Chapter 12
Dimensions of Market Liquidity: The Case of the Polish Stock Market

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Abstract Liquidity in a financial market is not a one-dimensional variable but it includes several dimensions. The main aim of this paper is an empirical analysis of market liquidity dimensions on the Warsaw Stock Exchange (WSE). We investigate market depth and market tightness for the 53 WSE-listed companies divided into three size groups. The high-frequency data covers the period from January 3, 2005 to June 30, 2015. The additional goal is robustness analysis of the results obtained with respect to the whole sample period and three adjacent subsamples of equal size: the pre-crisis, crisis, and post-crisis periods. The order ratio (OR) is employed as a proxy of market depth, while market tightness is approximated using the relative spread (RS). In line with the expectations, the empirical results indicate that the OR values rather do not depend on firm size, while the RS estimates are slightly higher for small companies. Moreover, the results turn out to be robust to the choice of the sample. Furthermore, an initial research concerning interaction between liquidity dimensions on the WSE is provided by analyzing the degree of correlation between market depth and market tightness. In general, the correlation results are consistent with the literature. The majority of correlation coefficients between daily estimates of the order ratio and the relative spread indicators are not significantly different from zero.

Keywords Dimensions of market liquidity • Market depth • Market tightness • Trade classification algorithms

12.1 Introduction

Liquidity indicates the speed and ease at which one can trade, but it is not directly observable (Huberman and Halka, 2001, p. 161). Liquidity, by its very nature, is difficult to define and even more difficult to estimate (Lesmond, 2005). Usually, simple definitions are not able to capture the phenomenon "liquidity," because

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liquidity is not a one-dimensional variable but includes several dimensions (von Wyss, 2004). Kyle (1985, p. 1316) pointed out that market liquidity "is a slippery and elusive concept, in part because it encompasses a number of transactional properties of markets." He distinguished the following three dimensions of market liquidity: (1) depth—the size of an order flow innovation required to change prices a given amount; (2) tightness—the cost of turning around a position over a short period of time; (3) resiliency—the speed with which prices recover from a random, uninformative shock. von Wyss (2004, p. 5) emphasized the following four aspects: (1) trading time—the ability to execute a transaction immediately at the prevailing price; (2) depth—the ability to buy or to sell a certain amount of an asset without influence on the quoted price; (3) tightness—the ability to buy and to sell an asset at about the same price at the same time; (4) resiliency—the ability to buy or to sell a certain amount of an asset with little influence on the quoted price.

There is a growing body of empirical literature concerning direct measurement of liquidity, but relatively little empirical research has been conducted directly on the liquidity dimensions of equity markets in the world. Market depth has been investigated more extensively than other dimensions of liquidity, e.g., Ahn et al. (2001), Chordia et al. (2000a,b, 2005), Engle and Lange (1997, 2001), Huberman and Halka (2001), Lee et al. (1993), Lin et al. (2012), Ranaldo (2001), Wong and Fung (2002), von Wyss (2004). Moreover, there has been quite extensive research on the bid/ask spread, which may be treated as a measure of market tightness, e.g., Acker et al. (2002), Chordia et al. (2000a,b, 2001, 2005), Huberman and Halka (2001), Korajczyk and Sadka (2008), Lesmond (2005), Levin and Wright (1999), Peterson and Sirri (2003), Piwowar and Wei (2003), Ranaldo (2001), von Wyss (2004). Undoubtedly, the least empirical investigation has been conducted on the stock market resiliency, as this dimension of liquidity is especially difficult to estimate, e.g., Dong et al. (2007), Hmaied et al. (2006), Lo and Hall (2015), Ranaldo (2001). Since resiliency is a measure of price elasticity, it is difficult to define a straightforward indicator to gauge it (Ranaldo, 2001, p. 311). Moreover, as Engle and Lange (1997) perceived, this measure obviously requires some estimate of the equity equilibrium price.

The main goal of this paper is an empirical analysis of market liquidity dimensions on the Warsaw Stock Exchange (WSE). Fifty-three WSE-listed companies divided into three size groups are investigated. The proxies of market depth and market tightness are calculated. The order ratio is employed as a proxy of market depth, while market tightness is approximated using the relative spread. Generally speaking, the empirical findings confirm that a high order ratio indicates low market depth and low stock liquidity. Conversely, a small order ratio denotes high market depth and high stock liquidity. By analogy, a wide relative spread means high market tightness and low stock liquidity. Conversely, a narrow relative spread expresses low market tightness and high stock liquidity.

Moreover, the paper provides a robustness analysis of the obtained results with respect to the whole sample January 2005 to June 2015 and three adjacent subsamples of equal size: the pre-crisis, crisis, and post-crisis periods. The Global Financial Crisis (GFC) on the WSE was formally set based on the papers (Olbrys

and Majewska, 2014, 2015), in which the Pagan and Sossounov (2003) method for statistical identification of market states was employed. We can assert that the obtained results turn out to be robust to the choice of the sample for all groups.

Furthermore, an initial research concerning interaction between liquidity dimensions on the WSE is provided by analyzing the degree of correlation between the order ratio and the relative spread. The majority of correlation coefficients are not significantly different from zero and these results are rather in accord with the literature.

To the best of the authors' knowledge, the empirical results regarding dimensions of market liquidity on the WSE are novel and have not been presented in the literature thus far.

The remainder of the study is organized as follows. Section 12.2 specifies a methodological background concerning dimensions of market liquidity. In Sect. 12.3, we briefly describe trade classification algorithms. Section 12.4 presents and discusses the empirical results on the WSE. The last section encompasses the conducted research with a brief summary.

Nomenclature	
WSE	The Warsaw Stock Exchange
GFC	The 2007–2009 Global Financial Crisis
LR	The Lee and Ready (1991) trade classification algorithm
OR	The order ratio
RS	The relative spread

12.2 Dimensions of Market Liquidity

According to the literature, the majority of researchers follow Kyle (1985) and they distinguish between three dimensions of market liquidity: depth, tightness, and resiliency. Wong and Fung (2002) pointed out that another commonly used concept is immediacy, but it incorporates elements of all three dimensions, and therefore it could be not considered as a separate dimension. Bernstein (1987, p. 55) mentioned the following three dimensions: depth, breadth, and resiliency. He stressed that these three attributes are generally accepted as the basic requirements for good markets. Harris (2003, p. 75) emphasized that when people think about liquidity, they may think about trading quickly, about trading large size, or about trading at low cost. However, people rarely distinguish among these dimensions when discussing liquidity. In this paper, we approximate and explore depth and tightness as market liquidity dimensions on the Polish stock market.

12.2.1 Measuring of Market Depth

Each security has its own liquidity, which may vary over time. Some quantities are related to liquidity, and one of them is market depth. The value of depth could be approximated by various methods. The related literature proposes the following proxies of market depth:

- Depth as the number of units offered at the ask price plus the number of units bid at the bid price, e.g., Ahn et al. (2001), Huberman and Halka (2001), Lee et al. (1993), Ranaldo (2001), von Wyss (2004), Wong and Fung (2002).
- Dollar depth, i.e., depth measures in currency terms, e.g., Huberman and Halka (2001), von Wyss (2004), Wong and Fung (2002).
- An average depth of the bid and the ask depth, e.g., Chordia et al. (2000b), Chordia et al. (2001), von Wyss (2004).
- An average dollar depth calculated in currency terms, e.g., Chordia et al. (2001), von Wyss (2004).
- An enhanced modified depth measure for the limit order book Lin et al. (2012).
- Various versions of the order ratio as a proxy of realized market depth, e.g., Engle and Lange (1997), Engle and Lange (2001), Lee et al. (1993), Ranaldo (2001), von Wyss (2004).

In this paper, we employ the order ratio (OR) as a refined measure of market depth, e.g., Ranaldo (2001). It compares depth measured as market order imbalance to cumulated daily trading volume:

$$\mathrm{OR} = \frac{|\sum_{i=1}^{m} V\mathrm{Buy}_i - \sum_{j=1}^{k} V\mathrm{Sell}_j|}{\sum_{n=1}^{N} V_n}, \tag{12.1}$$

where the sums $\sum_{i=1}^{m} V\mathrm{Buy}_i$, $\sum_{j=1}^{k} V\mathrm{Sell}_j$, $\sum_{n=1}^{N} V_n$ denote daily cumulated trading volume related to transactions classified as buyer- or seller-initiated trades, and daily cumulated trading volume for all transactions, respectively. The OR indicator (1) captures imbalance in the market since it rises as the difference in the numerator becomes large. A high order ratio denotes low market depth and low liquidity. Conversely, a small order ratio denotes high market depth and high liquidity. The daily order ratio is equal to zero when daily cumulated trading volumes related to transactions classified as buyer- and seller-initiated trades are equal. Furthermore, the daily order ratio is set down as equal to zero in two cases: (1) when all transactions within a day are unclassified, or (2) when total daily trading volume is equal to zero.

12.2.2 Measuring of Market Tightness

The related literature indicates that various versions of the bid/ask spread are proper measures for tightness because they approximate the cost of immediate execution of a trade. In this paper, we employ the relative spread (RS) as a measure of market tightness, e.g., von Wyss (2004). This measure is sometimes referred to as inside bid/ask spread, e.g., Acker et al. (2002), Levin and Wright (1999). Considering that the bid and ask prices are not public information on the WSE, the best bid price is approximated by the highest price at time t, while the best ask price is approximated by the lowest price at time t. Then the relative spread RS is given by Eq. (12.2):

$$\mathrm{RS}_t = \frac{2(P_t^H - P_t^L)}{P_t^H + P_t^L}, \tag{12.2}$$

where P_t^H, P_t^L are the highest and lowest prices at time t, respectively (Olbrys and Mursztyn, 2015, p. 43).

The relative spread is the measure most extensively used, as it is quite easy to estimate and it makes tightness of different stocks comparable to each other. Another advantage is that it may be calculated even if no trade takes place. A wide relative spread denotes high market tightness and low liquidity. Conversely, a narrow relative spread denotes low market tightness and high liquidity. The relative spread is equal to zero when a transaction is unclassified based on the LR trade classification algorithm.

12.3 Trade Classification Algorithms

To measure dimensions of liquidity on the order-driven market it is helpful to recognize the side initiating the transaction and to distinguish between the so-called buyer- and seller-initiated trades. The classification indicates which of the two participants in the trade, the buyer or the seller, is more eager to trade. The WSE is classified as an order-driven market with an electronic order book, but the information of the best bid and ask price is not publicly available, e.g., Nowak (2014), Olbrys and Mursztyn (2015). In fact, even the non-proprietary financial databases that provide information on trades and quotes do not identify the trade direction. As a consequence, the researchers rely on indirect trade classification rules to infer trade sides. There are some trade classification procedures described in the literature, but the Lee and Ready (1991) algorithm (LR) remains the most frequently used, e.g., Ahn et al. (2001), Asquith et al. (2010), Chakrabarty et al. (2007, 2012), Chan and Fong (2000), Chordia et al. (2000a, 2002, 2005), Dong et al. (2007), Ellis et al. (2000), Finucane (2000), Korajczyk and Sadka (2008), Lee and Radhakrishna (2000), Lu and Wei (2009), Odders-White (2000), Olbrys

and Mursztyn (2015), Peterson and Sirri (2003), Piwowar and Wei (2003), Theissen (2001).

In this paper, the LR method is employed because Olbrys and Mursztyn (2015) indicated that the LR algorithm performs well on the WSE, and the empirical results turn out to be robust to the choice of the sample and rather do not depend on firm size.

12.4 Data Description and Empirical Results on the Warsaw Stock Exchange

In this research, we used a database containing high-frequency data "rounded to the nearest second" for the WSE-listed stock, in the period from January 2, 2005 to June 30, 2015. When forming the database, we included only those securities which existed on the WSE for the whole sample period since December 31, 2004, and were not suspended. All companies entered into the database (147) were sorted according to their market capitalization at the end of each year. Next, the stocks were divided into three size groups based on the breakpoints for the bottom 30 % (small companies), middle 40 % (medium companies), and top 30 % (big companies) (Fama and French, 1993). The companies that remained in the same group during the period investigated were selected. Finally, the 53 WSE companies were entered into separate, representative groups, specifically: 8 firms into the SMALL group, 18 firms into the MEDIUM group, and 27 firms into the BIG group (Nowak and Olbrys, 2015).

We investigated dimensions of market liquidity on the WSE over the whole sample and three adjacent subsamples of equal size (436 trading days): (1) the pre-crisis period September 6, 2005 to May 31, 2007, (2) the crisis period June 1, 2007 to February 27, 2009, and (3) the post-crisis period March 2, 2009 to November 19, 2010 (Olbrys and Mursztyn, 2015). As mentioned in Introduction, the GFC on the WSE was formally set based on the papers (Olbrys and Majewska, 2014, 2015), in which the Pagan and Sossounov (2003) method for statistical identification of market states was employed.

12.4.1 Empirical Results of Market Depth on the WSE

As the data set does not identify a trade direction on the WSE, firstly the trade classification LR algorithm was employed to infer trade sides. Next, the OR indicator (1) was utilized to measure daily market depth for each stock.

In the first step, we calculated daily cumulated trading volume related to transactions classified as buyer- and seller-initiated trades, as well as daily cumulated trading volume for all transactions (also those unclassified), for each WSE-listed

company entering the size group (i.e., BIG, MEDIUM, or SMALL, respectively). In the second step, an average daily market depth was approximated. The empirical results are presented in Table 12.1.

Table 12.1 The average daily market depth (OR)

	B	P_1	P_2	P_3	P_4	M	P_1	P_2	P_3	P_4	S	P_1	P_2	P_3	P_4
1	BHW	0.38	0.47	0.47	0.49	ALM	0.43	0.39	0.47	0.37	APL	0.29	0.31	0.32	0.30
2	BPH	0.40	0.33	0.41	0.40	AMC	0.37	0.37	0.40	0.27	BDL	0.29	0.26	0.25	0.30
3	BNP	0.31	0.27	0.38	0.16	ATG	0.44	0.43	0.47	0.50	EFK	0.42	0.36	0.42	0.48
4	BOS	0.34	0.31	0.28	0.35	ATM	0.44	0.45	0.43	0.42	ENP	0.38	0.30	0.32	0.37
5	BDX	0.43	0.53	0.47	0.45	CNG	0.44	0.37	0.50	0.47	KMP	0.33	0.33	0.34	0.36
6	BZW	0.31	0.32	0.25	0.26	COL	0.37	0.47	0.40	0.25	MZA	0.36	0.33	0.39	0.33
7	DBC	0.44	0.41	0.49	0.41	IND	0.44	0.45	0.46	0.46	PLA	0.36	0.32	0.32	0.35
8	ECH	0.45	0.48	0.40	0.43	IPL	0.45	0.38	0.42	0.42	SME	0.42	0.38	0.39	0.43
9	GTN	0.27	0.26	0.29	0.25	LTX	0.34	0.28	0.28	0.33	**Mean**	**0.36**	**0.32**	**0.34**	**0.37**
10	GTC	0.30	0.33	0.25	0.26	MCI	0.25	0.24	0.25	0.17					
11	ING	0.48	0.58	0.53	0.43	MNI	0.34	0.27	0.28	0.41					
12	KTY	0.46	0.44	0.51	0.49	PEK	0.43	0.41	0.46	0.48					
13	KGH	0.17	0.17	0.19	0.19	PUE	0.41	0.42	0.39	0.43					
14	LPP	0.46	0.53	0.49	0.52	SKA	0.44	0.44	0.43	0.46					
15	MBK	0.29	0.40	0.28	0.24	STF	0.41	0.28	0.39	0.42					
16	MIL	0.35	0.38	0.39	0.30	STX	0.30	0.24	0.18	0.28					
17	MOL	0.47	0.44	0.49	0.50	TIM	0.43	0.38	0.46	0.48					
18	NET	0.36	0.29	0.42	0.39	VST	0.36	0.48	0.50	0.23					
19	OPL	0.21	0.20	0.20	0.22	**Mean**	**0.39**	**0.38**	**0.40**	**0.38**					
20	ORB	0.50	0.45	0.49	0.51										
21	PEO	0.21	0.24	0.21	0.21										
22	PKN	0.19	0.19	0.19	0.20										
23	PKO	0.20	0.23	0.21	0.20										
24	STP	0.45	0.43	0.47	0.46										
25	SNS	0.32	0.41	0.38	0.34										
26	TVN	0.27	0.28	0.25	0.26										
27	ZWC	0.39	0.41	0.42	0.43										
	Mean	**0.35**	**0.36**	**0.36**	**0.35**										

The table is based on: (1) the whole sample period P_1 (3.01.2005 to 30.06.2015); (2) the pre-crisis period P_2 (6.09.2005 to 31.05.2007); (3) the crisis period P_3 (1.06.2007 to 27.02.2009); (4) the post-crisis period P_4 (2.03.2009 to 19.11.2010). Ticker symbols are in alphabetical order according to the company's full name
B BIG, *M* MEDIUM, *S* SMALL

Several results in Table 12.1 are worth special notice. The value of the OR indicator varies between 0.16 and 0.58, and it rather does not depend on a firm size. Moreover, in line with expectations, we observe the lower values of the OR (i.e., the higher market depth) for the most liquid big companies with the largest market

capitalization (namely KGH, OPL, PEO, PKN, PKO), regardless of the subsample choice. Otherwise, the results reveal that the largest values of the OR indicator (i.e., not less than 0.45) occur for several companies from all size groups. Such big values of the OR inform about low market depth and low liquidity. Furthermore, the results turn out to be robust to the choice of the period. To sum up, it is worthwhile to note that using the order ratio disentangles the effect of firm size from the market depth measure and therefore the results for different stocks are comparable to each other.

12.4.2 Empirical Results of Market Tightness on the WSE

The RS indicator (2) was utilized to measure the market tightness for each stock. In the first step, we estimated the relative spread related to each transaction (at time t). In the second step, daily market tightness was calculated as an average of relative spreads for all transactions within a day. The daily relative spread was set down as equal to zero when daily trading volume was equal to zero. To avoid numerical problems, the daily data were rescaled by multiplying by 10^2. In the third step, an average daily market tightness was approximated in all periods investigated, for each WSE-listed company entering the size group (i.e., BIG, MEDIUM, or SMALL, respectively). The empirical results are presented in Table 12.2.

The results in Table 12.2 are in line with the expectations and they are worth a comment. The RS estimates are especially low for the most liquid big companies with the largest market capitalization (namely KGH, OPL, PEO, PKN, PKO). This evidence confirms low market tightness and high stock liquidity in these cases. Conversely, the RS proxies are slightly higher for small companies and this evidence denotes high market tightness and low stock liquidity. Moreover, the findings turn out to be robust to the choice of the sample for all groups. Specifically, we do not observe that the RS estimates are quantitatively different in the crisis period (P_3) compared to the other periods.

12.4.3 Correlation Analysis Between Market Depth and Market Tightness on the WSE

The results presented in Tables 12.1 and 12.2 reveal that, generally, low order ratios (OR) are accompanied by narrow relative spreads (RS). Otherwise, high order ratios are accompanied by wide relative spreads. This evidence is consistent with overall relations between these two measures. Table 12.3 briefly summarizes basic relationships between market liquidity dimensions and market liquidity.

In order to carry out an initial assessment of interaction between market depth and market tightness on the WSE, correlation coefficients between daily measures

Table 12.2 The average daily market tightness (RS)

	B	P_1	P_2	P_3	P_4	M	P_1	P_2	P_3	P_4	S	P_1	P_2	P_3	P_4
1	BHW	0.02	0.02	0.03	0.02	ALM	0.08	0.09	0.08	0.08	APL	0.10	0.10	0.16	0.11
2	BPH	0.05	0.01	0.04	0.05	AMC	0.05	0.05	0.07	0.05	BDL	0.07	0.09	0.08	0.05
3	BNP	0.11	0.14	0.14	0.07	ATG	0.09	0.10	0.10	0.06	EFK	0.14	0.12	0.11	0.10
4	BOS	0.07	0.09	0.10	0.10	ATM	0.06	0.07	0.08	0.05	ENP	0.11	0.11	0.15	0.11
5	BDX	0.03	0.05	0.04	0.03	CNG	0.06	0.05	0.06	0.05	KMP	0.12	0.15	0.11	0.11
6	BZW	0.02	0.01	0.02	0.02	COL	0.06	0.09	0.08	0.04	MZA	0.11	0.13	0.15	0.10
7	DBC	0.05	0.04	0.05	0.06	IND	0.06	0.008	0.06	0.07	PLA	0.11	0.12	0.11	0.11
8	ECH	0.04	0.04	0.04	0.05	IPL	0.06	0.06	0.09	0.07	SME	0.13	0.16	0.10	0.18
9	GTN	0.02	0.02	0.02	0.02	LTX	0.06	0.006	0.05	0.07	**Mean**	**0.11**	**0.12**	**0.12**	**0.11**
10	GTC	0.02	0.02	0.02	0.02	MCI	0.04	0.05	0.05	0.04					
11	ING	0.03	0.03	0.04	0.03	MNI	0.07	0.04	0.06	0.05					
12	KTY	0.04	0.02	0.05	0.04	PEK	0.08	0.07	0.06	0.11					
13	KGH	0.01	0.01	0.01	0.01	PUE	0.10	0.09	0.12	0.11					
14	LPP	0.04	0.05	0.05	0.04	SKA	0.05	0.07	0.05	0.04					
15	MBK	0.02	0.02	0.02	0.02	STF	0.07	0.04	0.08	0.06					

(continued)

Table 12.2 (continued)

	B	P_1	P_2	P_3	P_4	M	P_1	P_2	P_3	P_4	S	P_1	P_2	P_3	P_4
16	MIL	0.02	0.02	0.03	0.02	STX	0.04	0.04	0.04	0.02					
17	MOL	0.04	0.02	0.05	0.04	TIM	0.08	0.06	0.08	0.09					
18	NET	0.02	0.01	0.03	0.02	VST	0.05	0.05	0.06	0.04					
19	OPL	0.01	0.005	0.009	0.01	**Mean**	**0.06**	**0.06**	**0.07**	**0.06**					
20	ORB	0.05	0.02	0.04	0.07										
21	PEO	0.009	0.008	0.01	0.01										
22	PKN	0.008	0.006	0.01	0.01										
23	PKO	0.007	0.006	0.01	0.01										
24	STP	0.07	0.06	0.07	0.05										
25	SNS	0.02	0.04	0.02	0.02										
26	TVN	0.02	0.01	0.02	0.02										
27	ZWC	0.07	0.08	0.12	0.07										
	Mean	**0.03**	**0.03**	**0.04**	**0.03**										

See Table 12.1 for explanation

Table 12.3 Overall relations between market depth, market tightness, and liquidity

Indicator	Market liquidity dimension	Market liquidity
Order ratio (OR)		
High order ratio	Low market depth	Low liquidity
Low order ratio	High market depth	High liquidity
Relative spread (RS)		
Wide relative spread	High market tightness	Low liquidity
Narrow relative spread	Low market tightness	High liquidity

of these liquidity dimensions for each stock were calculated. Table 12.4 presents empirical results concerning the correlation analysis.

The results reported in Table 12.4 are rather consistent with the literature. The majority of correlation coefficients between daily values of the OR and RS indicators are not significantly different from zero. Only in the case of the small companies we observe especially high and statistically significant correlations in the whole sample period (P_1). This evidence is a consequence of extraordinarily many zeros appearing simultaneously both in the OR and RS daily time series of those firms. This phenomenon is mainly connected with a non-trading problem on the WSE (Nowak and Olbrys, 2015). Non-trading is understood as a lack of transactions over a particular period when the WSE is open for trading, and it leads to zero daily volume (and zero value of the OR and RS indicators as a consequence). Another explanation of this phenomenon would be the rather large quantity of unclassified trades recognized in the case of small firms, which also leads to zero value of the OR and RS indicators.

To sum up the correlation analysis, Table 12.5 directly reports correlations averaged over the size groups.

12.5 Conclusions

The purpose of this paper was an empirical analysis of market liquidity dimensions on the WSE. We investigated market depth and market tightness using the high-frequency data for the 53 WSE-listed companies divided into three size groups. Moreover, a robustness analysis of the obtained results with respect to the whole sample January 2005 to June 2015 and three adjacent subsamples of equal size: the pre-crisis, crisis, and post-crisis periods, was provided. The order ratio (OR) was employed as a proxy of market depth, while market tightness was approximated using the relative spread (RS). Our findings have been in accord with the existing literature. The obtained results indicated that the lower values of the OR (i.e., the higher market depth) and the lower estimates of the RS (i.e., the lower market tightness) have been observed for the most liquid big companies with the largest

Table 12.4 Correlation coefficients between market depth (OR) and market tightness (RS)

B	P_1	P_2	P_3	P_4	M	P_1	P_2	P_3	P_4	S	P_1	P_2	P_3	P_4
BHW	−0.02	−0.04	−0.03	−0.05	ALM	−0.02	0.03	0.03	−0.07	APL	**0.27**	0.07	−0.02	0.04
BPH	**−0.10**	0.01	−0.02	−0.02	AMC	**−0.05**	−0.08	−0.01	**−0.15**	BDL	**0.11**	**0.41**	−0.04	−0.01
BNP	−0.03	**−0.12**	0.05	−0.06	ATG	−0.03	−0.02	−0.03	−0.02	EFK	**0.08**	0.05	0.04	**0.15**
BOS	−0.01	0.09	−0.07	−0.04	ATM	−0.01	−0.09	−0.01	0.06	ENP	**0.06**	−0.05	0.08	−0.03
BDX	−0.04	−0.04	0.05	−0.03	CNG	0.02	−0.05	−0.03	−0.06	KMP	**0.11**	−0.01	−0.07	0.01
BZW	−0.04	−0.03	0.03	0.02	COL	−0.02	**−0.10**	−0.01	−0.08	MZA	**0.10**	**0.10**	0.04	0.09
DBC	−0.01	−0.06	**0.09**	**−0.10**	IND	**0.09**	0.04	0.06	0.01	PLA	**0.11**	**0.39**	0.08	−0.09
ECH	0.003	0.06	−0.07	0.02	IPL	−0.01	−0.03	−0.04	**0.11**	SME	**0.05**	0.03	0.07	**0.15**
GTN	**−0.07**	−0.07	0.01	−0.07	LTX	0.01	0.01	0.02	0.00					
GTC	−0.03	−0.01	**−0.11**	−0.05	MCI	0.00	−0.01	**0.11**	**−0.14**					
ING	−0.03	0.02	−0.07	−0.01	MNI	**0.06**	−0.05	−0.03	−0.07					
KTY	0.00	0.05	−0.04	−0.03	PEK	0.02	**0.10**	−0.04	−0.03					
KGH	0.02	−0.07	−0.05	0.08	PUE	0.01	−0.02	0.06	−0.05					
LPP	**0.07**	0.06	−0.02	0.06	SKA	−0.01	−0.05	0.08	−0.03					
MBK	**−0.10**	−0.08	0.00	**−0.12**	STF	**0.08**	**0.10**	−0.02	0.03					

MIL	0.00	−0.01	0.01	**−0.14**	STX	**−0.04**	0.04	0.02	−0.04					
MOL	**0.08**	**0.12**	**0.10**	0.07	TIM	0.00	−0.02	0.02	−0.03					
NET	0.01	−0.06	−0.01	**−0.14**	VST	0.00	−0.01	−0.06	−0.01					
OPL	**−0.11**	0.08	0.00	0.00										
ORB	0.01	0.01	−0.06	−0.06										
PEO	−0.02	−0.06	−0.02	−0.03										
PKN	**−0.09**	−0.08	−0.09	−0.03										
PKO	−0.02	0.00	−0.03	0.07										
STP	−0.01	−0.05	−0.07	0.05										
SNS	−0.01	0.00	−0.04	0.00										
TVN	−0.04	0.08	−0.06	0.00										
ZWC	**0.11**	**0.11**	0.01	**0.12**										

See Table 12.1 for explanation

The correlation critical value is equal to 0.038 (the whole sample period P_1; 2626 daily observations) or 0.094 (the pre-, post-, and crisis periods P_2, P_3, P_4; 436 daily observations), at the 5 % significance level. The significant coefficients marked in bold

Table 12.5 Correlations between daily order ratio (OR) and daily relative spread (RS) for stocks, averaged over the size group

Period	BIG	MEDIUM	SMALL
Whole sample (P_1)	−0.018	0.005	0.111
	[−0.017]	[−0.003]	[0.105]
Pre-crisis period (P_2)	−0.004	−0.012	0.125
	[−0.009]	[−0.019]	[0.062]
Crisis period (P_3)	−0.019	0.005	0.023
	[−0.024]	[−0.007]	[0.040]
Post-crisis period (P_4)	−0.019	−0.030	0.039
	[−0.025]	[−0.031]	[0.022]

See Table 12.1 for explanation. Median values for each group are given in brackets

market capitalization. Moreover, the results turned out to be robust to the choice of the sample.

In general, low order ratios (OR) were accompanied by narrow relative spreads (RS). Otherwise, high order ratios were accompanied by wide relative spreads. It is important to note that, from an investor's point of view, these findings were in accordance with the investor's intuition. Therefore, an initial research of interaction between liquidity dimensions on the WSE was performed by analyzing the degree of correlation between the market depth and market tightness.

Given the importance of the topic, one of the possible directions for further research would be a deeper analysis of the relation between market depth and market tightness on the WSE, following for example the methodology proposed by Lee et al. (1993), Ranaldo (2001), or Lesmond (2005). Moreover, the evidence is that the order ratio and the relative spread could be utilized as liquidity/illiquidity measures in further broader investigation concerning commonality in liquidity on the WSE, e.g., Chordia et al. (2000a), Huberman and Halka (2001), Korajczyk and Sadka (2008).

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