

CHARLES UNIVERSITY IN PRAGUE

FACULTY OF SOCIAL SCIENCES

Institute of Economic Studies

Bachelor thesis

2011

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Market Microstructure of Stock Exchanges
in the Visegrad Region

Bachelor thesis

Prague 2011

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Date of defense: 2011

Bibliografický záznam

FRAŇO, Filip. *Market Microstructure of Stock Exchanges in the Visegrad Region*. Praha 2011. 57 s. Bakalárska práca (Bc.) Univerzita Karlova, Fakulta sociálných vied, Institut ekonomických štúdií. Vedoucí diplomové práce PhDr. Petr Teplý, Ph.D.

Anotácia (abstrakt)

Cieľom práce je porovnať akciové trhy Vyšehradského regiónu s ohľadom na teóriu tržnej mikroštruktúry, ekonomického prúdu skúmajúceho obchodovanie a jeho výsledky pri platnosti špecifických pravidiel. V prvej časti práce sú vysvetlené bežne používané trhové štruktúry a poskytnutá motivácia, prečo je potreba brať v ekonómii do úvahy usporiadanie akciových trhov. V hlavnej časti práce sú okrem základných charakteristík búrz porovnané štruktúry ich trhu a obchodovacie systémy. Taktiež skúmame správanie cien dvoch segmentov spoločností kótovaných na burzách v Budapešti, Prahe a Varšave, usporiadaných podľa tržnej kapitalizácie. V poslednej časti je pomocou metódy vyvinutej Rollom (1984) odhadnuté trhové rozpätie najväčších firiem kótovaných na burzách v Budapešti, Prahe a Varšave. Výsledky, ktoré nie sú v súlade s predchádzajúcimi empirickými štúdiami, môžu byť zapríčinené pomerne nízkou likviditou týchto trhov a nezvyčajným správaním cien počas finančnej krízy.

Kľúčové slová

trhová mikroštruktúra; akciové trhy; trhové rozpätie; Vyšehradský región; Burza cenných papierov v Bratislave; Burza cenných papierov v Budapešti; Burza cenných papierov Praha; Burza cenných papierov vo Varšave

Abstract

The aim of this thesis is to compare stock exchanges in the Visegrad region with respect to the market microstructure theory, the field of economics studying the outcome of trading under specific rules. First, commonly used structures of markets are presented and the motivation why economists should be concerned with the design of markets is provided. In the main part of the work, besides the basic attributes of these markets, their market structures and trading systems are compared. Moreover, the price behavior of High Capitalization and Mid Capitalization segments of companies from the Budapest Stock Exchange (BSE), the Prague Stock Exchange (PSE), and the Warsaw Stock Exchange (WSE) is examined. Finally, the method developed by Roll (1984) is implemented to estimate the bid-ask spreads of the largest companies listed on the BSE, the PSE, and the WSE. The results that do not correspond with previous empirical studies probably stem from relatively low liquidity of these markets and unusual price behavior during crisis.

Keywords

market microstructure; stock markets; bid-ask spread; Visegrad region; Bratislava Stock Exchange; Budapest Stock Exchange; Prague Stock Exchange, Warsaw Stock Exchange

Declaration of Authorship

I hereby proclaim that I wrote my bachelor thesis on my own under the leadership of my supervisor and that the references include all resources and literature I have used.

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Prague, July 31, 2011

Signature

Acknowledgment

I would like to express my gratitude to Ing. Jan Novotný MA and PhDr. Petr Teplý, Ph.D. for supervising this thesis and for their valuable comments and suggestions.

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Akademický rok 2009/2010

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Garant studijního programu Vám dle zákona č. 111/1998 Sb. o vysokých školách a Studijního a zkušebního řádu UK v Praze určuje následující bakalářskou práci

Předpokládaný název BP:

Mikrostruktura akciových trhů zemí Višegrádského regionu

Charakteristika tématu, současný stav poznání, případné zvláštní metody zpracování tématu:

Cílem práce je studovat mikrostrukturu akciových trhů v zemích Visegrádského regionu (Česká Republika, Slovensko, Polsko, Maďarsko). Práce bude pokrývat několik oblastí. Prvním cílem je sesbírat informace o uspořádání čtyř burz v dnešní době, následně umístit jejich uspořádání do současné teorie mikrostruktury trhu a upozornit na možné problémy, které z uspořádání mohou plynout. V další části práce budou porovnány všechny čtyři burzy napříč v přehledné komparativní analýze. Nakonec budou získané poznatky o burzách a o jejich uspořádání použity k studování těchto burz v prostředí současné finanční krize.

Struktura BP:

Abstrakt

Osnova

1. Úvod
2. Finanční trhy, jejich principy a mikrostruktura trhu
3. Rešerše čtyř burz Visegrádského regionu
4. Porovnání mikrostruktury burz s teorií, možné problémy
5. Porovnání burz napříč
6. Efekt finanční krize na strukturu burz
7. Závěr

Seznam základních pramenů a odborné literatury:

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Datum zadání:	Červen 2010
Termín odevzdání:	Červenec 2011

Podpisy konzultanta a studenta:

V Praze dne

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Chapter 1

Introduction

After the collapse of communism in the countries of the Visegrad Region (the Czech Republic, Hungary, Poland, and Slovakia), a difficult task to transform their centrally planned economies to market economies arose. Undoubtedly, one of the fundamental features of well performing market economies is sound capital market. Therefore, during the transition period of the early 1990's, in all four countries the stock markets were established to support the privatization efforts and investments in new emerging companies.

One may say that these exchanges started from very similar initial position. All established in countries distorted by the long years of central planning and without any embeded tradition of equity corporate financing. Nowadays, after almost two decades from their establishment, the Budapest Stock Exchange, the Bratislava Stock Exchange, the Prague Stock Exchange, and the Warsaw Stock Exchange all operate in somewhat different way and hold different position within their home economies. Hence, our goal in this thesis is to compare these exchanges in comprehensible analysis.

Throughout the thesis we shall not merely look at the exchanges' performance as at some "black box", but the market microstructure attributes of these markets will be presented and discussed as well. As we know, stock markets are complex markets with many rules and regulations. Market microstructure is an emerging branch of economics that studies markets and outcome of trading with respect to these trading rules, mechanisms employed and agents present therein. Thus besides

the comparison of basic attributes of stock exchanges in the Visegrad region, we shall analyze the structure of these exchanges, their institutional setup and trading mechanisms.

The thesis is structured as follows. In the second chapter, basic principles and functions of stock markets are presented. Since we are concerned with market structure, commonly utilized types of markets and systems used to execute trades are discussed as well. Also, market liquidity, one of the essential attributes of stock markets, is explained.

In the third chapter, market microstructure theory is introduced. We present works that demonstrate why various agents operating on stock exchanges should be concerned with their structure and trading mechanisms.

The fourth chapter is devoted to the actual comparison of stock exchanges in Visegrad region. Basic attributes such as their market capitalization, trading volume, and turnover velocity are compared. Naturally, we also discuss the trading mechanisms and execution systems employed on these exchanges. Moreover, in the last section of Chapter 4, the distribution of daily price returns of the largest companies, divided into two segments according to their market capitalization, is compared.

In the fifth chapter, the bid-ask spread present on the Budapest Stock Exchange, the Prague Stock Exchange, and the Warsaw Stock exchange is discussed. The size of this spread is estimated using Roll's estimator. The Bratislava Stock Exchange, similarly as in the section devoted to the behavior of the price returns, is omitted from analysis because of lack of the data.

Chapter 2

Stock markets, their function and principles

Financial markets are the fundamental component of all market economies. When operating efficiently, financial markets enable economic agents to allocate scarce financial resources to sectors where they are needed the most. People whose income is higher than their expenses have the opportunity to invest these excess resources. On the other hand, economic agents who lack financial resources at present but expect higher future cash inflow may borrow the financial resources from the investors (Barnes, 2009). We can say that the financial markets' main function is to solve intertemporal cash flow timing problem of economic agents, since their income and expenses not always correspond over time (Harris, 2003). This allocation process is the moving force of economic growth; thus, it is no surprise this sector is subject to extensive economic research. Above mentioned allocation of resources is carried out by trading with financial instruments. As market economies have evolved in time, increasing technological demands of production and application of the economies of scale resulted in the inability of entrepreneurs to raise sufficient funds themselves.

Generally, two types of financial instruments are recognized according to the asset they underlie: debt instruments and equity claims (Fabozzi and Modigliani, 2003). The former represent the claim of holder of the financial instrument to receive specified amount of money in specified time in the future. Frequently used

instruments of this type are corporate bonds or Treasury bills.¹ The equity based instruments represent a certain interest in ownership of the company. Nowadays, the issuance of stocks and debt securities is a standard way to acquire funds necessary for running the business.

The most popular form of equity claim is by far a common stock. The common stock entitles its holder to receive dividend payment from issuing company proportional to the amount of stocks he owns; however, this payment is conditioned by company's performance, and is not obligatory for companies. With the proliferation of stock issuance, the stock markets were designed to minimize searching costs spent in order to find a person willing to trade exactly the same amount of certain stock. Without the existence of some central place where investors may trade, potential traders' search for counterparty would be costly and time consuming.

Stock markets are generally highly sophisticated markets, governed by a set of specific rules, where buyers and sellers can reveal their demands, and trades are executed at determined price. The structure of these markets varies from place to place. Some exchanges use intermediaries such as dealers or specialists, who are obliged to take position in every realized trade and thus offer necessary liquidity. Other exchanges use systems in which traders place their orders via brokers to central order book, where these orders are matched according to used trading rules. Moreover, hybrid systems containing elements of both mentioned mechanisms exist.

Despite the ongoing economic research on structure of stock markets, there is no general consensus on the most efficient market structure of stock exchanges among the economists. Though, as will be shown in remainder of this work, trading systems, mechanisms, and sets of rules under which the exchanges are operating have considerable influence on price determination, volatility and liquidity of markets. Further in this chapter we shall describe the most frequently used trading systems.

¹Treasury bills are short-term obligation with the maturity of less than 1 year, issued by United States Department of the Treasury.

2.1 Floor-based vs. electronic-based systems

First distinction of stock exchanges can be made with respect to the actual place, where the trading takes place. We distinguish *floor-based* and *electronic-based* trading systems. At the former, exchange members are physically present on the trading floor. The New York Stock Exchange (NYSE) is a characteristic example of a floor-based exchange. In the past, naturally, this used to be the only system that could be employed.

With the gradual spread of information technologies, electronic-based systems have emerged. At the exchanges utilizing these systems, exchange members place their order via electronic trading systems; hence there is no requirement for traders to be physically present. This allows brokers and other exchange members to place their orders from any place provided with the Internet connection. Another merit of electronic-based systems is the fact that they increase transparency of markets by publicly displaying information about the prices and demand and supply of assets in real time (Jain, 2005).

2.2 Continuous vs. Call markets

Trading generally takes place in trading sessions, i.e. periods when traders are allowed to trade. There are two types of trading sessions: continuous trading and call markets. In continuous trading, trader may attempt to trade whenever the market is open. This trading is very common and almost all major stocks have continuous trading sessions.

In call or single-priced auction markets all traders trade at the same time, when a market is called. They place their orders to the system and consequently, the call price is determined at which all trades are settled (Harris, 2003). Call markets are employed on the stock exchanges with small trading volume; moreover, many continuous markets open their trading with single-price auction (Stoll, 1992).

2.3 Execution systems

Another crucial element influencing trading on exchange is the execution system it utilizes. Execution system is a procedure for matching buyers and sellers (Harris, 2003). In general, the most popular markets according to the execution system they use are *quote-driven* and *order-driven* markets.

2.3.1 Quote-driven markets

In quote-driven markets, dealers participate in every trade. Dealers are the exchange members who trade on their own account. The rules specifying their duties vary from exchange to exchange. In general, their primary function is to quote bid and ask prices. Bid price is the maximum price at which the dealer is willing to buy a stock; ask price, on contrary, is the minimum price at which the dealer is willing to sell a stock from his inventory. Best bid is the highest bid price on the market; analogically, best ask price is the lowest ask price on the market. Difference between best bid and ask price is called the *bid-ask spread*. It is considered to be the compensation dealers charge for their services. The bid-ask spread, which will be discussed later, is an important indicator of market liquidity and performance. Some exchanges designate so-called specialists, i.e. the dealers obliged to quote continuously the bid and ask prices for certain security. They are compensated for these responsibilities with a special status on exchange.

2.3.2 Order-driven markets

On contrary, in order-driven markets, traders may arrange their trades without intermediation of dealers. Buyers or sellers specify the price and amount of stocks they wish to trade and their order is placed in the order book. Consequently, orders are matched according to the order precedence rules. Firstly, all buy and sell orders are ranked separately in order of increasing primary precedence. Orders with the highest precedence are matched first. The price precedence is usually used as a primary precedence. This means that the buy orders with the highest price and sell orders with the lowest prices rank highest. Naturally, several orders with the

same price may exist, thus secondary precedence needs to be applied in such cases. Usually, exchanges use time precedence as their secondary precedence, where orders are ranked according to the time of their submission (Harris, 2003). Majority of exchanges use electronic systems to match their orders, however, on some exchanges this is still done manually.

2.3.3 Alternative execution systems

In addition to previous two types of markets, various other execution systems are used. For instance, brokered markets, where brokers search for buyers and sellers. If one wants to trade on this market, he or she has to contact a broker, who will subsequently initiate search for counterparty. Execution system of this type is used in illiquid markets or in markets, where large blocks of securities are traded. Execution of large trade in dealer market could be rather difficult, since dealers might not hold sufficient inventories. Another advantage of this system is that contrary to the order-driven or the quote-driven markets, where traders' identity is not publicly revealed, broker may disclose trader identity to counter-parties, which may provide valuable information about the source and motivation formed based on their previous trading experience (Madhavan, 2000). Moreover, revealing publicly a person's intention to trade a large block of securities could significantly move market price of given security, therefore it could be unfavorable to place large orders publicly in order-driven or quote-driven markets.

2.4 Orders

In general, majority of investors do not personally arrange their trades; they do this with assistance of their brokers. Therefore, it is necessary to specify the price, amount, and conditions under which the investor is willing to trade. These instructions are called orders. Investors have various incentives why to trade. Some prefer their trades to be executed immediately; others are willing to wait rather a long period of time for favourable price. Due to this diversity of investors' needs, various types of orders exist.

First, commonly used type of order is the *market order*. Market order represents an instruction to trade specified amount of security at the best price currently available in the market. These orders are placed by traders who want to be sure their order will be executed as soon as possible. In liquid markets, small market orders are often executed immediately. On the other hand, it might be complicated to find a person willing to take the opposite side of a large trade, thus an execution of large market orders might take rather a long time. Another danger associated with market orders regards the adverse price movement of the security, since stock prices may change quickly between the time the order was placed and the time the order is executed.

Traders, who are not willing to bear the risk of sudden price movement, have the possibility to place other types of orders, so-called *conditional orders*. These orders are executed only when specified price conditions, set by the trader, are met. By far, the most frequently used conditional order is the *limit order*. Limit order designates a price threshold for the execution of the trade, i.e. a buy limit order may be executed at a designated price or lower, a sell limit order may be executed at designated price or higher. (Fabozzi and Modigliani, 2003). If a limit order is not executed immediately, it is placed into the limit order book, where it stays until it is either executed or cancelled. Limit order may be cancelled automatically at the date of its expiry, which is set by the investor, or manually.

Other types of conditional orders are:

- *Stop order*, which is not executed until a market moves to a designated stop price. When a market reaches the stop price, stop order acts like a market order. In case of a buy order, stop order is activated when the market price rises to the stop price.
- *Market-if-touched order* is the order activated when a market reaches the designated touch price. Then, it becomes a market order. In case of buy order, this means that market-if-touched order is activated when prices fall to the touch price.

2.5 Liquidity

Previously, we used the notion of market liquidity several times without any further explanation. Liquidity is one of the key characteristics of financial markets. Despite its importance, there is no clear and uniform definition of this issue among economists. According to Harris (2003), liquidity is the ability to trade large size of given instrument quickly, at low cost, and when investor wants to trade. Regarding this definition, he recognizes three dimensions of liquidity.

- *Immediacy*, which refers to how quickly trades of a given size can be arranged at a given cost.
- *Width*, which refers to the cost of doing a trade of a given size
- *Depth*, which refers to the size of trade that can be arranged at a given cost.

Given these dimensions, it is clear that liquidity is an important feature of a well functioning stock market. It is no surprise that the traders prefer trading on liquid markets. The bid-ask spread, which in fact represents trading cost spent for opportunity to trade immediately, is generally lower on highly liquid markets. Regarding the size of a trade that is needed to affect the price of security, it is usually higher on liquid markets. Therefore, markets with sufficient order flow tend to be less volatile than illiquid markets, where only few trades are executed during a trading session.

2.5.1 Suppliers and demanders of liquidity

When speaking of liquidity of markets, it is essential to clarify which market participants supply, and which on contrary demand liquidity from markets. When we want to determine whether a person is the supplier or demander of liquidity, it is unimportant whether the person is buyer or seller of assets. In other words, both buyers and sellers may be its suppliers or demanders. As was already mentioned, in one of its dimensions, we can consider market liquidity to be an ability of the traders to trade whenever they want. Viewed this way, suppliers of liquidity are persons who offer an option to trade to other traders.

In quote-driven markets, main suppliers of liquidity are the dealers; they quote their bid and ask prices, which enable impatient traders to trade immediately for these prices. From previous description of orders that market participants may place, it is clear what kind of orders impatient traders use. These traders generally place market orders in order to ensure that their trades will be executed as soon as possible. Thus, we can say that they are demanding immediacy, which may be regarded as one dimension of liquidity. Therefore, traders placing market orders are considered to be the main demanders of liquidity in both order-driven and quote-driven markets since they exploit the opportunity to trade offered by other traders.

On contrary, traders who place limit orders are considered to be the suppliers of liquidity. Limit orders are placed by a trader who does not need their orders to fill immediately, but rather, they would wait for the desired price (Stoll, 1992). Until these orders are executed (if they are executed at all), they represent an option to trade, similar to the opportunity offered by bid and ask prices quoted by the dealers. Usually, traders placing limit orders are compensated for this option to trade by obtaining possibly better price than the price they would obtain if they had placed a market order. In quote-driven markets, limit orders compete with bid and ask prices in providing liquidity; in pure order-driven markets, the limit orders supply main portion of liquidity.

Chapter 3

Market microstructure

As we have shown in the previous chapter, stock markets operate in many different forms and structures throughout the world. Various systems, sets of rules and regulations are employed in order to establish trading on these markets. In fact, almost every market is unique with respect to its structure, trading rules, execution system applied, etc. These differences in trading systems attract attention of economists, who make an effort to determine how the employment of various trading systems and mechanisms is reflected into the functioning and performance of these markets. This effort is related to emergence of market microstructure literature. While much of economics abstracts from the mechanics of trading, market microstructure research puts emphasis on this mechanics and its effects on markets. Market microstructure, still an evolving branch of economics, is characterized by the study of the processes and outcomes of exchanging assets under explicit trading rules (O'Hara, 1995).

One of the essential questions in market microstructure literature is how the prices are determined on markets. In standard economic paradigm, the equilibrium price is set as the intersection of supply and demand curve. Question how this equilibrium price is actually achieved is not clearly answered. Some claim this adjustment process is irrelevant. Other approach to the explanation of the price setting mechanism is the employment of the Walrasian auctioneer's process, commonly referred to as tatonnement, which lacks time dimension in determination of equilibrium price (O'Hara, 1995). This hypothetical aggregation process is far away from existing trading mechanisms employed on stock exchanges.

3.1 Field of interest

Market microstructure research includes many theoretical concepts and empirical research. In general, main fields market microstructure deals with are:

- *Price setting mechanism.* Theoretical work in this segment includes models explaining determination of prices on financial markets. These models take into account trading costs, demands of agents performing on these markets, and their influence on prices. Generally, microeconomic perspective of behavior of securities prices is emphasized (O'Hara, 1995). Various issues are addressed, particularly determination of the bid-ask spread and analysis of dealer behavior related to the inventory costs and informed trading, or analysis of traders with private information.
- *Market structure and design.* This segment studies, how employment of various trading mechanisms and protocols affects performance on markets, its liquidity, volatility, and price discovery process as well.
- *Information disclosure.* The research is devoted to study the issues concerning how the dissemination of various trading information, such as traders' identity, executed trades, or order flow affects behavior of investors (Madhavan, 2000).

3.2 Bid-ask spread

In previous chapter, we mentioned the bid-ask spread when we were discussing liquidity of markets. Market microstructure literature is concerned with the analysis of this spread, both theoretically and empirically. We already know that the bid-ask spread is the difference between the lowest ask and the highest bid price quoted by dealers in dealer markets, or in order-driven markets, analogically, the difference between the lowest sell limit order and the highest buy limit order. Many agents operating on the markets are concerned with bid-ask spread. For dealers, it represents compensation they earn for their services; since they are buying assets at the lower price than they are selling.

The bid-ask spread is a subject to extensive research; however, there is no general consensus among economists on this issue. For instance, the works of Garman (1976) or Ho and Stoll (1981) emphasize the inventory cost component of the bid-ask spread. Since dealers have to face constant inflow of orders they need to adjust their bid and ask prices properly to keep their inventories balanced. Other works, such as that of Glosten and Milgrom (1985) advocates the idea that bid-ask spread arises mainly from asymmetric information problem. The dealers do not know whether they are trading with informed or uninformed traders. Informed traders often dispose with information that is not available for dealers. Because of this adverse selection, the dealers must recoup their losses to informed traders by setting adequately large bid-ask spread (Glosten and Milgrom, 1985).

For traders, who demands immediacy, the bid-ask spread represents trading cost they have to face, along with other fees charged by brokers. The size of a bid-ask spread represents implicit trading costs of performing so-called round trip, which is the buy of an asset and then its immediate sell or vice versa. The size of the bid-ask spread is thus an important attribute of stock markets; usually the lower the bid-ask spread is, the more liquid the markets are. In markets with high trading volume and liquidity, dealers may quote narrower bid-ask spread. This happens because of constant inflow of market orders, which enables dealers to apply economies of scale; also, for dealers it is easier to keep their inventories balanced in well performing markets.

3.2.1 Roll's estimator

The most straightforward way, how to determine the size of bid-ask spread in the market would be to observe the electronic order book, where all orders and quotes are stored. Unfortunately, economists do not always have access to these data sets. Therefore, another technique how to estimate the size of bid-ask spread had to be discovered. One of such techniques was presented by Roll (1984).

Roll (1984) in his work developed a simple measure of an effective bid-ask spread

on stock markets. It is defined as follows:

$$Spread = 2\sqrt{-Cov}, \quad (3.1)$$

where *Spread* is the bid-ask spread agents have to face, and *Cov* is the first-order serial covariance of subsequent price changes. The advantage of this method is that it does not require other data but the prices of assets themselves. It requires, however, two assumptions. First, assets are traded in informationally efficient markets; and second, probability distribution of price changes is stationary for at least a short time interval. The idea of this estimation lies in the fact that in informationally efficient markets, the center of the spread should fluctuate randomly; however, the actual prices are not independent, because recorded transaction occur either at the bid or the ask price (Roll, 1984).

When computing spread by equation (5.1), absolute size of bid-ask spread is obtained. For practical reason such as comparison of bid-ask spreads of different companies, it is utile to obtain the size of bid-ask spread as a percentage of the price of underlying asset. The bid-ask spread in this form is obtained, when in equation (5.1), instead of first-order serial covariance of subsequent price changes, first-order covariance of percentage returns will be computed. It is worth noting that the bid-ask spread computed this way, as Roll claims, is not necessarily the bid-ask spread quoted by dealers, but it is an effective spread that agents trading on the exchange have to face. After all, not all trades executed on the exchanges are with market makers. Nevertheless, the previous still applies.

Roll in his analysis estimated bid-ask spreads of companies listed on American exchanges. In the paper, he provides a proof that, “the expected value of the spread-induced serial covariance is independent of the time interval chosen for collecting successive prices (Roll, 1984, p. 1130).” Hence, to perform estimation he used daily and weekly returns of given stocks. To verify obtained results, he used OLS regression with the estimated values of bid-ask spread as a response variable and the market capitalization of each stock at the end of previous year as an explanatory variable. The results indicated strong negative dependence of estimated bid-ask spread on the size of the company, which is in accordance with the previous empir-

ical studies. Although, despite the theoretical independence of serial covariance on the chosen time interval, results obtained from weekly returns was on average six times higher and more stable over time.

Nyholm (1997) in his study implemented Roll's method to analyze the bid-ask spread of stocks listed on Copenhagen Stock Exchange using intra-daily data. This time the method and its results could be verified by comparing the results with actual bid-ask spread, which was obtained from database containing trade information and quotes. Despite claiming that it does not comprise all components of bid-ask spread, Roll's method was used because of its simplicity. Again, obtained result were verified using OLS regression, this time, actual bid-ask spread was used as an explanatory variable. The regression revealed significant correspondence of the estimated and the real spread. The value of coefficient of determination was around 0.5 in all three periods of the analysis and hence the estimator explains about 50% of quoted spread (Nyholm, 1997). On average, estimated values of bid-ask spread was lower than the actual bid-ask spread, thus Roll's estimator seems to be downward biased, which corresponds to the fact that the estimator is not concerned with all components of bid-ask spread.

3.3 Market design

As we already mentioned, designs of real world stock markets differ significantly from theoretical concepts. Every market is designed in somewhat different way. In general, no optimal structure exists that would suit every particular market. All markets are, in fact, different in their nature, as to their size, location, or historical and institutional background. One of the tasks of the market microstructure research in this area is to analyze, what the main advantages and disadvantages of different markets structures are. The outcomes of this research should be beneficial for regulators and designers of new markets, who should put this knowledge into practice and choose the best fitting structure.

Usually, various combinations of execution systems are implemented to ensure markets perform efficiently. Many markets, for instance, use continuous trading

system preceded by a call auction. Implementation of different trading systems within a single market allowed to study influences of these mechanisms on price determination and volatility. Amihud and Mendelson (1987) compare in their study behavior of open-to-open and close-to-close returns on NYSE. Returns of the same stocks are examined during the same periods. They find that open-to-open returns exhibit greater variance. Since open and close prices are determined in different mechanisms—the former in a single price call auction, the latter in continuous dealer market—and both periods last 24 hours, it is likely that divergence in results will reflect differences in employed trading mechanism. Biasis, Glosten and Spatt (2005) claim that that this divergence, apart from the previous, may also stem from the uncertainty the traders must face after the overnight halt of trading.

Useful insight in differentiating two previous interpretations provided the paper of Amihud, Mendelson and Murgia (1990). The return volatility in the Milan Stock Exchange is studied, where trading starts with continuous trading and then, the call auction comes after; however, this sequence of trade is sometimes reversed. Although both systems, the call auction and continuous regime, exhibited greater variance when they were employed at the opening, the call auction's variance at the opening was lower than the variance of the continuous regime at the opening. This fact supports both the hypothesis about investors' uncertainty and the hypothesis about the different efficiency of market mechanisms. Amihud, Mendelson and Murgia (1990) conclude that opening call auction is more efficient in price discovery and information processing than continuous regime employed when the markets are opened.

From previous text it is apparent why the economist should be concerned with the market microstructure issues of stock markets. Different trading mechanisms have different impact on the price discovery, information procession or trading cost. Every regulatory authority or person responsible for designing a new market should keep this in mind. In the next chapter, we will continue with the comparison of stock exchanges from the Visegrad region. We shall point out existing differences in the nature and in the structure of these markets. In Chapter 5, where the bid-ask spreads of the companies from the BSE, the PSE, and WSE will be estimated we

shall also utilize the knowledge presented in Section 3.2.

Chapter 4

Comparison of stock exchanges in the Visegrad region

In the following chapter, we start with basic facts and brief information about history a of Visegrad region stock exchanges. Further we discuss main attributes of these exchanges regarding their market structure, performance and position within capital markets of their home countries.

4.1 Basic facts about exchanges

4.1.1 Prague Stock Exchange

Although the modern Prague Stock Exchange (PSE), as known today, was established on 24th November 1992, trading with securities and commodities in Prague dates back to third quarter of 19th century. As early as 1871, Prague exchange was founded in Austro-Hungarian Empire, and trading therein continued until the outbreak of World War II. The trading in Prague after the war, however, was not restored until the fall of Communism and the emergence of effort to build up the capital markets in post-communistic countries. Trading at the Prague Stock Exchange after the post war break initiated in April 1993. First, the securities were

traded in weekly auctions (Prague Stock Exchange).¹

Nowadays, trading at the exchange is characterized by continuous, electronic-based mechanism, where securities are traded in two systems. In order-driven system, where traders place their orders through exchange member, or in a quote-driven system SPAD, intended for the most traded securities. These two systems perform independently. In essence, the latter one, SPAD, is a dealer market, where constituted market makers are obliged to continuously quote their bid and ask prices in order to provide for liquidity. Trading in SPAD was introduced in 1998 with one traded security. At present, 15 most liquid securities are included in the system.

4.1.2 Warsaw Stock Exchange

In Poland, as in all post-communistic countries, the operation of capital markets was halted during the period of communistic regime. Shortly after the fall of the regime, capital markets were reintroduced and in 1991 the Warsaw Stock Exchange (WSE) was founded. Initially, it was listing five domestic companies formerly in possession of the state and meant to be privatized (Warsaw Stock Exchange).² In the beginning of its existence, the WSE was the main institution used in a process of privatization of state owned companies and by 1993 became one of the fastest growing and most liquid markets in Central Europe (Hussain and Nivorozhkin, 1997). First, trading occurred on a weekly basis, and was gradually extended to three days in a week in 1993 and to five-day trading week in 1994 (Gordon, Rittenberg, 1995).

Introduction of Warsaw trading system in 2000 was substantial breakthrough in then existing trading mechanism, as continuous trading was established for the first time at the WSE. Vast majority of securities are now traded in continuous trading system, which is usually preceded by the opening auction and terminated by the closing auction. Generally, the WSE consists of three markets:

- *The Main List*, operating since the very beginning of the WSE and supervised

¹More information about the Prague Stock Exchange is available on the official web page <http://www.pse.cz>.

²For more information about the history or trading on the Warsaw Stock Exchange see the official web page <http://www.gpw.pl>.

by Polish Financial Supervision Authority.

- *New Connect*, founded in 2007, and intended for small and emerging companies. (2009 - 89 % individual investors)
- *Catalyst*, debt instrument market founded in 2009.

Further in this thesis, we will be concerned with The Main List of the WSE; generally, when we refer to the WSE, we shall have in mind The Main List.

4.1.3 Budapest Stock Exchange

The predecessor of the Budapest Stock Exchange, the Budapest Stock and Commodity Exchange gained international significance in the last decades of 19th century. In the period following World War II, it shared common destiny with other stock markets in then communistic countries in the way that trading on the floor of the Budapest Stock and Commodity Exchange stopped.

The exchange was reopened in year 1990 as the first stock exchange in the CEE countries. Initially, floor trading dominated at the exchange; however, by 1999, floor trading was completely abolished. Since then, all trades are executed through MultiMarket Trading System (MMTS). Securities are traded in four segments, namely Equity section, Debt securities section, Derivative section and non-regulated OTC market.³ These days, schedule of trading in majority of securities consists of three periods: opening period, free period, and closing period. The free period is characterized by continuous, order-driven trading mechanism, where exchange members submit orders into the Order Book. The orders are matched according to price priority and time priority principle.

4.1.4 Bratislava Stock exchange

Bratislava Stock Exchange (BSSE), by far the smallest exchange from those discussed in this thesis, started its existence on 15th March 1991; although trading

³For more information about the Budapest Stock Exchange see the official web page <http://www.bse.hu>.

therein did not commence until 26th March 1993.⁴ The exchange was created in response to demand to create capital market in Slovakia, where shares received in coupon privatization might have been traded.

Stock and bonds are traded in 3 markets: Main Listed, Parallel Listed, and Regulated Free Market. Trades are settled in accordance with order-driven trading system, both in single price auction and in continuous regime. In fact, there is a possibility for exchange members to act as a market maker who would trade in particular security; however, this option is currently utilized mainly in debt securities.⁵ As regards the trading volume, trading in obligations comprises the major portion of all trades executed on this exchange.

Despite its name, the BSSE is mainly a debt market, where only a small trading volume in stock market is achieved every year. In 2010, merely 11% of stock trades was executed via order-book; the rest of the trades was pre-negotiated by the investors. We consider the BSSE to be very illiquid market and thus we do not include him in majority of analyses carried out further in this study.

4.2 Market Indices

Frequently used and very popular indicator of the performance of the market as a whole is a stock index. A stock index aggregates price behavior of several stocks into one figure at a particular time. There are several ways how indices are computed. First, composition of indices differs as to what companies' issues are included in index. Certain indices include all companies listed on an exchange, as is done in NYSE Composite, or NASDAQ index.⁶ Further, only companies with market capitalization from particular range may be included in some indices, for instance, high

⁴For more information about the Bratislava Stock Exchange see the official web page <http://www.bsse.sk>.

⁵The only company traded with presence of the designated market maker is Tatry Mountain Resort.

⁶For more information about NYSE Composite and NASDAQ index and their see the web pages <http://www.nyse.com/about/listed/nya.shtml> and http://dynamic.nasdaq.com/reference/Comp_Eligibility_Criteria.stm, respectively.

capitalization, mid capitalization or small capitalization indices. Moreover, along with indices regarding market capitalization, various sector indices are produced, which track price behavior of stocks that belongs into particular sectors of economy, such as banking, IT, telecommunication, etc.

In fact, all indices are mere averages of the prices of their components. Although, there are several methods how to compute these averages; these methods diverge mainly in the way how the weight is attributed to particular stock. Generally, we recognize the two most common types. First, *price-weighted indices*, where the weight of particular stock is proportional to its price, thus issues with the highest price will have the highest influence and vice versa. Well-known indices of this type are Nikkei 225 Stock Average or The Dow Jones Industrial Average.⁷ The second and by far the most popular are the *value-weighted indices*, which take into account market capitalization of the company when its weight in index is calculated. Vast majority of indices are computed this way.

Each of stock exchanges discussed in this work publishes its own indices. The most prominent (so-called blue chips indices) on WSE, PSE, and BSE are WIG20 Index, PX Index, and BUX Index, respectively. In these indices, most prominent companies with highest market capitalization are included. The rules, under which companies are incorporated into index, are different, though.

4.2.1 WIG20 Index

The WSE's WIG20 Index is index of 20 the biggest and the most liquid companies listed therein. Index was firstly calculated on 16th April 1994 and started on an initial value of 1000. Companies, which meet criteria set by exchange, are selected according to their trading volume during last 12 months and their market capitalization. General formula for calculation of WIG20 index is:

$$WIG20(t) = \frac{\sum_{i=1}^{20} p_i(t)q_i(t)}{\sum_{j=1}^{20} (p_j(0)q_j(0)) \cdot K(t)} \cdot 1000. \quad (4.1)$$

⁷More information about Nikkei 225 Stock Average and The Dow Jones Industrial Average is available on web pages <http://www.djaverages.com/> and <http://e.nikkei.com/e/fr/info/nifaq/225.aspx>, respectively.

As we can see, WIG20 is value-weighted index, because weight of each index component is proportional to its share on the total market capitalization of whole index portfolio. This index is adjusted quarterly. Apart from WIG20, WSE publish many other indices, such as:

- mWIG40, index of 40 mid size companies
- sWIG80, index of 80 small size companies
- WIG, index of all WSE companies
- Various sector indices and strategy indices of short and leverage type



Figure 4.1: Time development of the WIG20 Index

Source: <http://www.gpw.pl>

4.2.2 PX Index

Similarly to the WIG20, the official index of the PSE, the PX index, is value-weighted index, and hence the formula for its computation is very similar. PX index was calculated for the first time on 20th March 2006, when it replaced previous PX 50 and PX-D indices. The index took over values of PX 50 index, calculation of which started on 5th April 1994 with initial opening value of 1000. Unlike WIG20 index, there is no predetermined number of base issues that are included in the index.

Currently, the index is composed of 15 share issues; all of them are traded in SPAD trading mechanism. Index composition is adjusted quarterly. Any company, which complies with conditions, set by PSE and has market capitalization higher than $p1$ billion CZK at the day prior to the index adjustment, or it has an average trading volume higher than $p2$ million CZK during 6 month prior to index adjustment, may be included in this index. Parameters $p1$ and $p2$ are set by Commission for the Administration of Exchange Indices.



Figure 4.2: Time development of the PX Index

Source: <http://www.pse.cz>

4.2.3 BUX Index

The BUX Index is an official blue-chip index of the BSE. Again it is value-weighted index, similar to the PX and the WIG20 indices. Number of its base issues is not fixed, although it is limited to 25. Currently, the base is comprised of 13 issues. Computation of the BUX index, however, is different to computation of the WIG20 and the PX indices. While the last two are price indices, which means that dividend payment is not taken into account when they are computed, BUX is computed as total return index. The difference between these two approaches to index calculation lies in the fact that usually on the day after the dividend payment, decrease in stock prices is observed.

The price indices are concerned only with price movement of an index portfolio, thus decrease of stock price after dividend payment is treated in the same way as any other price decrease. On the other hand, the total return index takes into account dividend payments; it tracks index portfolio value under an assumption that dividend payment is fully reinvested in the same stock. Thus, dividend payment *ceteris paribus* does not lower index values.

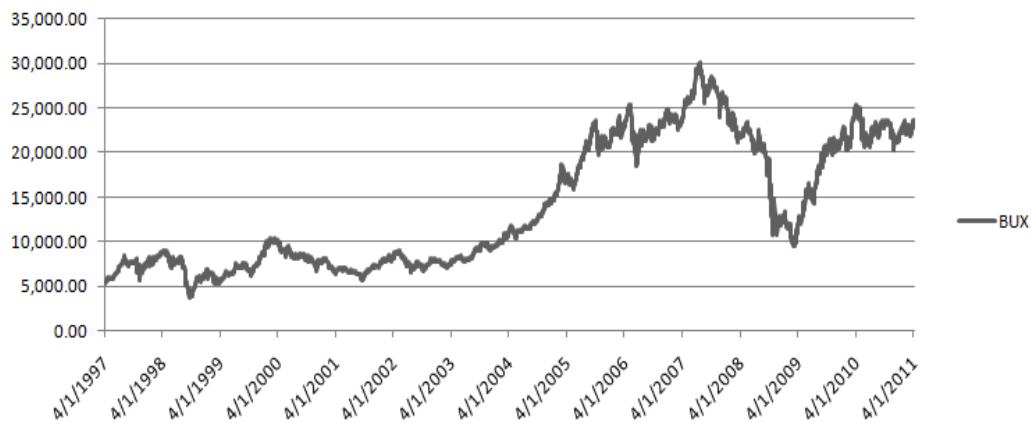


Figure 4.3: Time development of the BUX Index

Source: <http://www.bse.hu>

4.2.4 SAX Index

The SAX Index is official share index of Bratislava Stock Exchange. Again it is value-weighted index, revised twice a year. Compared to other previously described official indices, it has the smallest number of base issues, only seven. In contrast to the WIG20, the PX, and the BUX, this index is not calculated throughout the whole trading session, but its values are set at the end of trading day according to closing price of base issues.

4.3 Market Capitalization

When we want to compare various stock markets, first, we need to look at basic figures and characteristics of these markets. Undoubtedly, market capitalization of the

whole market is one of these characteristics. Definition of market capitalization is quite straightforward. When speaking of one company, we obtain its market capitalization as a product of price of company's stock and number of stocks outstanding. Market capitalization of market as a whole is a sum of market capitalizations of all companies listed on this market. It is a market value of all shares traded on this market. Naturally, this number changes over time as prices or the total number of listed market change.

In our comparison, we will look first at the end of year values of market capitalization over last decade. As we can see in Figure 4.4, over the whole period, the WSE's market capitalization is by far the highest; the second is the PSE. The last position in terms of market capitalization belongs to the BSSE, where the lowest number of shares is traded. As we already mentioned, the BSSE serves mainly as a debt market and because of its illiquidity, low performance and lack of available data, it is not included in further analyses.

Generally, all exchanges follow very similar pattern in development of market capitalization. Until 2007, we can observe a rising trend. This generally corresponds to development of all official indices of compared exchanges, and hence part of this increase is due to general rise in prices. In 2008, market capitalization of all four exchanges dramatically declined. This rapid decline is related to the outbreak of global financial crisis, when stock prices globally declined in its value. The Visegrad region exchanges were no exception and hence downward trend is observed during period from year 2007 to the end of 2009. This steep fall of asset prices is reflected in decline of market capitalization of exchanges. The steepest fall of value of assets experienced WSE, where market capitalization decreased in almost 57% from 2007 to 2008.

4.3.1 Market capitalization to GDP

In Figure 4.4, absolute values of market capitalizations were indicated. It is reasoned to expect these numbers to be, at least to a certain extent, proportional to the size of the countries where these markets reside. The exchanges described in this work form large proportions of capital markets of their home countries, and major part

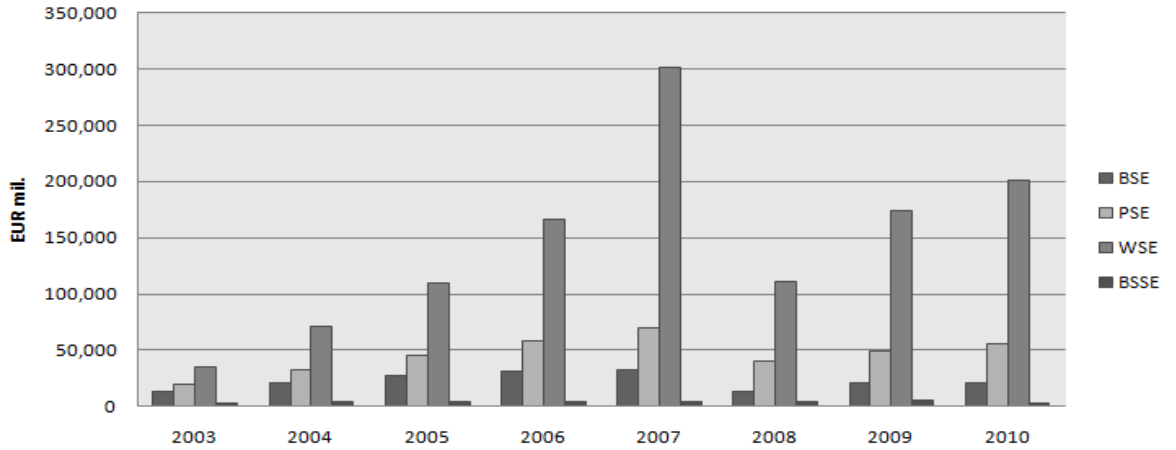


Figure 4.4: Market capitalization of the BSE, the BSSE, the PSE, and the WSE

Source: <http://www.bse.hu>, <http://www.bcpb.sk>, <http://www.pse.cz>, <http://www.gpw.pl>

of companies listed on these exchanges is of domestic origin. Thus the market value of the exchange's assets is linked to the size of home economies.

Therefore, it is insightful to look at a measure that reflects this size and performance of home economies when we want to understand exchange's position in home capital market. Market capitalization to GDP will serve as this measure. We shall define it as follows:

$$\text{Market Capitalization to GDP} = \frac{M(t)}{GDP(t)} \cdot 100, \quad (4.2)$$

where $M(t)$ is market capitalization at the end of year t , and $GDP(t)$ is gross domestic product of year t . In Figure 4.5, growth trend until year 2007 and subsequent fall can be observed, similar to development of absolute values of market capitalization. Although, from figure of market capitalization to GDP, we can see that the WSE is not only the largest market in absolute value of market capitalization at present, but also its market capitalization is the highest of all four stock exchanges when it is compared to GDP of home country. The second and third place in the market capitalization to GDP belongs to the WSE and the BSE, respectively.

Unusually high peak, compared to other exchanges, experienced the WSE at the end of 2007, when its market capitalization to GDP rose up to almost 103%, with

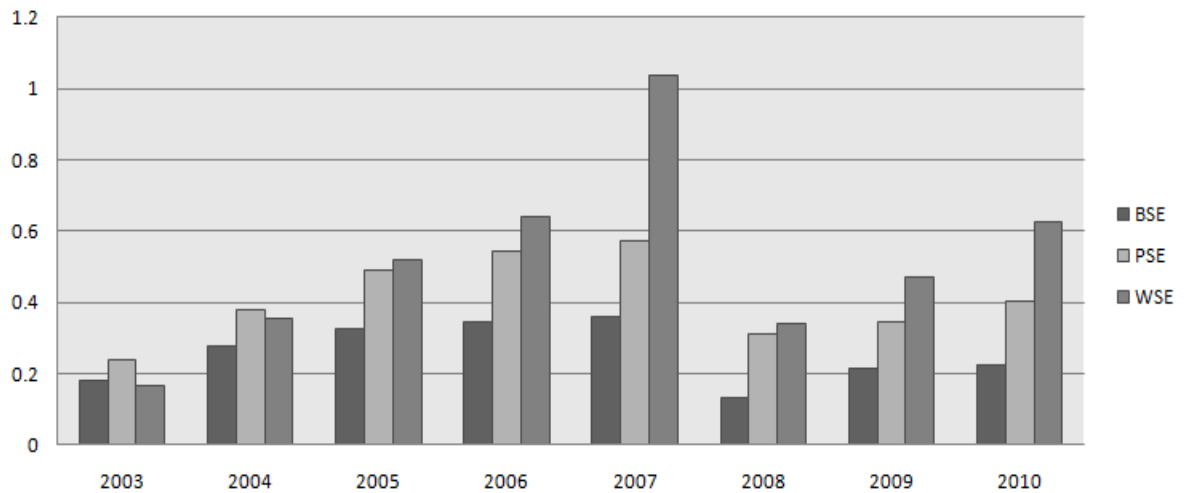


Figure 4.5: Market capitalization to GDP of the BSE, the PSE, and the WSE

Source: <http://www.bse.hu>, <http://www.pse.cz>, <http://www.gpw.pl>,
<http://ec.europa.eu/eurostat>

annual increase of almost 40 percentage points. This rapid growth between 2006 and 2007 on the WSE, in both absolute and market capitalization to GDP values can be attributed mainly to increase of market capitalization of foreign companies listed therein. At the end of 2007, value of foreign companies increased more than two times and exceeded 52% of the whole market capitalization of the WSE. Moreover, year 2007 was one of the most successful years for WSE regarding new listings, since the record high number of new companies, 81 exactly, entered the Main List market. Many of these companies undertook Initial Public Offerings (IPO's), or offered new issued shares to public. In this respect the WSE confirmed its stable position in providing business with capital within Central Europe region, and still continues performing well in this direction.

In the first quarter of 2011, the WSE conducted the largest number of IPO's in whole Europe, 45, of which 7 were from WSE's Main List. On contrary, on both the BSE and the WSE, there was only one IPO since 2008, and these exchanges are gradually ceasing to function as a source of corporate financing in Hungary and the Czech Republic. We may say that their function since their creation has been mainly price discovery. Currently, there are only 28 listed companies on the PSE

and 51 listed on the BSE. Compared to the WSE's 405 companies in Main List, it is indeed a small number. There are plenty of reasons why this situation emerged. Let's mention at least few of them. One of them is rules and regulation regarding pension funds in home countries. According to Bloomberg (2010), Polish pension funds, which managed jointly about 201 billion zloty in 2009, are obliged to invest at least 95% of their resources into home assets; and stock investments represented about 33% of their investments in 2009. On the other hand, in Czech pension funds, allowed to invest up to 50% in foreign assets, investments in shares constituted only 3.4% of their portfolio. Apparently, because of rules regulating management of pension funds in the Czech Republic, they find investing in stocks rather risky.

Obviously, Polish government is striving to support its stock market, thus the WSE cannot complain about lack of attention from state authorities. For instance, many strategic state-owned companies were offered on the WSE instead of being directly sold to other enterprises as was done in the case of the Czech Republic.

4.4 Trading volume

Another important indicator illustrating performance of stock exchange is its trading volume, which is the value of all trades executed therein. In Table 4.6, we show yearly trading volumes of BSE, PSE and WSE in millions of EUR. These figures were calculated as yearly trading volumes in the currency of home country divided by end of year exchange rate to EUR; thus these numbers are biased by exchange rate movement. Nevertheless, they still may serve as a good measure of trading activity on these markets.

Again, the WSE has been the leading exchange in terms of trading volume since 2006, when it replaced the PSE on this position. This leadership is no surprise when we take into account the value of all companies listed therein. The total trading volumes of all three exchanges peaked in 2007; then in two consequent years fall occurred. After this fall, figures of year 2010 show that the trading volume of the WSE and the BSE again raised, in fact the WSE almost recovered to pre-crisis values. As for the PSE, these values still stagnate.

High trading volume is especially important to exchanges. Usually, the higher value of executed trades implies higher liquidity of a market. Of course, this is not always the case, since we cannot infer the frequency of trades from these figures. It is different when a particular amount of stocks is traded almost continuously throughout some period, or when this amount is reached by very few but large block trades. In latter situation, we definitely cannot speak about liquid market. Thus the trading volume itself is not sufficient measure when we want to estimate market's liquidity, or at least it serves as a very rough measure. Although, when certain trading volume is achieved regularly during some time interval, and the smaller this interval is the better, we can conclude that there is stable supply and demand for assets, which is one of the conditions of liquid markets.

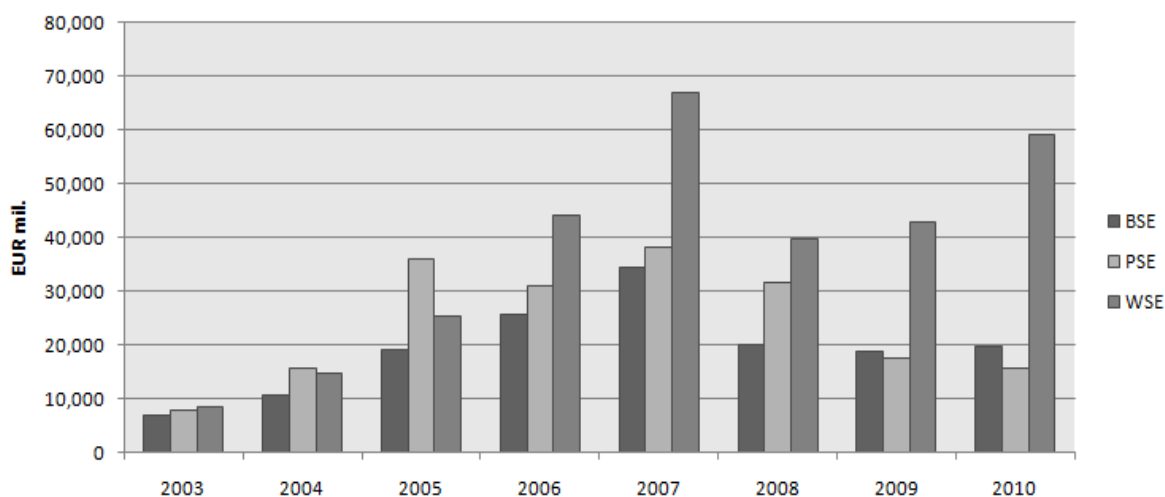


Figure 4.6: Trading volume of the BSE, the PSE, and the WSE

Source: <http://www.bse.hu>, <http://www.pse.cz>, <http://www.gpw.pl>

4.5 Turnover velocity

An interesting measure that can provide information about trading on exchange and structure of the market is a turnover velocity. Definition is again straightforward; it is a ratio of trading volume of particular financial instrument, set of instrument or whole market during certain period to its market capitalization. Similar to the mar-

ket capitalization to GDP, this measure can help us with comparing performance of stock exchanges. When we look solely on the figures of trading volume of particular stock exchange, we have no information about the value of executed trades with respect to the size of the market. It is clear, that two exchanges with the same trading volume, but very different size (which is represented by market capitalization), hold very different position. Since turnover velocity measure is not an absolute value, it solves this problem. Thus, we will look at figures of turnover velocity of the BSE, the PSE, and the WSE.

The first fact that we may notice from Figure 4.7 is that despite the WSE is the largest exchange both in terms of trading volume and market capitalization, its turnover velocity is during observed time interval, except of year 2010, smaller than the PSE's and the BSE's values. It lies in interval from 0.2 to 0.36. On contrary, BSE's values are by far the largest; in 2008 it even reached 1.49, which means that the value of all trades that took place on the exchange exceeded the market capitalization of the BSE almost by one half.

Although, we cannot conclude from these figures, that the BSE is better off in terms of its performance or liquidity. As we discussed earlier, the WSE is considerably larger market than the BSE and the PSE, with by far the largest number of listed companies. Hence it is apparent that a higher number of companies not as prominent for investors as so-called blue chips is present on the market. On the other hand, main portion of BSE's market capitalization and trading volume is achieved by few large companies listed there. For instance, in 2010, the two largest companies, OTP and MOL, with market capitalization exceeding 61% of the market capitalization of the whole BSE, together accounted for more than 82% of all trading volume on the exchange.

4.6 Trading mechanisms and rules

In this section, we will describe and discuss trading mechanism and rules employed at the BSE, the PSE, and the WSE. Although these exchanges are placed in the same region, and started their operation with similar initial position, we have shown

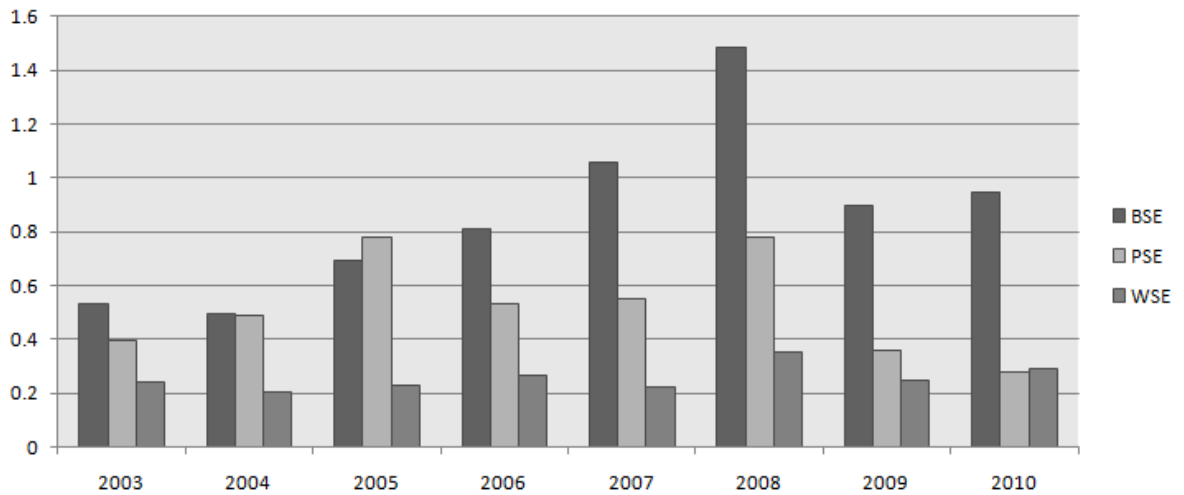


Figure 4.7: Turnover velocity of the BSE, the PSE, and the WSE

Source: <http://www.bse.hu>, <http://www.pse.cz>, <http://www.gpw.pl>

that their performance vary significantly these days. Not only their position within a domestic capital markets are different, they also employ somewhat different mechanism and rules to execute their trades. We will mainly focus on trades in the most liquid issues that account the highest trading volume and market capitalization. Within the last decades, there has been a general trend to employ continuous trading on modern exchanges. The BSE, the PSE, and the WSE are no exceptions, and hence vast majority of shares is traded in continuous regime therein.

At the PSE, currently all shares, apart from one, are traded continuously. Generally, two trading mechanisms are employed to execute trades in shares. In first, order-driven system (which is called Continual regime), all shares listed on the PSE are traded. Trading in this system is initiated by an opening single price auction. Firstly, the orders to buy and sell are collected. During this order collection period, no information about price or state of the market is published and no trades are actually executed. After this period, opening price is determined in such way to ensure the highest quantity of shares to be traded. Subsequently, continuous order-driven trading in its essence identical to that discussed in Chapter 2 commences.

As was already mentioned, the PSE introduced so-called SPAD (Support of Share and Bond Market System) trading mechanism in 1998. SPAD is essentially a dealer

market where dealers (or market makers) are obliged to continuously quote their bid and ask prices within an allowable spread. Continuous trading in SPAD is followed by closing auction, where closing price for given issues is determined. Trading lots are significantly higher than in Continual regime, thus SPAD is attractive mainly for medium and large investors (Kopřiva, 2008). Currently, 15 the most liquid shares are traded in SPAD; and all shares traded there, as we mentioned, are also traded in Continual regime. The previous means, that one issue might be traded in two independent systems and prices at the given time may vary within these two systems. In year 2010, trades in this system covered more than 81% of all trading volume in equity section of the PSE.

Unlike at the PSE, every company listed at the BSE and the WSE is included solely in one trading mechanism at a time. Both of these exchanges employ a single price auction before and after the continuous trading; however, the process preceding the actual realization of auction trades and the determination of opening or closing price is slightly different to that used at the PSE. Contrary to the PSE, where no feedback is provided for traders during order collection period, at the WSE and the BSE, an indicative price is published during this period. This practice slightly resembles process of Walrasian auctioneer in the sense that during mentioned period, orders are collected and processed, and indicative price is published; however, no trading actually takes place. The feedback provided to investors allows them to modify their already placed orders, or place new ones with respect to the actual indicative price in the market.

Between opening and closing auction, both BSE and WSE employ their continuous trading regimes, however, we can again find differences between these regimes. First, at the BSE, all stock issues are traded continuously. This is not the case at the WSE, where listed companies are traded either continuously or in auction regime, but main portion of them is traded in the former regime. In fact, only issues experiencing very low liquidity during last 6 months are moved to pure auction regime, where solely two single price auctions take place. Second difference between these two markets lies in the actual process used to execute trade therein.

In its continuous regime, the BSE operates as a typical order-driven market, in

essence identical to the system discussed in Chapter 2. No official intermediaries such as market makers are present in shares market. Although, market makers are present in other segments of the market, for instance in investment certificates markets. On the other hand, despite the WSE also started as an order-driven market, presence of market-makers in stock market gradually emerged. Nowadays, WSE recommends to every issuing company to establish its own market maker, with whom the company signs market making contract. In addition to companies' own market makers, other exchange members (and also non-members) are able to act as market makers in particular security as well. "A WSE market maker who has no WSE membership operates through a WSE member authorized to act on a client's account (Warsaw Stock Exchange, 2010, p. 135)."

In general, market makers at the WSE are obliged to quote their bid and ask prices within an allowable spread set by exchange and have to do this for at least minimum time interval during the trading session (usually 80% of trading session). This means that WSE's continuous regime is combination of order-driven market and quote-driven market. Although market makers are present in trading system and required to support liquidity, they are not necessarily counterparty in every trade executed during trading session. Furthermore, not every stock issue is traded with support of market making institutions.

As we can see from pervious paragraphs, every exchange relies on slightly different trading mechanism to execute their trades. The main portion of PSE's trading volume is carried out in SPAD, a dealer market; the WSE also relies on market makers in its trading mechanism. On the other hand, the BSE relies only on standards orders from market participants discussed in previous chapters; no official intermediaries constituted by the exchange operate on this market.

4.6.1 Trading hours

Another market microstructure effect worth discussing is the trading hours of stock exchanges. It is well known that stock markets in the same region opened at the same or at the similar time usually exhibit a high degree of price correlation. According to Flavin (2002), this happens because markets react simultaneously to the arrival

of new information from other markets and economies. “Another more practical explanation may be that traders just find it easier to conduct business with other financial market participants who are active at the same time (Flavin, 2002, p. 98).”

We know that interdependence of global stock markets is increasing gradually; markets tend to become more and more integrated over time. Although the great deal of economic literature was written on market correlation and volatility spillovers among stock markets, to illustrate previous statement, we shall mention the work of King and Wandwani (1990), who find in their paper significant increase in volatility of returns of London’s FTSE Index at the time of the opening of the NYSE. As we can see, trading hours and activity on other markets plays significant role in price discovery and price volatility on the stock markets.

Since new information on global financial markets is generated throughout the whole day, at the opening the stock markets must process the information that arrived overnight. This initial information processing is usually associated with higher variance of opening price due to uncertainty about the development of the asset prices. Caporale and Spagnolo (2010) study in their paper integration of the BSE, the PSE, the WSE and also integration with the markets in United Kingdom and Russia. Their work suggests significant price co-movements between the BSE, the PSE, the WSE and also volatility spillovers from UK and Russian market. We may conclude that Visegrad region stock markets are to certain extent sensitive to price behavior of assets on more developed markets.

In Table 4.1 we show schedules of trading at the BSE, the PSE, and the WSE. The actual trading at the BSE and the WSE starts almost at the same time, 9:00 a.m.; however, PSE’s SPAD does not start its trading session until 9:20 a.m. This might have an influence on initial opening price on these exchanges. Traders on the PSE may face lesser degree of uncertainty, since they can observe how overnight information was processed and transformed into prices at the BSE and the WSE. Nevertheless, this hypothesis requires further study to be approved, which is beyond the scope of this work.

BSE	
8:30 a.m. – 9:00/9:01 a.m.	Opening order-collection sub-period
9:00/9:01 a.m. – 9:02 a.m.	Opening sub-period of transactions
9:02 a.m. – 5:00 p.m.	Free period
5:00 p.m. – 5:05/5:06 p.m.	Opening sub-period of transactions
5:05/5:06 p.m.	Closing sub-period of transactions
5:06 p.m. – 5:10 p.m.	Closing price trading period
PSE	
8:00 a.m. – 9:15 a.m.	SPAD - closed phase
8:00 a.m. – 8:45 a.m.	Auction regime – orders collection
8:45 a.m. – 9:10 a.m.	Auction regime
9:10 a.m. – 4:20 p.m.	Continual regime
9:15 a.m. – 4:20 p.m.	SPAD - open phase
4:20 p.m. – 4:27 p.m.	Closing auction for selected securities
WSE	
8.00 a.m. – 9:00 a.m.	Pre-opening
9:00 a.m.	Opening (Auction)
9:00 a.m. – 5:20 p.m.	Continuous trading
5:20 p.m. – 5:30 p.m.	Pre-closing
5:30 p.m.	Closing (Auction)
5:30 p.m. – 5:35 p.m.	Post-auction trading

Table 4.1: Trading hours on the BSE, the PSE, and the WSE

Source: <http://www.bse.hu>, <http://www.pse.cz>, <http://www.gpw.pl>

4.7 Analysis of price behavior

Next, we shall focus on the analysis of price behavior of the largest companies on the BSE, the PSE, and the WSE. We analyze this behavior by observing their daily returns. To compute daily asset returns of the largest companies, the data on the daily prices of these companies are required.

Because we do not have access to official data from the exchanges, these data were obtained from X-Trade broker platform's database.⁸ X-Trade broker is an online trading platform, trading with so-called CFDs (contract for difference). Trading with CFDs resembles the real trading on the exchange, however, no change in ownership of asset takes place. CFDs are financial derivatives, where provider of this service (or seller of CFD) commits to pay to the trader (buyer of CFD) the difference between selling and buying price; we speak about so-called price betting. Since X-Trade broker platform uses the actual and current prices of equities in their system, we shall use prices from their database instead of the official data.

Our analysis will be realized as follows. For each year from 2007 to 2010, 8 companies from each exchange were included according to the size of their market capitalization at the end of the previous year. The companies will be divided in two segments:

- *High Capitalization segment*, formed by the first four companies in terms of market capitalization for which the daily data were available.
- *Mid Capitalization segment*, formed by the companies ranked from 5th to 8th place.

Totally, we obtain six independent sets of companies, which will be analyzed separately. The companies included in analysis for year 2010 and their segmentation are shown in Table 4.2. The composition of the samples for the whole observed period is provided in Appendix. The purpose of this division is to study how the prices behave on particular exchanges. Apart from that, we want to observe and

⁸More information about X-Trade broker platform is available on the web page <http://www.xtb.com>.

	BSE	WSE	PSE
High Capitalization	OTP	CEZ	PKOBP
	MOL	ERSTE	PEKAO
	MTELEKOM	KOMERCNI BANKA	PGNIG
	RICHTER	TELEFONICA	KGHM
Mid Capitalization	EGIS	VIG	TPSA
	FHB	NWR	PKNORLEM
	TVK	UNIPETROL	BZWBK
	FOTEX	CETV	INGBSK

Table 4.2: Company segmentation according to the market capitalization for year 2010

Source: <http://www.bse.hu>, <http://www.pse.cz>, <http://www.gpw.pl>

compare the price behavior of two segments of differently large companies within one exchange. This may provide us with useful information about the structure of trading on these markets.

In the next step, we compute returns for each company separately; the arithmetic price returns are used, that is:

$$R_t = \frac{p_t - p_{t-1}}{p_{t-1}}. \quad (4.3)$$

When we have the daily returns for individual companies, we compute the average daily return of given segment for each day simply by averaging the daily returns of four included companies and denote this average return as r_t . This average daily return time series for years 2007–2010 is the subject to our analysis.

4.7.1 Equally Weighted Return Based Index

Disposing of the average return time series, we can indirectly define and compute our own indices that will be characterized by return series r_t . These indices represent a portfolio of four assets with the same nominal value at the end of every day. Thus the weights of the base issues are revised automatically every day. Index defined in such

way is rather concerned with the price movements of the base issues than with the development of the value of these assets. We will name the index Equally Weighted Return Based Index (EWRB). Its values are computed by employing simple formula:

$$EWRB_t = EWRB_{t-1}.r_t + EWRB_{t-1}, \quad (4.4)$$

where $t = 0$ corresponds to 26 July 2007 and the initial value $EWRB_0 = 1000$ for all indices.

In Figure 4.8, 4.9, and 4.10 is shown development of EWRB on the BSE, the PSE, and the WSE, respectively. Both High Capitalization and Mid Capitalization segments are shown. In all three figures, we can see similar development of indices for the High Capitalization and Mid Capitalization segments. Since the end of 2007 general decline in prices can be observed; however, the Mid Capitalization segment prices decreased more rapidly and the level of Mid Cap Index stayed below the High Capitalization Index for the whole period of our observation. This difference may be due to investors' uncertainty and mistrust of stock markets in times of financial crisis, since investors prefer invest rather to the small number of large and renowned companies, included generally in High Cap segment. Another impact of financial crisis may be seen, in addition to previous, in September 2008, when after sharp downturn of prices increased price volatility is observable.

4.7.2 Comparison of the distributions of returns

In the next part, statistical properties of the average return time series are examined. To be more exact, the statistical distribution of returns of different segments are compared to see whether there exist differences in price behavior among exchanges and their segments. For this purpose, Mann-Whitney-Wilcoxon test is used; non-parametric test, which tests for an identity of distribution of two independent samples. The idea of the test was first proposed by Wilcoxon (1945) for two samples with the same number of observation and later it was extended by Mann and Whitney (1947) for two independent samples. The rejection of the null hypothesis can be interpreted as there is a significant difference in the medians of compared samples. The test statistic of this test has under the null hypothesis approximately



Figure 4.8: Equally Weighted Return Based Index for the BSE

Source of data: X-Trade Brokers Web Trader application, downloadable from <http://www.xtb.cz>

normal distribution for sufficiently large samples.

In the first step, the test is used to compare the return series of the High Cap and Mid Cap segment of each exchange included in analysis. For all three exchanges, the p -value of Man-Whitney-Wilcoxon test is considerably high, and hence we cannot reject the null hypothesis. In other words, we cannot conclude that medians of average return time series of High Cap and Mid Cap samples differ. This result is quite reasonable since returns are usually distributed around zero. Another interesting insight should provide a similar analysis of absolute values of average returns. Potential difference in median of absolute returns should reflect the difference in volatility of the markets. Generally, we may say, that the higher the median of absolute return is the more volatile markets are on the daily basis.

This time, low p -values, 0.0350, 0.0011, and 0.0000 for the BSE, the PSE, and the WSE call for rejection of the null hypothesis on the significance level of 5%. We can conclude that there is a significant difference in the median of absolute returns on all three exchanges. This fact is implying different price behavior between the High Capitalization and Mid Capitalization segments. It is worth to note, that the sign of the test statistic in case of significant result of the Man-Whitney-Wilcoxon test tells us that median of which sample is exceeding another. In the case of the PSE



Figure 4.9: Equally Weighted Return Based Index for the PSE

Source of data: X-Trade Brokers Web Trader application, downloadable from <http://www.xtb.cz>

and the WSE, the negative sign means that the median of the Mid Capitalization sample exceeds the median of the High Cap sample, which corresponds with our expectations, that High Capitalization segment should be less volatile since the market of larger companies is usually more liquid and thus its prices are less likely to be moved by sudden change in preference of investors. On contrary, the result on the BSE is contradicting the previous hypothesis. However, we have to keep in mind that the result of our analysis does not take in consideration all dimension of the volatility of the markets.

In the second step, High Capitalization segments of exchanges are compared amongst themselves; three tests are used to test all three possible pairs of exchanges. Subsequently, the same is done with Mid Capitalization segments. Again, testing the returns series did not reveal any significant difference among exchanges, in both High Capitalization and Mid Capitalization segments. Different results were obtained, when we employed the Mann-Whitney-Wilcoxon test for absolute returns. P -value, low enough to reject null hypothesis at 10% level of significance occurs when testing the BSE's and the PSE's High Capitalization segments. For other two pairs, we do not reject the null hypothesis.

Significant results of the test, however, were obtained in Mid Capitalization seg-



Figure 4.10: Equally Weighted Return Based Index for the WSE

Source of data: X-Trade Brokers Web Trader application, downloadable from <http://www.xtb.cz>

BSE	PSE	WSE
0.01414	0.02300	0.01580

Table 4.3: Standard deviation of absolute returns of Mid Capitalization segments

ments of the exchanges, where for all three pairs the null hypothesis of the Mann-Whitney-Wilcoxon is rejected at the 5% level of significance. This implies different behavior of absolute returns between exchanges. Surprisingly, the WSE Mid Capitalization segment has according to the test significantly higher median of absolute returns than the BSE's and the PSE's Mid Capitalization segments. Prior to the analysis, the opposite result was expected, since we consider the WSE to be the most developed and liquid market of those included in analysis; hence the volatility of returns was expected to be lower than at the BSE and the PSE. To understand better this result, the standard deviation of these samples was examined. The standard deviation of absolute returns of Mid Capitalization segments is provided in Table 4.3. We can see that although the WSE's Mid Cap median of absolute returns is higher than the PSE's Mid Cap, the standard deviation is lower. This may signify less frequent, but relatively higher price changes on the PSE.

In this chapter we discussed the basic features of the BSE, the PSE, and the

WSE, such as their market capitalization or trading volume. Apart from this, we described their trading systems, mechanisms, and studied the price behavior of different segments of companies. These attributes may provide us with helpful information about the performance, the size, trading activity and interdependence of these markets. Next chapter is devoted to the estimation of bid-ask spreads of the largest companies from the the BSE, the PSE, and the WSE.

Chapter 5

Estimation of bid-ask spread using Roll's estimator

In this chapter, we examine and compare how the BSE, the PSE and the WSE stand in terms of bid-ask spread size. The BSSE will be omitted from the analysis because of lack of data. In Chapter 3, we discussed the estimator of bid-ask spread proposed by Roll (1984). We already know, that the size of bid-ask spread estimated by Roll's method is not necessarily the same as the quoted spread, and the size may vary according to the time interval chosen for collecting the successive price changes. Although, in presented studies its value significantly depended on the actual spread, as was shown in the empirical study of Nyholm (1997). Further, we implement the Roll's method to estimate the bid-ask spreads of companies listed on the BSE, the PSE, and the WSE. Our objective is not to determine the real size of the bid-ask spread on the BSE, the PSE, and the WSE, but to use the estimated values as a benchmark for comparison of these stock exchanges.

Before we perform the analysis itself, we expect, in accord with the theory and empirical studies, that the bid-ask spread of companies with high trading volume and large market capitalization will be lower compared to those traded less. That means that companies, such as MOL or OTP, which have relatively high turnover velocity among the companies traded on the BSE, the PSE, and the WSE, are expected to be more liquid and traded more frequently, which usually implies smaller bid-ask spread. Also the performance and liquidity of market as a whole should affect

the average size of bid-ask spread quoted by dealers or of the bid-ask spread that arises from the difference between the lowest limit sell orders and highest limit buy orders. From previous discussion and analysis of the attributes of exchanges, the WSE appears to be the most liquid and the most complex market of those operating in the Visegrad region, thus we are expecting that the WSE will do well in term of the size of the bid-ask spread present on this market.

5.1 Data

Price returns needed for the estimation are computed from prices that we obtained from X-trade broker platform's database. Since the data on the prices are not available for all companies listed on the exchanges, we shall focus in our analysis only on the largest and the most traded companies. In fact, the same sample of companies as in Section 4.7 is included for each year. Similar to the analysis of Roll (1984), we shall use both daily and weekly returns to perform estimation. First, for every exchange, the bid-ask spreads of 8 companies with the highest market capitalization at the end of the previous year-for which the data are available-were computed separately for each year from 2007 to 2010. If the sign of serial covariance is negative, we will use the following formula, as was proposed by Roll (1984):

$$Spread = -2\sqrt{Cov}. \quad (5.1)$$

5.2 Results

The mean values of bid-ask spread estimates obtained from daily and weekly returns are presented for each year in Table 5.1. Similar to the Roll's results, bid-ask spread derived from weekly data are on average higher than those derived from daily data; however, they are not more stable over time. In fact, when we look at our results, both daily and weekly estimates are very unstable over the observed time interval. At first sight, it is difficult to determine which exchange has on average the lowest or highest bid-ask spread; in every year, the order is different. For verification of

our results, we chose indirect method used by Roll (1984); however, because our sample is considerably smaller, we decided to perform for each exchange solely one cross-sectional OLS regression for all periods, i.e. the following linear model was estimated for each exchange:

$$s_{i,t} = \alpha + \beta CAP_{i,t} + \varepsilon_{i,t}, \quad i = 1, \dots, 8, \quad t = 1, \dots, 4, \quad (5.2)$$

separately for estimates $s_{i,t}$ obtained from daily and weekly returns.

Unfortunately, the results did not prove apparent relation between the size of the company $CAP_{i,t}$ and the size of the bid-ask spread $s_{i,t}$. In Table 5.2 and 5.3 the results of performed OLS regressions are provided for estimates obtained from daily and weekly returns, respectively. As we can see, coefficients of determination (R^2) are considerably low for all regression, thus the market capitalization of company does not explain well the size of the estimated bid-ask spread. In fact, the estimate of parameter β is significant and has the desired sign at the same time only in the case of the BSE; however, only for the daily estimates of the bid-ask spreads. The regression results obtained from weekly estimates differ considerably; plus all parameters are highly insignificant.

These results that do not correspond with empirical studies presented in previous text may stem from various factors. First, our sample of examined companies from every exchange is very small; however, we are of opinion that it is large enough to reveal any apparent differences between the exchanges or relation between the estimated bid-ask spread and market capitalization of companies, if it is present. The problem seems to be rather in the price behavior of companies that are listed on the BSE, the PSE and the WSE. First, the exchanges were observed during turbulent period of recent financial crisis, when the asset prices and returns experienced rapid downturn and volatility. This fact may significantly affect the outcome of our estimation. Second, the examined exchanges are relatively small and less developed compared to those in the USA or Denmark; markets used in our analysis do not dispose of such trading volume and liquidity. This fact is closely related to the first assumption required for Roll's estimator to function well, which is the informational efficiency of markets. It is disputable to claim whether this assumption

is met on these markets; its violation may have huge impact on the suitability of Roll's estimator as an estimator of bid-ask spread.

	Daily Data			Weekly Data		
	BSE	PSE	WSE	BSE	PSE	WSE
2007	0.78416	1.23402	3.55456	0.36815	-0.11475	0.63993
2008	1.92265	5.81357	-0.87513	-0.43804	-0.51498	-0.77264
2009	0.54947	-0.70897	-2.68346	-0.11152	-1.85667	-1.56082
2010	2.80873	3.40626	1.72518	0.26765	-0.03413	-0.15240

Table 5.1: The mean values of the estimated bid-ask spreads

Exchange	α (<i>p</i> -value)	β (<i>p</i> -value)	R^2
BSE	0.52950 (0.12180)	$-7.10 \cdot 10^{-07}$ (0.02810)	0.15071
PSE	-0.99951 (0.02210)	$1.94 \cdot 10^{-06}$ (0.19550)	0.05521
WSE	-1.25591 (0.02360)	$3.17 \cdot 10^{-05}$ (0.12750)	0.08094

Table 5.2: Results of cross-sectional OLS regressions $s_{i,t} = \alpha + \beta CAP_{i,t} + \varepsilon_{i,t}$ for individual exchanges; bid-ask spread estimates obtained from daily returns

Exchange	α (<i>p</i> -value)	β (<i>p</i> -value)	R^2
BSE	0.93122 (0.28980)	$8.17 \cdot 10^{-7}$ (0.31470)	0.03368
PSE	1.94155 (0.15140)	$1.57 \cdot 10^{-6}$ (0.73880)	0.00376
WSE	0.22952 (0.88300)	$8.00 \cdot 10^{-6}$ (0.88240)	0.00074

Table 5.3: Results of cross-sectional OLS regressions $s_{i,t} = \alpha + \beta CAP_{i,t} + \varepsilon_{i,t}$ for individual exchanges; bid-ask spread estimates obtained from weekly returns

Chapter 6

Conclusion

In the thesis, we compared stock exchanges residing in the Visegrad region. Before the actual comparison, the basic function and principles of stock markets, commonly used execution systems, and market structures were described so that we can compare the Budapest Stock Exchange, the Prague Stock Exchange, the Warsaw Stock Exchange, and the Bratislava Stock Exchange in comprehensible analysis. Although, because of illiquidity of the Bratislava Stock Exchange and problem with the data, it was omitted from several analyses. Moreover, we provided introduction to market microstructure theory, where we reviewed the fundamental studies that demonstrate why economists or other persons dealing with stock markets should be concerned with the trading rules and mechanisms.

In the first part of the comparison we focused on the basic features of these markets, such as their market capitalization, trading volume or turnover velocity. Consequently, we pointed out the main differences in trading systems and market structures of these markets. We showed that the Warsaw Stock Exchange is by far the largest and the most active market, which attracts foreign companies' attention the most and strives to compete with other markets from Central European region. In fact, it is the only market in Visegrad region that continuously undertakes new IPO's and serves as a source of corporate financing for new companies. The Budapest Stock Exchange, the Bratislava Stock Exchange, and the Prague Stock Exchange stagnate in this respect; findings suggest that recently their main function is the price discovery of the stock issues traded therein.

In the work we were also interested in the trading activity on these exchanges. Hence we analyzed price behavior of the largest companies listed on the Budapest Stock Exchange, the Prague Stock Exchange, and the Warsaw Stock Exchange. For this purpose, the eight largest companies from each exchange were divided into two segments, High Capitalization and Mid Capitalization, according to their market capitalizations. Subsequently, the distribution of average returns of these independent samples was examined separately using the test by Mann and Whitney (1945). The results showed that the distribution of the absolute returns varies significantly between High Capitalization and Mid Capitalization segments within one exchange. Similarly, the same segments were compared across all three exchanges. The results did not show any difference in distribution of returns, both standard and absolute, for High Capitalization segments. On the contrary, the distribution of absolute returns for Mid Capitalization segments varied significantly, implying the different price behavior of these segments. This may indicate a higher degree of interdependence of these markets in the segment of the most prominent companies.

In the thesis we also discussed the role and function of the bid-ask spread, which is subject to extensive market microstructure research. In the Chapter 5, we implemented the method developed by Roll (1984) for estimation of bid-ask spread of the eight largest companies on the Budapest Stock Exchange, the Prague Stock Exchange, and the Warsaw Stock Exchange. The obtained results were not consistent with previous empirical studies of Roll (1984) and Nyholm (1997). The estimated bid-ask spreads did not exhibit general dependence on the market capitalizations of individual companies; and their size varied significantly each year. The reason for this may stem from various factors, such as the turbulent behavior of prices during the period of global financial crisis or lesser degree of informational efficiency on stock exchanges in the Visegrad region.

The information provided in this thesis may serve as a starting point for a more profound study of these markets, their interdependence, and integration. The understanding of the differences and common attributes of stock markets within one region might be beneficial not only for economists, but for regulators and policy making authorities as well.

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Appendix

	2007	2008	2009	2010
High Capitalization	OTP	OTP	OTP	OTP
	MOL	MOL	MOL	MOL
	MTELEKOM	MTELEKOM	MTELEKOM	MTELEKOM
	RICHTER	RICHTER	RICHTER	RICHTER
Mid Capitalization	EGIS	TVK	EGIS	EGIS
	TVK	EGIS	TVK	FHB
	FHB	FHB	FHB	TVK
	FOTEX	FOTEX	FOTEX	FOTEX

Table 6.1: Segmentation of companies from the BSE according to the market capitalization

Source: <http://www.bse.hu>

	2007	2008	2009	2010
High Capitalization	CEZ	CEZ	CEZ	CEZ
	Erste	Erste	Telefonica	Erste
	Telefonica	Telefonica	Erste	Komerční Banka
	Komerční Banka	Komerční Banka	Komerční Banka	Telefonica
Mid Capitalization	CETV	CETV	VIG	VIG
	Unipetrol	Unipetrol	Unipetrol	NWR
	Orco	Orco	NWR	Unipetrol
	Philip Morris	Philip Morris	CETV	CETV

Table 6.2: Segmentation of companies from the PSE according to the market capitalization

Source: <http://www.pse.cz>

	2007	2008	2009	2010
High Capitalization	PKOBP	PEKAO	PKOBP	PKOBP
	PEKAO	PKOBP	PEKAO	PEKAO
	TPSA	TPSA	TPSA	PGNIG
	PGNIG	PGNIG	PGNIG	KGHM
Mid Capitalization	PKNORLEM	PKNORLEM	PKNORLEM	TPSA
	KGHM	KGHM	BZWBK	PKNORLEM
	BZWBK	BZWBK	HANDLOWY	BZWBK
	INGBSK	BRE	BRE	INGBSK

Table 6.3: Segmentation of companies from the WSE according to the market capitalization

Source: <http://www.gpw.pl>