 (0.04)	2.00 [b] (0.75)	1,949	0.60	0.04
IPS	1.44 [a] (0.03)	0.21 [a] (0.01)	0.13 [a] (0.03)	0.07 [c] (0.05)	3,035	0.75	0.11
Average	**n.m.**	**0.18**	**0.07**	**0.55**	**2,052**	**0.68**	**0.08**
Average of all 10 stocks	**n.m.**	**0.17**	**0.06**	**0.23**	**16,115**	**0.68**	**0.08**

Note: PRESS 6 denotes the case in which we require the cumulative trade indicator to exceed 6 for selling pressure to exist. The results for other definitions of the PRESS variable can be found in the Appendix. Standard errors are reported in parentheses.

The symbol [a] stands for rejection of the null hypothesis (that the coefficient equals zero) at the 1 percent level of significance, while [b] and [c] denote rejection at the 5 percent and 10 percent levels. In the case of RIF, we encountered problems with the convergence of estimates. The reason might be the rather low number of observations; we obtained implausible estimates and do not report them here.

Table 4: Traded and posted spread

Company	Posted spread (%)	Traded spread (%)	Traded/ Posted
Group 1			
SPT (ČESKÝ) TELECOM	1.07%	0.70%	0.66
ČEZ	1.21%	0.77%	0.64
Č. RADIOKOMUNIKACE	1.50%	0.92%	0.61
KOMERČNÍ BANKA	1.41%	0.92%	0.66
ČESKÁ SPOŘITELNA	1.83%	1.11%	0.61
UNIPETROL	2.07%	1.41%	0.68
Average	**1.51%**	**0.97%**	**0.64**
Group 2			
RIF	0.74%	0.49%	0.66
IPB	5.23%	3.01%	0.58
TABÁK (PHILIP MORRIS ČR)	2.05%	1.10%	0.53
IPS	2.90%	1.90%	0.66
Average	**2.73%**	**1.63%**	**0.61**
Average of all 10 stocks	**2.07%**	**1.27%**	**0.63**

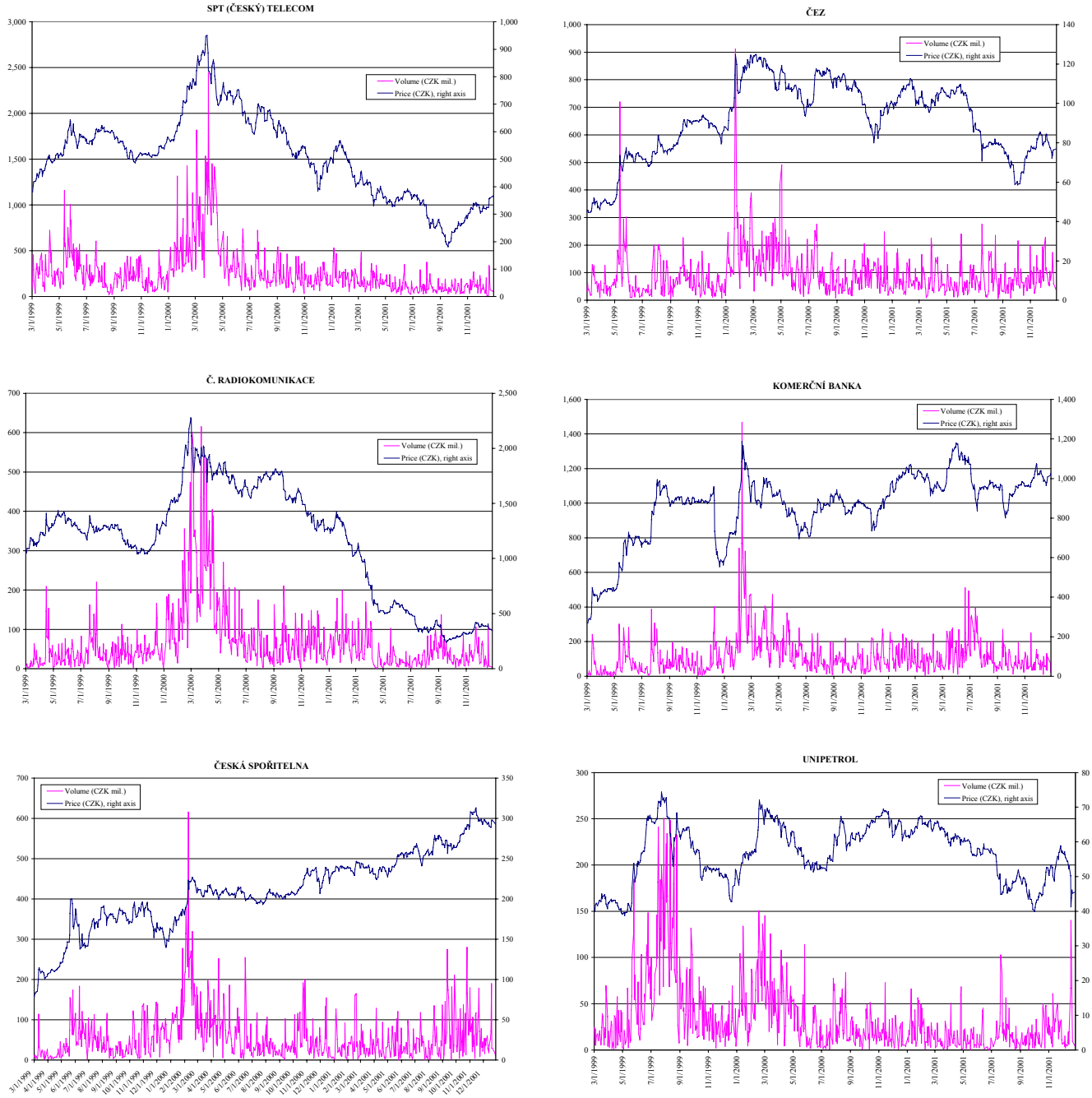
Note: Estimates and calculations in this table are based on all trades recorded during the active trading period (9:30 a.m. to 4:00 p.m.) and the posted spread is therefore slightly different from the posted spread shown in Table 1.

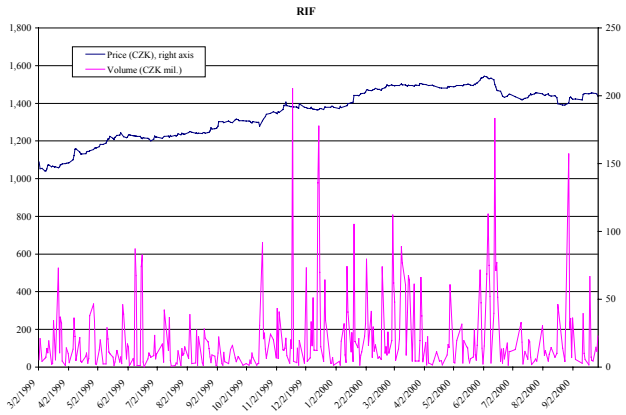
Table 5: Results of the Huang and Stoll (1997) model

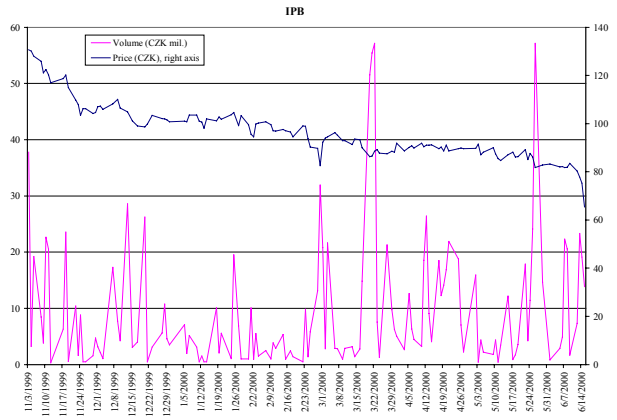
Company	S/2	α	β	1-2π	N	R^2 (eq. 10)	R^2 (eq. 11)
Group 1							
SPT (ČESKÝ) TELECOM	1.85 [a] (0.01)	0.02 [a] (0.01)	0.20 [a] (0.005)	0.62 [a] (0.003)	45,420	0.45	0.28
ČEZ	0.35 [a] (0.003)	0.07 [a] (0.01)	0.16 [a] (0.01)	0.58 [a] (0.004)	27,509	0.42	0.25
Č. RADIOKOMUNIKACE	6.02 [a] (0.05)	0.07 [a] (0.01)	0.17 [a] (0.01)	0.65 [a] (0.004)	26,936	0.41	0.30
KOMERČNÍ BANKA	4.10 [a] (0.03)	0.03 [a] (0.01)	0.20 [a] (0.01)	0.58 [a] (0.004)	26,111	0.46	0.25
ČESKÁ SPOŘITELNA	1.10 [a] (0.01)	0.07 [a] (0.01)	0.17 [a] (0.01)	0.60 [a] (0.01)	13,815	0.40	0.27
UNIPETROL	0.40 [a] (0.004)	0.11 [a] (0.01)	0.14 [a] (0.01)	0.57 [a] (0.01)	13,140	0.47	0.24
Average	**n.m.**	**0.06**	**0.17**	**0.60**	**25,489**	**0.43**	**0.27**
Group 2							
RIF	3.33 [a] (0.07)	0.02 (0.03)	0.29 [a] (0.03)	0.52 [a] (0.01)	2,068	0.42	0.20
IPB	1.47 [a] (0.05)	0.12 [a] (0.04)	0.07 [b] (0.04)	0.57 [a] (0.02)	1,155	0.45	0.23
TABÁK (PHILIP MORRIS ČR)	32.97 [a] (1.15)	0.14 [a] (0.04)	0.12 [a] (0.04)	0.61 [a] (0.01)	1,948	0.25	0.28
IPS	1.39 [a] (0.02)	0.08 [a] (0.02)	0.24 [a] (0.02)	0.62 [a] (0.01)	3,034	0.37	0.30
Average	**n.m.**	**0.09**	**0.18**	**0.58**	**2,051**	**0.37**	**0.25**
Average of all 10 stocks	**n.m.**	**0.07**	**0.18**	**0.59**	**16,114**	**0.41**	**0.26**

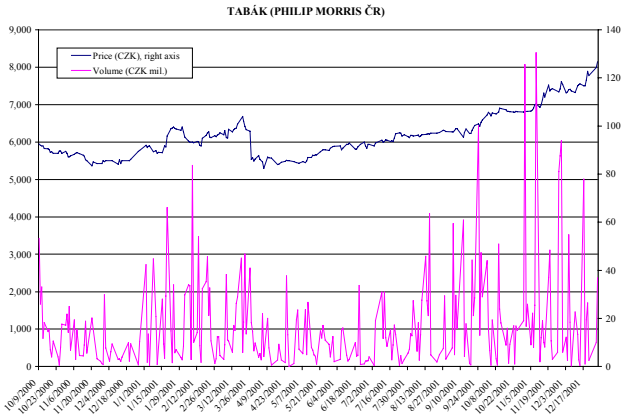
Note: The symbol [a] stands for rejection of the null hypothesis (that the coefficient equals zero) at the 1 percent level of significance, while [b] and [c] denote rejection at the 5 percent and 10 percent levels. Standard errors are reported in parentheses.

Figure 1: Prices and volumes (daily data)




RIF
Price (CZK), right axis
Volume (CZK mil.)


IPB
Volume (CZK mil.)
Price (CZK), right axis


TABÁK (PHILIP MORRIS ČR)
Price (CZK), right axis
Volume (CZK mil.)

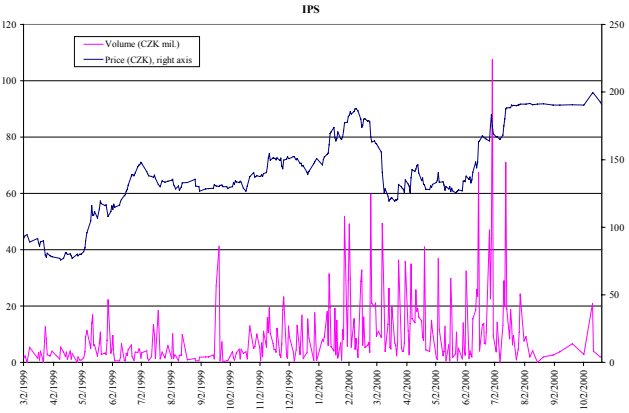
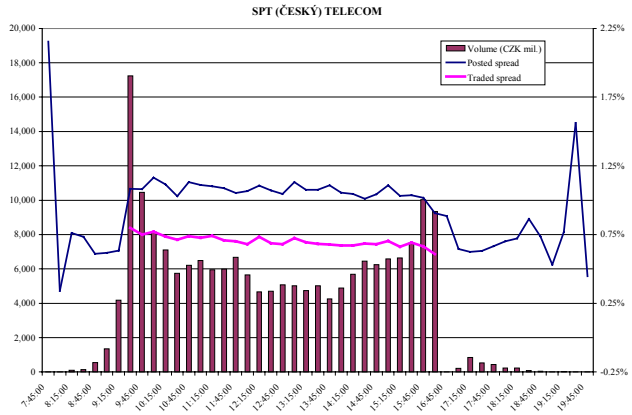
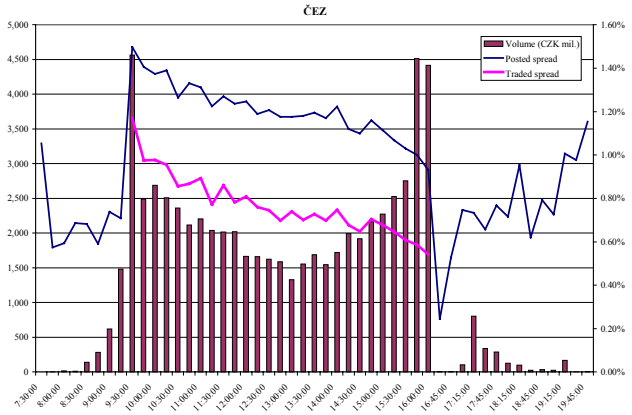
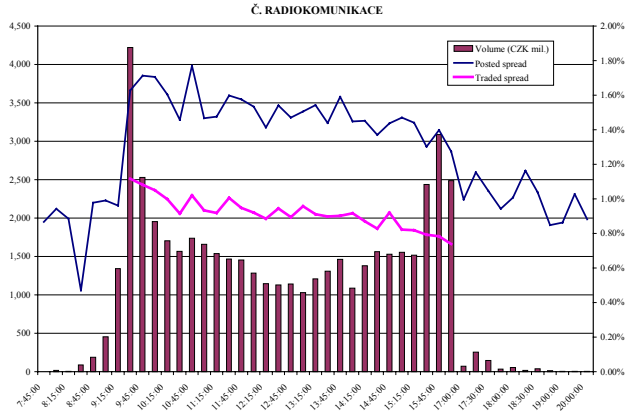
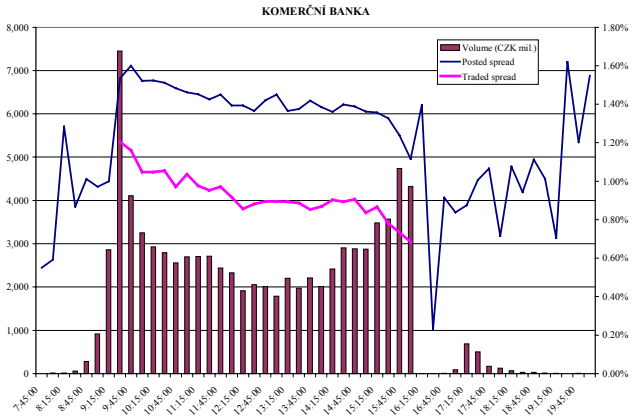

IPS
Volume (CZK mil.)
Price (CZK), right axis

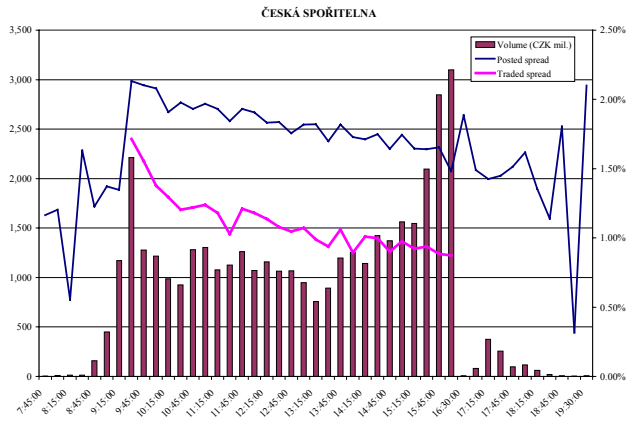
Figure 2: Intraday development of volumes and posted and traded spreads

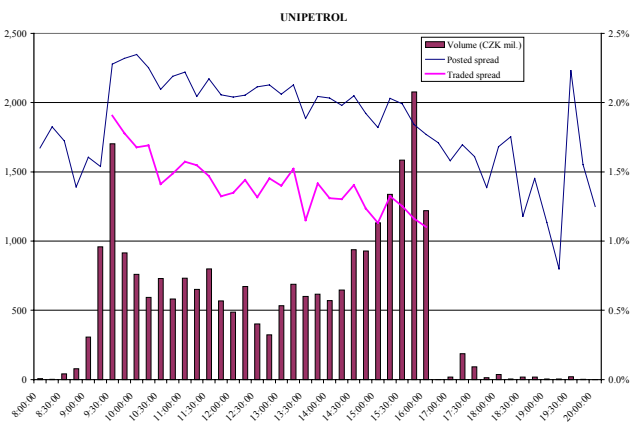


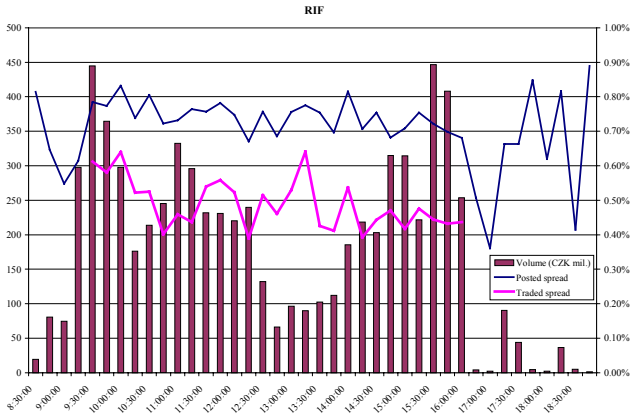


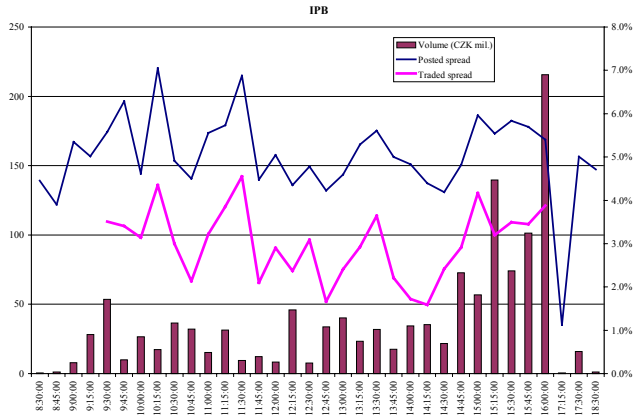


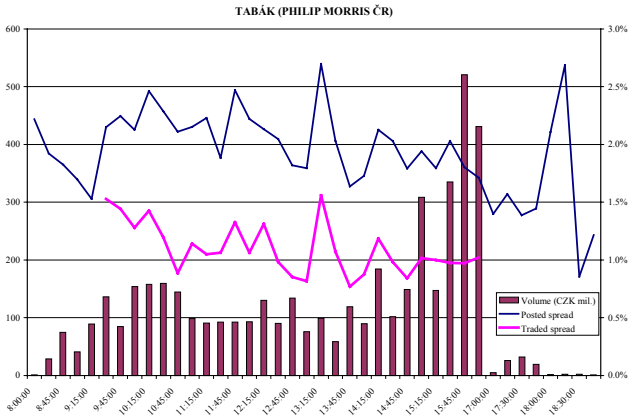







RIF
Volume (CZK mil.)
Posted spread
Traded spread


IPB
Volume (CZK mil.)
Posted spread
Traded spread


TABÁK (PHILIP MORRIS ČR)
Volume (CZK mil.)
Posted spread
Traded spread

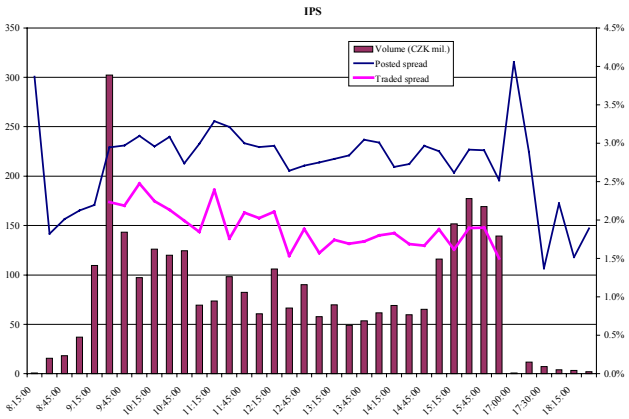
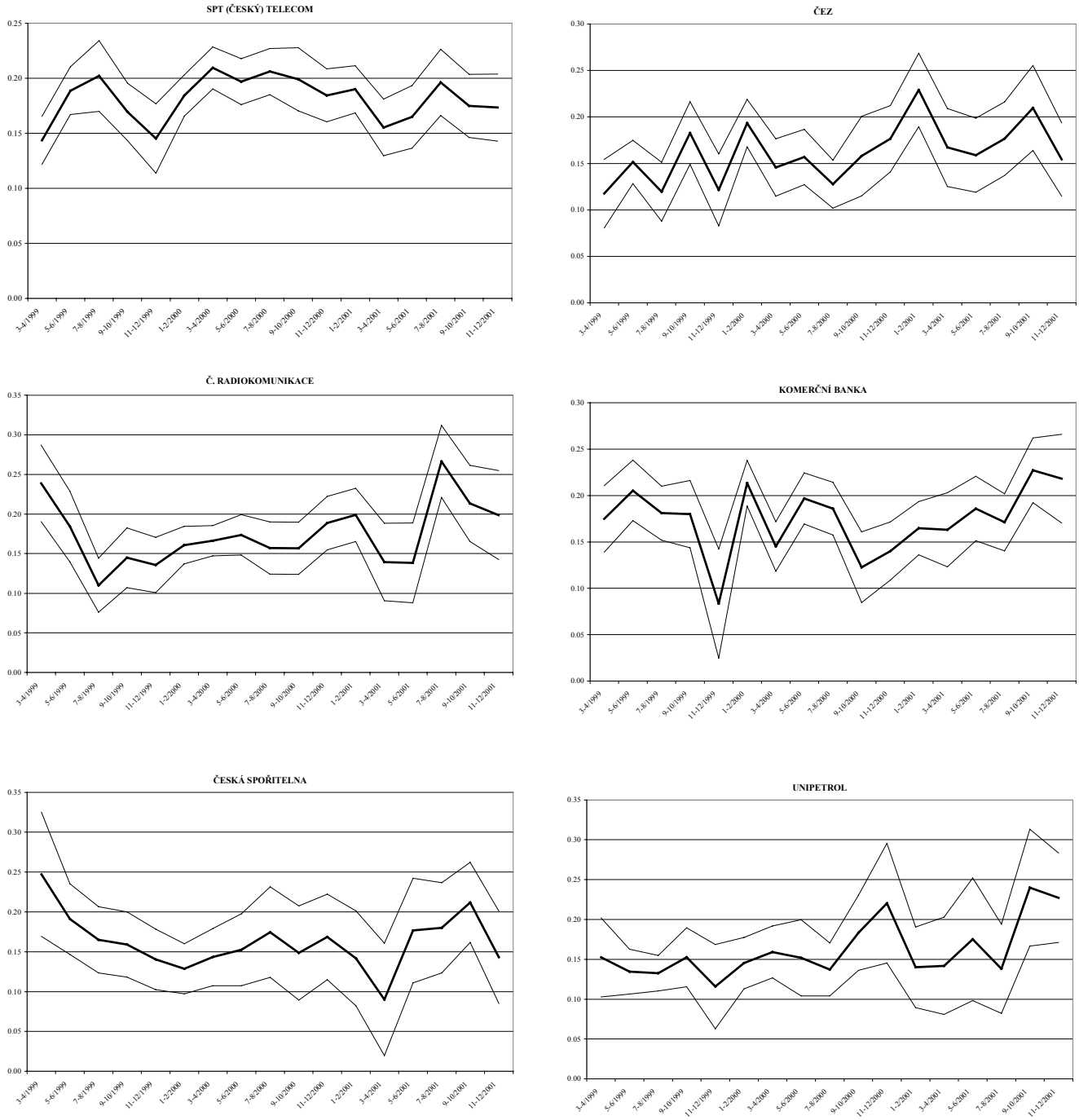

IPS
Volume (CZK mil.)
Posted spread
Traded spread

Figure 3: Estimates of the Share of Adverse Selection (α) Using Two-month Windows of Data (interval of ± 2 standard errors also shown)



Appendix – Estimation results for different choices of the PRESS variable

Table A1: Results of estimation (for PRESS 4)

Company	S/2	α	β	δ (Cross)	NOB	R^2 (eq. 1)	R^2 (eq. 2)
Group 1							
SPT (ČESKÝ) TELECOM	1.90 [a] (0.01)	0.18 [a] (0.004)	0.03 [a] (0.01)	-0.01 (0.01)	45,421	0.69	0.10
ČEZ	0.36 [a] (0.003)	0.16 [a] (0.005)	0.03 [a] (0.01)	-0.001 (0.002)	27,510	0.64	0.08
Č. RADIOKOMUNIKACE	6.06 [a] (0.05)	0.17 [a] (0.01)	0.03 [a] (0.01)	0.02 (0.06)	26,937	0.68	0.07
KOMERČNÍ BANKA	4.18 [a] (0.03)	0.17 [a] (0.01)	0.04 [a] (0.01)	0.06 [c] (0.03)	26,112	0.71	0.08
ČESKÁ SPOŘITELNA	1.13 [a] (0.01)	0.16 [a] (0.01)	0.03 [a] (0.01)	-0.002 (0.01)	13,816	0.66	0.08
UNIPETROL	0.41 [a] (0.004)	0.15 [a] (0.01)	0.05 [a] (0.01)	-0.02 [a] (0.004)	13,141	0.69	0.09
Average	**n.m.**	**0.16**	**0.04**	**0.01**	**25,490**	**0.68**	**0.08**
Group 2							
RIF	3.45 [a] (0.08)	0.21 [a] (0.02)	0.09 [a] (0.03)	0.06 (0.16)	2,069	0.70	0.11
IPB	1.50 [a] (0.05)	0.14 [a] (0.03)	-0.01 (0.04)	0.05 (0.07)	1,156	0.67	0.04
TABÁK (PHILIP MORRIS ČR)	32.88 [a] (1.12)	0.18 [a] (0.03)	0.004 (0.04)	1.98 [b] (0.75)	1,949	0.60	0.04
IPS	1.44 [a] (0.03)	0.21 [a] (0.02)	0.08 [a] (0.03)	0.08 [c] (0.05)	3,035	0.75	0.11
Average	**n.m.**	**0.18**	**0.04**	**0.54**	**2,052**	**0.68**	**0.08**
Average of all 10 stocks	**n.m.**	**0.17**	**0.04**	**0.22**	**16,115**	**0.68**	**0.08**

Table A2: Results of estimation (for PRESS 8)

Company	S/2	α	β	δ (Cross)	NOB	R^2 (eq. 1)	R^2 (eq. 2)
Group 1							
SPT (ČESKÝ) TELECOM	1.90 [a]	0.19 [a]	0.06 [a]	-0.01	45,421	0.69	0.10
	(0.01)	(0.003)	(0.01)	(0.01)			
ČEZ	0.36 [a]	0.17 [a]	0.06 [a]	-0.001	27,510	0.64	0.08
	(0.003)	(0.004)	(0.01)	(0.002)			
Č. RADIOKOMUNIKACE	6.06 [a]	0.17 [a]	0.09 [a]	0.02	26,937	0.68	0.07
	(0.05)	(0.004)	(0.01)	(0.06)			
KOMERČNÍ BANKA	4.18 [a]	0.18 [a]	0.09 [a]	0.06 [c]	26,112	0.71	0.08
	(0.03)	(0.004)	(0.01)	(0.03)			
ČESKÁ SPOŘITELNA	1.13 [a]	0.16 [a]	0.09 [a]	-0.002	13,816	0.66	0.08
	(0.01)	(0.01)	(0.02)	(0.01)			
UNIPETROL	0.41 [a]	0.16 [a]	0.11 [a]	-0.02 [a]	13,141	0.69	0.09
	(0.004)	(0.005)	(0.02)	(0.004)			
Average	**n.m.**	**0.17**	**0.08**	**0.01**	**25,490**	**0.68**	**0.08**
Group 2							
RIF	3.45 [a]	0.23 [a]	0.19 [a]	0.08	2,069	0.70	0.12
	(0.08)	(0.01)	(0.05)	(0.16)			
IPB	1.49 [a]	0.14 [a]	-0.04	0.05	1,156	0.67	0.04
	(0.05)	(0.02)	(0.05)	(0.07)			
TABÁK (PHILIP MORRIS ČR)	32.95 [a]	0.19 [a]	-0.02	1.96 [b]	1,949	0.60	0.04
	(1.13)	(0.03)	(0.05)	(0.75)			
IPS	1.44 [a]	0.23 [a]	0.15 [a]	0.08 [c]	3,035	0.75	0.11
	(0.03)	(0.01)	(0.04)	(0.05)			
Average	**n.m.**	**0.20**	**0.07**	**0.54**	**2,052**	**0.68**	**0.08**
Average of all 10 stocks	**n.m.**	**0.18**	**0.08**	**0.22**	**16,115**	**0.68**	**0.08**

Note: PRESS 4 and 8 denote the cases in which we require the cumulative trade indicator to exceed 4 and 8 for selling pressure to exist. Standard errors are reported in parentheses. [a] *stands for rejection of the null hypothesis (that the coefficient equals zero) at the 1% level of significance, while* [b] *and* [c] *denote rejection at the 5% and 10% levels.*