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High-volume return premium on the stock markets in Warsaw and Vienna

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Abstract

In this paper we analyze the properties of the high-volume return premium on the Warsaw Stock Exchange and on the Vienna Stock Exchange. The premium arises from the different behaviour of returns of stocks with unusually high trading volume and stocks with unusually low relative trading volume. The analysis of monthly returns confirms the existence of the high-volume return premium on the WSE and shows significantly positive returns of volume-based portfolios. Our study also indicates the insignificance of the high-volume return premium on the Vienna Stock Exchange, where an adverse effect of large companies is observed. The paper also examines possible factors that impact the magnitude of the premium on the WSE. We find that returns of volume portfolios depend on firms' capitalization and momentum. However, the Fama-French four-factor asset pricing model does not explain the premium or the differences in returns of volume portfolios.

Keywords: extreme volume, high-volume return premium, asset pricing, risk factors

JEL: C32,C14

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1 Introduction

One of the main conjectures about the way that new information impacts dynamic relationships between variables describing stock prices is sequential information arrival hypothesis (SIAH) by Copeland (1976). It assumes that not all traders receive new information at exactly the same time, but they receive it sequentially. First, new information is perceived by a group of well-informed investors. As these informed traders react to news by changing their trading positions and executing transactions, information is transmitted to other traders (non-informed or noisy traders) who can notice changes in stock prices or the trading activity caused by informed traders. In consequence, a reaction of these investors also impacts prices and volume transmitting information further on. The reaction of each group of investors to new information leads to an incomplete equilibrium. The final market equilibrium is reached when all the traders have obtained information and have made a trading decision based on it. Thus, SIAH implies lead-lag relationships between prices, trading volume and volatility resulting from responses of different groups of investors to new information.

On the basis of SIAH, Blume, Easley and O'Hara (1994) and Suominen (2001) argue that the trading volume includes unique information that cannot be discovered from the analysis of stock prices. The model of Blume, Easley and O'Hara (1994) assumes that informed traders reveal their private information to the market through their transactions. Hence, uninformed traders can learn from trading volume data about the precision or dispersion of informational signals. Similarly, Suominen (2001) presents a market microstructure model, in which trading volume is used by uninformed traders as a signal of private information in the market. In that way, the trading volume reduces information asymmetry between various groups of investors. From these two models it follows that the trading volume not only describes prices and behaviour of the market, but it also affects prices because it is taken into account by investors in their decision processes. This point of view is also supported by empirical studies that confirm causalities from trading volume to returns or volatility (see, for example: Silvapulle, Choi 1999; Lee, Rui 2002).

Apart from causalities between returns and the trading activity, relationships between the trading volume and autocorrelation of returns are also observed. From the model of Gallant, Rossi and Tauchen (1992), it follows that returns accompanied by high trading volume tend to reverse during the following days. This means that high trading volume implies negative autocorrelation in returns, whereas low trading volume usually implies positive autocorrelation of returns. A similar conclusion can be drawn from studies of LeBaron (1992) and Conrad, Hameed and Niden (1994). Llorente et al. (2002) extend these results and present a model explaining differences in the impact of the high volume on returns observed between single securities and market indices. This model underlines the importance of information asymmetry.

The trading volume also impacts cross-correlations between stock returns. Chordia and Swaminathan (2000) show that returns of high volume stocks precede low volume stock returns. This result confirms the speed of adjustment hypothesis, which states that high volume stocks (i.e. more liquid stocks) react faster to new information than low volume stocks (less liquid stocks).

The value of the trading volume is also important in the prediction of future returns. As shown by Lee and Swaminathan (2000), the inclusion of information about trading activity improves the momentum strategy described first by Jegadeesh and Titman (1993).

In contrast to the above-mentioned works, which usually use the trading volume as a proxy for liquidity, Gervais et al. (2001) study the impact of extreme changes in trading activity on subsequent

returns. They analyze not the trading volume itself, but its value relative to values from the previous several weeks. Gervais, Kaniel and Mingelgrin (2001) show that, in general, extremely high trading activity (when compared to the recent activity) is followed by unusually high returns. And vice versa, the extremely low relative trading activity is followed by unusually small returns. Hence, as derived by Gervais, Kaniel and Mingelgrin (2001), returns of stocks with increased trading volume tend to be significantly higher than returns of stocks with reduced trading activity. This phenomenon is called the high-volume return premium. On the basis of data from the NYSE, Gervais, Kaniel and Mingelgrin (2001) show that extreme changes in the trading volume impact 50-day stock returns significantly. Moreover, the impact of extremely high trading volume on returns does not depend on any other factor, such as prices, dividend announcements, earning announcements or liquidity.

Gurgul and Wójtowicz (2009) examine the high-volume return premium on various European markets including the Warsaw Stock Exchange. In contrast to the previous work of Gervais, Kaniel and Mingelgrin (2001), Gurgul and Wójtowicz (2009) study the impact of changes in the trading activity on returns in a very short horizon: up to a few days after the occurrence of the extremely high (low) trading volume. This is a modification of the original concept of the high-volume return premium that referred to the impact of the trading activity of stock returns in a longer period. Moreover, they apply the event study methodology instead of the analysis of various volume-based portfolios. On the basis of data from the period before the global financial crisis 2007–2009, Gurgul and Wójtowicz (2009) show that the extremely high trading volume implies significantly positive returns on the next day and on a few following days. This confirms the existence of the high-volume return premium on the WSE (at least in a very short horizon). On the basis of these results, Gurgul and Wójtowicz (2009) construct short-term trading strategies based on volume portfolios and prove their profitability.

The existence of the high-volume return premium is also confirmed for the Australian stock market by Tang, Zou and Li (2013). Their analysis shows that the premium is stronger for large firms, whereas it does not exist for small firms. Tang, Zou and Li (2013) also indicate that the high-volume return premium on the Australian stock market is not explained by systematic risk.

According to Gervais, Kaniel and Mingelgrin (2001), the high-volume return premium can be explained by Merton's (1987) investor recognition hypothesis. Unexpected information about an increase in the trading volume (or information that has caused this change) attracts new investors, who have ignored the company in the past. This, in turn, increases the number of potential buyers interested in that stock and increases the stock price due to a limited number of the shares on the market.

Various potential factors explaining the high-volume return premium are examined by Kaniel, Ozoguz and Starks (2012), who study volume portfolios on 41 stock markets. This group of markets contains G-7 markets and other developed markets as well as emerging markets from various parts of the world, including the Warsaw Stock Exchange. Kaniel, Ozoguz and Starks (2012) conclude that the high-volume return premium is generally observed in developed markets, whereas performed tests do not confirm it in emerging markets. However, insignificant results for emerging markets are explained by the lack of sufficient data. For example, the analysis of the high-volume return premium on the WSE is performed on the basis of data from the period 1994–2001 with the average number of stocks in the sample equal to 86. As a potential explanation of the high-volume return premium on developed markets, Kaniel, Ozoguz and Starks (2012) consider various risk factors (such as size, value, momentum and liquidity) as well as cross-country characteristics (like demographics, level of

development and investor characteristics). On the basis of various tests, Kaniel, Ozoguz and Starks (2012) show that in general the volume premium is not related to differences in risk exposures.

The main goal of this paper is to examine the impact of extremely low and extremely high trading volume on monthly returns of stocks listed on the Warsaw Stock Exchange (WSE)[1] and on the Vienna Stock Exchange (VSE). The stock exchange in Warsaw is one of the largest and most liquid stock markets in the CEE region. Another market of a similar position in the region is the Vienna Stock Exchange. However, the VSE is a developed market while the WSE is still seen as an emerging market. Hence, a comparison of the high-volume return premium on both of these markets will show how these differences between markets impact relations between changes in the trading volume and returns. It should be noted that previous works (for example, Kaniel, Ozoguz and Starks 2012) were mainly devoted to developed markets and gave no clear answer concerning the high-volume return premium on emerging markets, like the WSE. Additionally, the application of the most recent data after the initial phase of the development of the WSE will ensure more adequate results.

In the analysis of the high-volume return premium on the WSE, we take into account the development of the Polish stock market and the appearance of an alternative market, namely, the NewConnect (the NC). The NewConnect attracts less investor attention than the WSE. Hence, the equities quoted on it have much lower liquidity. The analysis of relationships between changes in the trading volume and returns on the WSE and on the NewConnect will show how differences in capitalization, liquidity and regulations between these two markets impact the high-volume return premium. It will also show the behaviour of the premium for very small stocks.

The second goal of the paper is the analysis of various potential explanations of the high-volume return premium. We examine how it is related to commonly applied risk factors (size, value and momentum) and, whether it can be explained by the Fama-French four-factor asset pricing model. On the basis of the four-factor model, we also study the significance of the high-volume return premium and analyze how the model explains cross-sectional patterns in volume portfolio returns. We also study the impact of liquidity on the properties of volume-based portfolios as well. This extends the results of Gervais, Kaniel and Mingelgrin (2001) and Kaniel, Ozoguz and Starks (2012), who analyzed these issues mainly for large developed markets.

This paper also complements the results of Gurgul and Wójtowicz (2009) for the WSE. First, we analyze the high-volume return premium in a horizon of one month instead of a few days. Second, using the methodology typical for asset pricing, we analyze the relationships between the high-volume return premium and various risk factors. Third, we study the premium not only during the bull market before the global financial crisis 2007–2009, but also during it and afterwards. This allows us to verify the robustness of the high-volume return premium to different states of a market.

The study of the high-volume return premium is important for both theoretical and practical reasons. It helps describe information flow on the stock exchange, particularly in the context of the sequential information arrival hypothesis. It also shows that the trading volume is an important variable containing valuable information that can be applied in forecasting stock prices. Moreover, the results of the analysis of relationships between the high-volume premium and risk factors can form the basis for further research about the applicability of the premium in asset pricing. It is particularly important when we take into account a very limited number of studies concerning the high-volume

1 As it will be indicated below, the WSE also operates an alternative market – the NewConnect. Hence, in this paper, by the Warsaw Stock Exchange we mean its main market only.

return premium. From the practical point of view, results of the analysis of the high-volume return premium can be applied in the construction of investing strategies.

The results of the paper can be summarised as follows. First, the high-volume return premium on the WSE is significant and robust to the definition of volume-based portfolios and weighting scheme. The results for the VSE and the NewConnect are mixed: the premium is significant only when portfolios are equally-weighted. However, when portfolios are weighted by capitalization, the high-volume return premium is insignificant because of the adverse impact of large firms (the VSE) and very high volatility (the NewConnect). Second, the risk factors such as size, value, and momentum do not affect the high--volume premium on the WSE. It is also robust to liquidity of stocks. Moreover, the premium cannot be explained by the Fama-French four-factor model.

The rest of the paper is organized as follows. In the next section we present the data and methodology, which we use in the empirical study. Section 3 and 4 contains the main empirical findings about the high volume return premium on the Warsaw Stock Exchange, whereas the premium on the stock exchange in Vienna is analyzed in Section 5. A short summary concludes the paper.

2 Data and methodology

The analysis presented in this paper is based on daily returns and daily trading volume[2] of stocks listed on the Warsaw Stock Exchange from 3 January 2001 to 30 December 2015 and stocks listed on the Vienna Stock Exchange between 30 October 2004 and 30 December 2015. We also take into account shares traded on the NewConnect platform[3] from its inception in August 2007 to the end of 2015. The period under study is long when we take into account the short history of the modern capital market in Poland and the development of the WSE. Moreover, it covers various phases of economic development, including the global financial crisis 2007–2009. Thus, the results of the high-volume return premium analysis are robust to changing phases of a stock market.

The VSE and WSE are leading markets in the CEE region. Table 1 shows that the capitalization of the main market of the Warsaw Stock Exchange is about three times greater than that of the Vienna Stock Exchange and more than a hundred times greater than the capitalization of the NewConnect. On the other hand, the number of equities listed on both Polish markets is similar, whereas there are much fewer equities listed on the stock market in Vienna. Despite such a great difference in the number of equities listed on the WSE and VSE, both markets are characterized by a similar intensity of trading as approximated by the average daily turnover. However, in the case of the VSE, the value of the daily turnover is generated by trading on a much lower number of equities.

Similarly to previous papers (see, for example: Gervais, Kaniel, Mingelgrin 2001; Kaniel, Ozoguz, Starks 2012), to study the high-volume return premium we analyze returns of portfolios formed on

2 The trading volume is measured as the total number of shares traded. Prices and the trading volume are corrected to stock splits, i.e. after a split they are proportionally rescaled.

3 The NewConnect is an alternative market operated by the WSE outside the regulated market. It is designed for small, developing companies and thus it has more liberal information requirements and formal obligations.

the basis of the stocks relative trading volume.[4] However, in this paper the portfolio classification is made at the end of each month and it is similar to other procedures in the asset pricing literature, particularly to the momentum portfolio formation (see, for example: Fama, French 2012; Jegadeesh, Titman 1993).

At the end of each month, on the portfolio formation day, we compare the trading volume of each stock quoted on the given market with its trading volume over a reference period. This comparison allows us to compute the stock relative trading volume as the percentage of trading sessions in the reference period with the trading volume smaller than the trading volume on the portfolio formation day.

In this definition, the trading volume from the reference period is used to measure how high (or how low) the trading volume on the portfolio formation day is relative to the trading volume in the previous days. The value of the relative trading volume describes whether the trading volume at the end of the month is higher or lower than usually, and how the intensity of trading on the formation day is related to its usual level. The relative trading volume calculated in such a way is not a measure of liquidity, but it provides information about a change in the trading activity. High relative trading volume indicates that the stock attracts the attention of investors on the formation day. On the other hand, low relative volume shows that investors pay no attention to that stock.

To improve the correctness of the portfolio formation procedure, the relative trading volume is computed only for stocks that were actively traded (had at least one transaction) on at least 75% of trading sessions in the reference period. Additionally, to avoid a wrong classification of stocks into portfolios due to the sensitivity of the relative trading volume to the total number of shares, we remove stocks with the change in the number of outstanding shares in the reference period exceeding 10% from the sample. Such a change may be caused, for example, by a new share issue or by buy-back.

The relative trading volume defined above is then used to divide all the stocks on the portfolio formation day into three portfolios (High, Medium and Low) of stocks with the high, medium and low trading activity. 10% of the stocks with the highest relative trading volume on the portfolio formation day are classified into High portfolio. Correspondingly, 10% of the stocks with the lowest values of the relative trading volume are classified into Low portfolio. All the other stocks are classified as medium volume stocks. At the end of the next month the whole formation procedure is repeated and portfolios are rearranged. To take into account various characteristics of the stocks under study (like the momentum effect) and because the longest reference period has the length of 12 months, we start the portfolio formation process on the WSE at the end of March 2002. A similar definition of low, high and medium volume portfolios can be found in Gervais, Kaniel and Mingelgrin (2001) and Kaniel, Ozoguz and Starks (2012). However, due to a more limited number of stocks, Kaniel, Ozoguz and Starks (2012) apply the top (bottom) 20^{th} percentiles in the definition of high (low) volume portfolios. We also apply such a definition of extreme volume portfolios further in Subsection 3.2 to verify the robustness of the results.

For each volume portfolio, we compute returns on the next month on the basis of stock prices at the end of the next month and on the portfolio formation day. To compute these monthly portfolio returns, we consider two weighting schemes: equal weighting and capitalization weighting.

4 In Gervais, Kaniel and Mingelgrin (2001) and Kaniel, Ozoguz and Starks (2012) portfolios are formed every 50 days and stocks are classified into them on the basis of a comparison of the trading volume on a portfolio formation day with its trading volume from the 49-day reference period containing data from the 49 trading sessions prior to the portfolio formation day.

A comparison between the returns of equally- and capitalization-weighted portfolios enables us to assess the impact of small and large firms on the high-volume return premium because returns of large-firm stocks have greater weights in a capitalization-weighted portfolio than the returns of small-firm stocks.

To study the existence of the high-volume return premium, we consider returns of zero-investment portfolios High-Low (High minus Low), i.e. we buy stocks from the high volume portfolio and short sell the stocks from the low volume portfolio. From this definition it follows that the returns of such portfolios are simply the differences between returns of high and low volume portfolios. This definition is similar to the definition of commonly-applied risk factors such as SMB, HML, and WML (see, for example: Fama, French 2012). Analysis of zero-investment portfolio returns is also a common approach in papers concerning stock market anomalies (see, for example: Jegadeesh, Titmann 1993; Jacobs 2015; Zaremba, Szyszka 2016).

The above procedure of portfolio construction, and thus the results of the analysis, may depend on the choice of the appropriate reference period. To analyze how the length of the reference period affects returns of volume-based portfolios we consider three different lengths of reference periods: 3, 6, and 12 months prior to the formation day. In the choice of the length of the reference period we must take into account two aspects. A shorter reference period allows us to study stock trading activity on the basis of more recent data. However, a longer reference period gives a more adequate value of the relative trading activity. For example, in the case of a 3-month reference period, the trading volume on the formation day is compared to about 60 values of the trading volume from the reference period (about 60 trading sessions).This leads to about 61 possible values of the relative trading volume. A 6-month reference period allows twice as many values of the relative trading volume. This means a more reliable comparison of the relative trading volume for various stocks.

3 The high-volume return premium

3.1 The Warsaw Stock Exchange

We start the analysis from a study of the high-volume return premium on the main market of the WSE. In order to assess the impact of the reaction of investors from the Warsaw Stock Exchange, we restrict the analysis to stocks quoted only on the WSE and we exclude from the sample the stocks listed also on other markets. As described in the previous section, the first portfolio was formed at the end of March 2002. Finally, in the whole period, we obtain 165 monthly returns of each volume portfolio which provides enough power for statistical tests. The application of the 10^{th} top and bottom percentiles in the definition of the extreme volume portfolios implies that the number of stocks in the High and Low portfolios varies from about 20 at the beginning of 2002 to about 60 at the end of the sample, with the average of 37 stocks in each of the extreme volume portfolios.

The main results of the analysis are reported in Table 2. It shows the averages of monthly returns of volume portfolios of stocks from the WSE created according to the procedure described in Section 2. It also shows the Newey and West (1987) t-statistics for whether the mean of the portfolio monthly returns is significantly different from zero. Each panel of Table 2 contains values of the average

monthly returns of extreme volume portfolios (Low and High), medium volume portfolios (Medium) and the averages of zero-investment portfolios (High-Low). The portfolios are formed on the basis of 3-, 6-, and 12-month reference periods, respectively. For each portfolio both weighting schemes are applied.

The most important conclusion from Table 2 is that the high-volume return premium is significant irrespective of the reference period and the portfolio weighting scheme. The means of monthly returns for High-Low portfolios are significantly greater than zero at the 1% level in each case reported in Table 2. The highest value of the premium (2.34% per month) is observed in the case of equally--weighted portfolios with a 12-month reference period. However, even the lowest average is greater than 1% per month. It is important to note that the significantly positive high-volume return premium on the WSE is opposite to the results reported by Kaniel, Ozoguz and Starks (2012), where the difference between returns of the High and Low portfolios on the WSE is insignificant. However, this discrepancy in the results may be explained by deficiency of data applied by Kaniel, Ozoguz and Starks (2012).

All the averages of equally-weighted portfolios are greater than the respective averages of capitalization-weighted portfolios. This comparison indicates that the high-volume premium is more pronounced for small stocks that have lower weights in portfolios weighted by capitalization[5].

From Table 2 it can be also concluded that the high-volume return premium is largely a consequence of significantly positive average returns of the high volume portfolios. The means for all high volume portfolios presented in Table 2 are significantly positive, whereas the other portfolios (except for the equally weighted Medium portfolio with a 12-month reference period) have insignificant means. From this fact it follows that an investing strategy of buying stocks with the extremely high relative trading volume is profitable. However, as indicated by the standard deviation, such portfolios are much more risky than portfolios of stocks without the extreme trading activity and, as can be seen in Figure 1, high volume portfolios, as long portfolios, are also vulnerable to a financial crisis. Offsetting them by a short position on very low volume stocks reduces that risk (measured by the standard deviation) and eliminates a negative impact of the financial crisis because the High-Low portfolios have not only the highest averages of monthly returns, but they are also characterised by the lowest values of the standard deviation.

Cumulative monthly average returns of the High-Low portfolios presented in Figure 1 remain unaffected by price declines in 2007–2009 and increase steadily through the whole 2002–2015 period. In 2003–2007, we can observe an upward trend in cumulative returns of all volume portfolios, even in the case of portfolios of low volume stocks. Then, the global financial crisis of 2007–2009 drastically reduces the values of the portfolios, but – as it is mentioned above – it does not decrease the cumulative returns of High-Low portfolio.

A comparison of the high and low volume portfolios also indicates that the source of the high--volume return premium on the WSE is different from the source of other stock market anomalies. For example, highly positive returns of the momentum strategy are mainly due to very large negative returns of losers portfolios (cf. Szyszka 2006; Wójtowicz 2011). In practice, however, it is very difficult to take advantage of significantly negative means of losers portfolios due to restrictions in short selling. In the case of the high-volume return premium, significantly positive means of high volume portfolios are even more important from a practical point of view because they concern stocks with higher trading volume than usual.

5 The relationship between firms' capitalization and returns of volume portfolios is also analyzed in details in Section 4.1.

The values of the averages in Table 2 depend on the length of the reference period, but all of them lead to the same conclusion about the high-volume return premium. To get a better insight into the dynamics and profitability of portfolios based on historical trading activity in Figure 1, we present cumulative returns of capitalization-weighted volume portfolios with 6-month and 12-month reference periods. As mentioned earlier, the choice of a suitable reference period is a compromise between the accuracy of the relative trading volume and the application of the most recent data. Longer reference periods ensure a more precise comparison of the trading volume in the formation day with historical data and a more adequate classification of stocks into extreme volume portfolios. On the other hand, sometimes they may contain outdated data. With this in mind, the analysis in the rest of the paper will be presented mainly on the basis of portfolios with 6-month reference periods. In this case, the trading volume on the portfolio formation day is compared with about 120 historical values of the trading volume from the reference period.

3.2 Alternative definition of High and Low portfolios

Kaniel et al. (2012) assign stocks to extreme volume portfolios using the 20^{th} and 80^{th} percentiles as break points. Such a definition of volume portfolios was motivated by the small number of available data. In the previous subsections we presented the analysis based on a more restrictive definition of High and Low portfolios. To verify the robustness of these results, we repeat the analysis with the 20^{th} and 80^{th} percentiles as breakpoints in the definition of the extreme volume portfolios. The results of this analysis are reported in Table 3. Not surprisingly, the widening of the extreme volume portfolios leads to less pronounced results. A larger number of stocks in the high and low volume portfolios reduces the high--volume return premium. On the other hand, it also makes the High-Low portfolios safer by reducing their standard deviations. When compared with the results in Table 2, the averages and standard deviations of the High-Low portfolios become smaller, irrespective of the weighting scheme. Nevertheless, for the most part, the high-volume return premium remains significant at almost the same level as in Table 2. The reduction of the averages is the most pronounced in the case of equally-weighted portfolios. This indicates that additional low volume stocks increase returns of Low portfolios, whereas additional high volume stocks reduce returns of High portfolios. Such changes are less visible when capitalization is applied to weight the returns. Despite that, the differences between the means of monthly returns from Table 2 and Table 3 computed on the basis of these two definitions are insignificant.

3.3 The NewConnect market

Additionally to the above analysis, we study the high-volume return premium on the NewConnect market. However, due to a relatively short history of the NC and a small number of stocks in its initial phase of development, the analysis covers a much shorter period. First volume portfolios are formed at the end of August 2009, i.e. two years after the start of the NC. At that time, there were enough stocks quoted on the NC to ensure the correctness of the analysis. Table 4 offers a short presentation of the results of the verification of the high-volume return premium in the period from August 2009 to December 2015, on the basis of the stocks listed only on the NewConnect and on the basis of the joint

sample of stocks listed on the WSE and on the NC. As a comparison, we also report results for the stocks quoted exclusively on the WSE. To save space, we present the results for the 6-month reference period only. Results for the other reference periods are similar.

The high-volume return premium on the NewConnect is significant only when stocks are equally--weighted. This is mainly due to a very high value of the average returns (4.35%) in that case, which leads to a significant value of the t-statistics, despite a very high standard deviation. The standard deviation of the High-Low portfolio of stocks from the NC is as much as four times greater than the standard deviation of respective portfolios on the WSE. This means that extreme volume portfolios on the alternative market are much more risky than similar portfolios on the WSE. The insignificance of the mean for the High-Low portfolio in the case of capitalization-weighting does not support the existence of the high-volume return premium on the NewConnect market.

On the other hand, the premium on the WSE is still significant when we restrict the analysis to the shorter, post-crisis period since August 2009. The standard deviations of High-Low portfolio returns in that period are similar to the standard deviations in the whole period under study (Table 2), while averages are only insignificantly smaller. This indicates the robustness of the high-volume return premium. The premium remains significant also when we add stocks listed on the NC to stocks from the WSE. This extension of the sample only slightly increases the average returns, but it also makes the High-Low portfolios much more risky than before. However, the premium is insignificantly different from the results limited to the WSE only.

3.4 The Vienna Stock Exchange

In this section, we compare the high-volume return premium on the WSE with a similar study performed for the Vienna Stock Exchange. The analysis for the VSE is performed on the basis of daily data from October 2004 to the end of December 2015. As reported in Table 1, at the end of 2015 there were 78 equities listed on the Prime Market, the Standard Market and the Mid Market of the VSE. Hence, due to a very limited number of equities, we take into consideration all the stocks listed on the VSE. Additionally, we apply the 20^{th} and the 80^{th} percentiles and 6-month reference periods in the procedure of assignment to volume portfolios.

About 15% of equities listed on the VSE were very rarely traded in the period under study. As described in Section 2, in every portfolio formation day stocks with too small a number of sessions with non-zero turnover in the reference period are excluded from the study. Hence, the number of stocks in the extreme volume portfolios on the VSE varies from 12 at the beginning of the sample to 10 at the end of the sample, with the average of 11.2. In contrast to the WSE, the number of stocks listed on the Vienna Stock Exchange has decreased since 2008.

The results reported in Table 5 indicate quite a different pattern in portfolio average returns for stocks from the VSE in comparison to stocks listed on the WSE. All the average returns of Low, Medium, and High portfolios are insignificant, irrespective of the weighting methods. Moreover, when returns are weighted by capitalization, the averages decrease with the increasing relative volume, i.e. the lowest average is observed for stocks with the high relative volume. It implies a negative – yet insignificant – value of the average for the High-Low portfolio. This is opposite to the results for the WSE (see Table 2) and to the results from Kaniel et al. (2012) for the stock exchange in Vienna. On the other hand,

the volume premium is significant (at the 10% level) when returns are equally-weighted, but its value (1.19% per month) is much smaller than the premium on the WSE. These results call into question the existence of the high-volume return premium on the Vienna Stock Exchange.

Panel A and B of Figure 2 illustrate the evolution of the cumulative returns of volume portfolios in both weighting methods. In Panel A, a very strong impact of the global financial crisis may be observed when returns are equally-weighted. Before the crisis, the returns of the High and Low portfolios are almost identical. Then, in 2008, a gap between them appears: the returns of low volume portfolios decline dramatically, whereas the change in the high volume portfolio returns is much smaller. After the crisis, that gap between the high and low volume portfolios steadily increases and cumulative returns of the High-Low portfolio indicate a constant upward trend. The crisis impacts also the capitalization-weighted volume portfolios, but their reactions are similar to each other and the changes in the high-volume premium around the crisis are less pronounced in Panel B.

In the case of the capitalization-weighted portfolios, the returns of large companies dominate the returns of small companies. Hence, a comparison between the averages in the left and right panel of Table 5 indicates a negative impact of large stocks on the high-volume return premium on the VSE: stocks of large firms increase the returns of the Low portfolios and decrease the returns of the High portfolios. To examine the impact of firms' capitalization on the premium on the VSE more adequately, we repeat the analysis, but this time excluding the largest firms from the sample. We consider three additional samples that do not contain stocks of 10%, 20% or 30% of the largest firms, respectively. More precisely, on each portfolio formation day we first sort stocks according to their capitalization and we take into account only stocks below the 90^{th}, the 80^{th}, and the 70^{th} percentiles, respectively. The further analysis proceeds as before and, for these reduced samples, we form volume portfolios and compute their returns. However, it should be noted here that the exclusion of a fraction of the largest firms reduces the average number of stocks in each extreme volume portfolio to about 10, 8.9, and 7.7, respectively and thus the results of this analysis should be treated mainly as an illustration.

The cumulative averages of the capitalization-weighted returns of the High-Low portfolios computed on the basis of the reduced samples are presented in Panel C and D of Figure 2. To facilitate the comparison of the averages, we also present the cumulative returns of the High-Low portfolios for the whole VSE (as in Panel B). Similarly to Panel A, we can observe a very strong impact of the financial crisis on the high-volume premium on the VSE when the largest firms are excluded from the analysis. Before the crisis, the cumulative returns of the High-Low portfolios are almost indistinguishable from each other but, after the crisis, they differ considerably. The strongest changes in the High-Low portfolio returns take place between August 2008 and March 2009. After that period, the returns tend to stabilise. Panel C of Figure 2 shows that in this whole period the volume premium increases with the number of big firms being excluded and it is the highest when we take into consideration only 70% of the firms with the lowest capitalization. The returns for the other cases increase, but not so dramatically. This tendency is also observed when we restrict our attention to the post-crisis period (Panel D) only. The averages in Table 6 increase when we exclude more and more large companies. As a result, the means of the monthly returns for the High-Low portfolios of 70% of stocks with the smallest capitalization (1.28% and 1.13%) are significant for both weighting methods. Moreover, they are significantly greater than the respective means for the whole sample of stocks. For the interpretation of these results it is important that the exclusion of 30% of the largest firms decreases the sample to about 40 stocks in 2005 and to about

30 stocks in 2015. These results indicate that the absence of high-volume return premium on the stock exchange in Vienna is caused by the returns of the largest firms listed on it.

Since the presence of the high-volume return premium on the VSE is doubtful, we perform further analysis of factors explaining the high-volume return premium solely for stocks from the stock exchange in Warsaw.

4 Potential explanations of the high-volume return premium

In the literature a lot of different market anomalies that led to profitable investment strategies and significantly positive returns have been mentioned (see, for example, Jacobs (2015) for a comprehensive overview of various anomalies on financial markets). However, many of them disappeared short time after their discovery, or were explained by other factors. The development of asset pricing models (see, for example: Fama, French 1993; Carhart 1997) have resulted in the inclusion of new risk factors into models that could explain cross-sectional patterns observed in average returns on a variety of stock markets. The model of Carhart (1997) contains four factors describing possible sources of risk: RM_t – the excess return of the market portfolio, SMB_t – the difference between returns on small and big stock portfolios (see, for example: Banz 1981; Reinganum 1981; Blume, Stambaugh 1983), HML_t – the difference between returns of value and growth stock portfolios (Stattman 1980; Rosenberg, Reid, Lans 1985; Chan, Hamao, Lakonishok 1991; Fama, French 1996; Rouwenhorst 1998; Waszczuk 2013; Zaremba, Konieczka 2015), and WML_t– the difference between returns on portfolios of stocks with the highest and lowest past returns (Jegadeesh, Titman 1993; Rouwenhorst 1998; Griffin, Ji, Martin 2003; Chui, Titman, Wei 2010; Szyszka 2006; Wójtowicz 2011).

In order to find a possible explanation of the high-volume return premium on the WSE, by the analysis of monthly returns of respective double-sorted portfolios, we study how capitalization, book-to-market ratio and momentum impact average monthly returns of volume-based portfolios. In the first step, we sort stocks by one of the three risk factors (the size, value or momentum). Then, we sort stocks by their relative trading volume. Below, as an example, we describe the procedure for stocks sorted by the size and relative volume. In the case of value-volume and momentum-volume portfolios the procedure is similar. At the end of each month in the period from March 2002 to November 2015, we divide stocks into three groups according to their capitalization. 30% of stocks with the lowest capitalization are classified as small stocks, 30% of stocks with the largest capitalization is classified as big stocks, while the remaining 40% of stocks are classified as medium stocks. Then, in each of these three groups, we perform the analysis of the high-volume return premium, as described in Section 2: within each size portfolio, we sort stocks according to their relative trading volume, divide them into three groups according to the 20^{th} and 80^{th} percentiles and compute the monthly returns of each portfolio. As a result of this procedure, we receive returns of nine portfolios, i.e. three volume-based portfolios (Low, Medium, High and High-Low) separately for small, medium and big firms. Results of the analysis of the monthly returns of these portfolios are reported in Table 7. To save space, we report only the results for the volume portfolios with 6-month reference periods. Results for the other reference periods are similar.

In the case of value-volume portfolios, we sort stocks by their book-to-market ratio on the portfolio formation day and we call the resulting portfolios Low, Medium, and High, respectively. When momentum is taken into account, we sort stocks at the end of the t-th month by their cumulative

returns from months t–12 to t–1, i.e. from the last year excluding the last month. This is a commonly used definition of the momentum factor (see, for example: Carhart 1997; Fama, French 2012). The resulting portfolios are called Losers, Medium, and Winners.

In the portfolio formation procedure we apply the 20^{th} and 80^{th} percentiles instead of the 10^{th} and 90^{th} percentiles due to a relatively small number of stocks in the double-sorted portfolios. The number of stocks in the extreme volume portfolio in groups of small or big stocks varies from about 10 at the beginning of 2002 to about 20 at the end of 2015.

4.1 Size

In Panel A of Table 7, the average monthly returns of the High-Low portfolios are significantly positive for each size group. Hence, it follows that the highvolume return premium is significant irrespective of the size of a firm, moreover, its significance does not depend on the weighting scheme. These results are in line with the results presented in the previous section, particularly with the ones in Table 2 and 3. The application of capitalization-weighting reduces the averages and thus, as before, the highest average of the premium is observed when portfolios are equally-weighted. A comparison of the averages of the High-Low portfolios indicates that the premium is the most pronounced for stocks of the smallest firms. Moreover, in the case of the equally-weighted portfolios, the high-volume return premium for small firms (2.6% per month) is significantly greater than the premium for big firms (0.73% per month). However, in the case of the capitalization-weighted portfolios, this difference (69 basis points) is insignificant and in that case the firm size does not influence the value of the high--volume return premium.

Another important observation arising from Table 7 is that the means of High portfolio returns are also significant for each size group of stocks. As before, the highest values (3.41% and 2.37% per month) are observed for small-firm stocks. Moreover, the differences between the means for small and big stocks (2.1 and 1.46 percentage points, respectively) are significant for both weighting schemes. This means that the size of a firm is an important factor for returns of stocks that attract extremely high interest from investors and small stocks with extremely high trading activity bring significantly greater returns than big stocks. It can be explained by Merton's (1987) investor recognition hypothesis because increasing trading volume is more important in the case of the smallest firms with a more limited number of outstanding shares.

For both weighting schemes, we observe a cross-sectional pattern in average monthly returns: they increase from the right to the left (from big to small firms) and from up to down (from low to high volume stocks). It is due to the overlapping size and volume effects. This pattern suggests the possibility of constructing the another portfolio by taking a long position in Small/High stocks (small stocks with a very high relative trading volume) and a short position in Big/Low stocks (large stocks with a very low relative trading volume). Such portfolios have averages higher than any average of the High-Low portfolio in respective parts of Panel A. For example, in the case of capitalization-weighting, the average return of Small/High-Big/Low portfolio is 2.09% (with standard deviation of 7.83%) and it is more than the averages of the High-Low portfolios in the right part of Panel A. It is also more than the average of the High-Low portfolio from Panel B of Table 2 constructed on the basis of all stocks from the WSE. Despite that fact, these differences are insignificant and, thus, an application of the observed cross-

-sectional pattern in average returns does not improve the value of the high-volume return premium on the Warsaw Stock Exchange.

4.2 Book-to-market ratio

When stocks are first sorted by their book-to-market ratio, the average returns in each value portfolio are positively related to the relative trading volume and the averages for the high volume portfolios are significant irrespective of the value of B/M. However, there is no monotonic dependence between the averages and the book-to-market ratio (see Panel B in Table 7), and also the cross-sectional pattern in returns is not so clear as in the case of size-volume portfolios. For equally-weighted portfolios, the average return of the low volume portfolios is higher for value stocks, whereas the average return of the high volume portfolios is higher for growth stocks. Clearer results are visible when returns are weighted by capitalization. The averages increase from the left (low B/M portfolios) to the right (high B/M portfolios) reaching the highest value (1.94% per month) for a portfolio of value stocks with high relative trading volume.

The high-volume return premium is significant in each value portfolio except for capitalization--weighted portfolios of stocks with medium B/M. However, the interpretation of the premium values is somehow mixed because the highest value is observed for growth stocks (when returns are equally--weighted) and for value stocks (when returns are weighted by capitalization). Despite these patterns, the differences between the premium for value and growth stocks are insignificant for both weighting schemes. Moreover, none of the differences presented in the H-L columns is significant. Hence, we can conclude that the returns of stocks with a different trading activity do not depend on the value of their book-to-market ratio. This result is probably due to the fact that the value effect is less pronounced on the WSE than size and momentum effects.

4.3 Momentum

A totally different behaviour of the average returns is observed when stocks are first sorted by their historical returns. In Panel C of Table 7, we observe a very strong horizontal pattern: the averages increase from the left (Losers) to the right (Winners). Moreover, almost all average returns of portfolios in Winners columns are significant irrespective of the value of the relative trading volume. This is the result of a very strong momentum effect on the WSE. Also, the differences between returns of Winners and Losers portfolios are significant for each group of volume stocks. The highest average is observed in the case of winners with the high relative volume (2.77% and 2.44% per month for equally--weighted and capitalization-weighted portfolios, respectively). These results are very close to average returns of small stocks with the extremely high trading activity in Panel A. This indicates a very strong impact of the momentum on returns of volume portfolios. It also suggests a theoretical trading strategy of buying winner stocks, which attract investors' attention (Winners/High) and short-selling loser stocks with a very low relative volume (Losers/Low).[6] Such a portfolio reaches the monthly average of 3.09%

6 This strategy can be seen as a modification of the momentum strategy similar to the one in Lee and Swaminathan (2000).

when returns are weighted by capitalization and 2.56% in the case of equally-weighted portfolios. However, this result cannot be applied in practice due to various restrictions in short selling.

The positive dependence between momentum and the returns of volume portfolios, however, does not impact the differences between the high-volume premiums. The averages of the High--Low portfolios remain practically at the same level, irrespective of the value of past returns and the differences between the premium for Winners and Losers are insignificant.

4.4 Exposures to risk factors

In this section we examine whether the high-volume premium can be explained by differences in risks of high and low volume portfolios. Thus, we test differences in risk factor exposures between those two groups of stocks.

Economic literature identifies a number of potential risk factors that are important for explaining cross-sectional patterns in stock returns. Since the factors proposed by Fama and French (1993) and Carhart (1997) are the most commonly used in asset pricing, we perform the analysis on the basis of the four-factor model described by the following formula[7]:

$$R_t = \alpha + \beta_{RM} RM_t + \beta_{SMB} SMB_t + \beta_{HML} HML_t + \beta_{WML} WML_t + \varepsilon_t,$$

where R_t is the portfolio excess return, while RM_t, SMB_t, HML_t and WML_t are risk factors described at the beginning of Section 4. The parameters β_{RM}, β_{SMB}, β_{HML}, β_{WML} are the risk premia associated with each of the risk factors.

In order to study the differences in risk factor exposures between portfolios of stocks with an extremely high relative volume and portfolios of stocks with an extremely low relative volume, we estimate the joint four-factor model for Low, Medium and High portfolios constructed in Subsection 3.1 and presented in Table 2. As a result, for each risk factor we obtain three estimates of risk exposures β_L, β_M and β_H for Low, Medium and High portfolios. The high-volume premium is a result of a shift in the systematic risk between stocks with low and high relative trading volume if β_H is significantly greater than β_L. Hence, we test the significance of the difference $\beta_H - \beta_L$.

We construct RM_t, SMB_t, HML_t and WML_t in line with the commonly-used procedure described in Fama and French (1993) and in Carhart (1997). We use monthly data of capitalization, book-to-market ratio and returns of stocks listed on the WSE in the period 2001–2015. In the portfolio formation procedure, we apply the most recent values of these characteristics instead of limiting ourselves to data from the previous year as, for example, in Fama and French (2012). RM_t is defined as the difference of the capitalization-weighted average of monthly returns of all stocks in the sample and the 1-month WIBID rate. In order to compute SMB_t and HML_t at the end of each month, stocks with a positive book value are independently sorted by capitalization and by book-to-market ratio (B/M). Sorting by capitalization results in two groups of stocks: small stocks (S) with capitalization below the 50th percentile and a portfolio of big stocks (*B*) with capitalization above the 50th percentile. The stocks

7 The applicability of the four-factor model to the Polish stock market is analyzed by Czapkiewicz and Skalna (2011), Czapkiewicz and Wójtowicz (2014), Zaremba and Konieczka (2015).

are also independently divided into three groups with low (*L*), medium (*M*) and high (*H*) values of book-to-market ratio according to the 30th and 70th percentiles, respectively. These sorting procedures result in six size-value portfolios: *SL*, *SM*, *SH*, *BL*, *BM* and *BH*. SMB_t is defined as the difference between the average of capitalization-weighted returns of three small-cap portfolios (*SL*, *SM*, *SH*) and the average of capitalization-weighted returns of three large-cap portfolios (*BL*, *BM*, *BH*). The HML_t factor is computed as the difference between the average of capitalization-weighted returns of small and large value stocks (*SH* and *BH*) and the average of capitalization-weighted returns of small and big growth stocks (*SL* and *BL*). The definition of WML_t is similar to the definition of HML_t, but stocks are sorted according to their cumulative returns from the previous year and are classified into three portfolios: Losers, Medium and Winners.

Results of the joint estimation of the four-factor model for Low, Medium and High volume portfolios weighted by capitalization and with a 6-month reference period are presented in Table 8. Additionally, we also report results of estimation of the four-factor model separately for the High-Low portfolio to verify how the risk factors under study explain the high-volume return premium observed on the Warsaw Stock Exchange. In the last row of the table, we report the differences between the risk exposures of extreme volume portfolios to each risk factor and the difference between the respective intercepts.

From Table 8 it can be concluded that the impact of all the risk factors on returns of Low, Medium and High portfolios is positive. Some of these relationships are significant, but for each of the risk factors under study, the difference $\beta_H - \beta_L$ is insignificant. In fact, all the estimated β_H coefficients are smaller than the corresponding β_L coefficients suggesting that low volume portfolios have higher exposures to the risk factors than high volume portfolios. Hence, the differences in exposures to the risk factors under study do not impact the high-volume return premium on the Warsaw Stock Exchange.

The results in Table 8 lead to another very important conclusion. In the case of the joint four--factor model, two intercepts (for the Low and High portfolios) are significant. Moreover, its difference is also significant. This means that the risk factors taken into account do not fully explain returns of these portfolios and the high-volume return premium is an anomaly that adds something new to commonly used risk factors. The final argument that the four-factor model fails to explain the high--volume return premium on the WSE and that it incorrectly describes a cross-sectional variation of volume portfolio returns is the result of the GRS test of Gibbons, Ross and Shanken (1989). If the factors price the portfolios under study and capture the variation of their returns correctly, the intercepts α for the Low, Medium and High volume portfolios are jointly equal to zero. However, in the case of volume portfolios, the GRS statistics is equal to 5.37 with the p-value of 0.002. Hence, the test rejects the null hypothesis of insignificance of all the intercepts in the joint four-factor model estimated for Low, Medium and High portfolios.

When we estimate the four-factor model only for High-Low portfolios, the intercept equals 1.5 and is significant at the 1% level, whereas all the betas are insignificant. This, once again, confirms that the high-volume return premium on the WSE is not explained by the commonly used factors, i.e. market, size, value and momentum.

A comparison of this result with the results in Zaremba and Szyszka (2016) indicates that the high--volume return premium is among the most significant anomalies on the WSE. Only seven out of 100 anomalies described in that paper (see Zaremba, Szyszka 2016, Table 3 and 4) has the intercept of

the four-factor model significant at the 1% level in the whole period.[8] To allow a better comparison, we re-estimated the model for the High-Low portfolio on the basis of data from June 2007 to November 2015 (this is one of the sub-periods in Zaremba, Szyszka 2016, Table 3). In that case, the intercept is equal to 1.17 and is still significant at the 5% level.

4.5 Liquidity

Another important factor that may explain the observed differences between returns of extreme volume portfolios is liquidity. From the investor's point of view, liquidity is an important issue in the analysis of potential investing opportunities. Buying illiquid equity is usually associated with higher trading costs and, thus, it is also accompanied by a higher expectation of future returns. These higher profits must compensate the illiquidity risks. The idea that liquidity may explain the high-volume premium is supported by the results of previous studies. Illiquidity may be a possible explanation of higher returns of small stocks (Amihud 2002) or the momentum effect (Sadka 2006).

There is no single common definition of liquidity, thus, to study whether the high-volume return premium on the WSE is related to differences in liquidity of stocks in volume portfolios, we apply a liquidity measure considered by Pastor and Stambaugh (2003). This measure is also used by Kaniel, Ozoguz and Starks (2012) and, in this way, we will be able to compare the results for the WSE with the previous results for developed markets. The analysis goes as follows. First, at the end of each month t, for each i –th stock from the sample, we compute an individual liquidity measure $\gamma_{i,t}$ given by equation (1) in Pastor and Stambaugh (2003):

$$R^e_{i,d+1,t} = \theta_{i,t} + \phi_{i,t} R_{i,d,t} + \gamma_{i,t} sign\left(R^e_{i,d,t}\right) \cdot v_{i,d,t} + \varepsilon_{i,d+1,t}, \qquad d = 1,\ldots,D$$

where $R_{i,d,t}$ is the return on stock i on day d in month t; $R^e_{i,d,t}$ is the stock excess return over market return and $v_{i,d,t}$ is a natural logarithm of the trading volume on day d. $\gamma_{i,t}$ measures how order flow (proxied here by a natural logarithm of the trading volume signed by excess stock return over the market) impacts future stock returns.

By definition, γ_{it} is expected to be negative. The larger its absolute value is, the lower the stock liquidity. In each month, we also estimate the market-wide liquidity measure by averaging individual liquidity measures across all the stocks in the sample. Then, we compute innovations in the aggregate liquidity. As shown by Pastor and Stambaugh (2003), such innovations are important risk factors in the asset pricing on US stock markets. Finally, as in Pastor and Stambaugh (2003), for the i –th stock and for each month from March 2005 to December 2015, we compute stock returns sensitivity to the innovation in the aggregate liquidity L_t. This sensitivity is equal to the liquidity beta ($\beta_{L,i}$) in the following enhanced three-factor model:

$$R_{i,t} = \alpha_i + \beta_{RM,i} RM_t + \beta_{SMB,i} SMB_t + \beta_{HML,i} HML_t + \beta_{L,i} L_t + \varepsilon_t,$$

where L_t is the innovation in the aggregate liquidity and the rest of the factors is as in the previous subsections.

8 Zaremba and Szyszka (2016) consider data from a wider period (from December 1998 to November 2015), but the application of earlier data only improves their results due to the decreasing profitability of stock market anomalies.

For each month the above regression is run on the basis of data from the given month and the previous 35 months. Hence, first values of liquidity betas ($\beta_{L,i}$) can be computed at the end of March 2005.

We analyze whether the liquidity has an impact on the high-volume return premium in a similar manner as in the case of size, value, and momentum. At the end of each month, we first sort stocks according to their liquidity betas and form three portfolios of stocks with low (below the 30th percentile), medium (between the 30th and 70th percentiles) and high (above the 70th percentile) liquidity betas. Then, within each liquidity portfolio, we study the high-volume return premium by comparing returns on the 20% of stocks with the extremely high and extremely low relative volume. The results of this study are reported in Table 9.

In each liquidity portfolio, the high-volume premium is significantly positive for both weighting methods. The highest averages of the High-Low portfolio returns are observed for stocks with extreme values of sensitivity to liquidity. However, the differences between the premium for the high liquidity and low liquidity stocks (-28 and 52 basis points for equally- and capitalization-weighted portfolios, respectively) are insignificant. This means that the value of the high-volume return premium is similar, irrespective of stocks' liquidity and differences in liquidity do not explain the observed differences in the average returns of stocks with extremely high and extremely low relative trading activity. This is in line with conclusions of Kaniel, Ozoguz and Starks (2012) for developed markets that liquidity does not impact the volume premium.

5 Conclusions

In this paper we study the existence and properties of the high-volume return premium on stock exchanges in Warsaw and Vienna. The high-volume return premium is a positive difference between returns of stocks with increased trading volume and stocks with reduced trading activity.

The application of daily data from January 2001 to December 2015 confirms the existence of the high-volume return premium on the Warsaw Stock Exchange: a portfolio that is long in stocks with high relative volume and short in stocks with a very low value of the relative volume has a significantly positive mean. The significance of the premium on the WSE is robust to the definition of extreme volume portfolios, the length of the reference period, and the portfolio weighting scheme. Our study also shows that even a strategy of buying only high-volume stocks has significantly positive monthly returns. On the other hand, the analysis of volume-based portfolios on the NewConnect gives mixed results: the premium is significant only when stocks in portfolios are equally-weighted. The insignificance of the premium on the NC is mainly due to the very high volatility of volume portfolios when compared with the portfolios from the WSE.

The analysis preformed on the basis of stocks listed on the Vienna Stock Exchange shows that the difference between returns of high and low volume stocks is significant only when returns are equally-weighted. In the capitalization-weighting, this difference is insignificant. This calls into question the existence of the high-volume return premium on the VSE. The main source for the insignificance of the premium is the adverse impact of large firms. The exclusion of their stocks from the analysis produces the significant value of the high-volume return premium. However,

this procedure substantially reduces the sample of remaining stocks of small firms that, additionally, to a large extent are very rarely traded.

We consider the size, value, momentum and liquidity as potential factors affecting the values of volume portfolios. Among them only the capitalization and momentum influence the returns of volume portfolios. Average returns of high-volume portfolios are significantly greater for small firms than for stocks of large companies and volume-based portfolio returns for winners are significantly greater than for losers. Despite that fact, the high-volume premium is significant irrespective of the size, value and momentum, the values of the premium do not differ significantly. This means that the factors do not affect the premium. The only exception is the significant difference between the premium for small and big stocks when portfolios are equally-weighted. Additional analysis also shows that the high-volume return premium remains significant regardless of stock liquidity.

Further tests prove that the high-volume return premium on the WSE is an anomaly that cannot be explained in the asset pricing framework on the basis of the four-factor model.

The results of the paper are important from both practical and theoretical points of view. First, they confirm that the trading volume is a variable that impacts stock prices and can be useful in the prediction of their changes. Second, the significance of the high-volume return premium may be applied in the construction of various investing strategies based on the analysis of trading activity. Moreover, the high-volume return premium can be considered as an alternative risk factor. However, this is an issue for further research.

References

Amihud Y. (2002), Illiquidity and stock returns: cross-section and time-series effects, *Journal of Financial Markets*, 5(1), 31–56.

Banz R.W. (1981), The relationship between return and market value of common stocks, *Journal of Financial Economics*, 9, 3–18.

Blume L., Easley D., O'Hara M. (1994), Market statistics and technical analysis: The role of volume, *Journal of Finance*, 49, 153–181.

Blume M.E., Stambaugh R.F. (1983), Biases in computed returns: an application to the size effect, *Journal of Financial Economics*, 12(3), 387–404.

Carhart M. (1997), On persistence in mutual fund performance, *Journal of Finance*, 52, 57–82.

Chan L., Hamao Y., Lakonishok J. (1991), Fudamentals and stock returns in Japan, *Journal of Finance*, 46, 1739–1789.

Chordia T., Swaminathan B. (2000), Trading volume and cross-autocorrelations in stock returns, *Journal of Finance*, 55, 913–935.

Chui A.C.W., Titman S., Wei J.K.C. (2010), Individualism and momentum around the world, *Journal of Finance*, 65(1), 361–392.

Conrad J., Hameed A., Niden C. (1994), Volume and autocovariances in short-horizon individual security returns, *Journal of Finance*, 49, 1305–1329.

Copeland T. (1976), A model of asset trading under the assumption of sequential information arrival, *Journal of Finance*, 31, 135–155.

Czapkiewicz A., Skalna I. (2011), Użyteczność stosowania modelu Famy i Frencha w okresach hossy i bessy na rynku akcji GPW w Warszawie, *Bank i Kredyt*, 42(3), 61–80.

Czapkiewicz A., Wójtowicz T. (2014), The four-factor asset pricing model on the Polish stock market, *Economic Research – Ekonomska Istraživanja*, 27(1), 771–783.

Fama E.F., French K.R. (1993), Common risk factors in the returns on stocks and bonds, *Journal of Financial Economics*, 33(1), 3–56.

Fama E.F., French K.R. (1996), Multifactor explanations of asset pricing anomalies, *Journal of Finance*, 51, 55–84.

Fama E.F., French K.R. (2012), Size, value, and momentum in international stock returns, *Journal of Financial Economics*, 3, 457–472.

Gallant A.R., Rossi P.E., Tauchen G.E. (1992), Stock prices and volume, *Review of Financial Studies*, 5, 199–242.

Gervais S., Kaniel R., Mingelgrin D. (2001), The high-volume return premium, *Journal of Finance*, 56, 877–919.

Gibbons M.R., Ross S.A., Shanken J. (1989), A test of the efficiency of a given portfolio, *Econometrica*, 57(5), 1121–1152.

Griffin J.M., Ji X., Martin J.S. (2003), Momentum investing and business cycle risk: evidence from pole to pole, *Journal of Finance*, 58, 2515–2547.

Gurgul H., Wójtowicz T. (2009), High-volume return premium: an event study approach, *Statistics in Transition*, 10(1), 129–151.

Jacobs H., (2015), What explains the dynamics of 100 anomalies? *Journal of Banking and Finance*, 57, 65–85.

Jegadeesh N., Titman S. (1993), Returns to buying winners and selling losers: Implications for stock market efficiency, *Journal of Finance*, 48, 65–91.

Kaniel R., Ozoguz A., Starks L. (2012), The high volume return premium: cross-country evidence, *Journal of Financial Economics*, 103(2), 255–279.

LeBaron B. (1992), *Persistence of the Dow Jones index on rising volume*, Working Paper, University of Wisconsin.

Lee B.S., Rui O.M. (2002), The dynamic relationship between stock returns and trading volume: domestic and cross-country evidence, *Journal of Banking and Finance*, 26, 51–78.

Lee C., Swaminathan B. (2000), Price momentum and trading volume, *Journal of Finance*, 55, 2017–2069.

Llorente G., Michaely R., Saar G., Wang J. (2002), Dynamic volume-return relation of individual stock, *The Review of Financial Studies*, 15, 1005–1047.

Merton R.C., (1987), A simple model of capital market equilibrium with incomplete information, *Journal of Finance*, 42, 483–510.

Newey W., West K. (1987), A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix, *Econometrica*, 55, 703–708.

Pastor L., Stambaugh R. (2003), Liquidity risk and expected stock returns, *Journal of Political Economy*, 111, 642–685.

Reinganum M.R. (1981), Misspecification of capital asset pricing: Empirical anomalies based on earnings' yields and market values, *Journal of Financial Economics*, 9, 19–46.

Rosenberg B., Reid K., Lanstein R. (1985), Persuasive evidence of market efficiency, *Journal of Portfolio Management*, 11, 9–17.

Rouwenhorst K.G. (1998), International momentum strategies, *Journal of Finance*, 53, 267–284.

Sadka R. (2006), Momentum and post-earnings-announcement drift anomalies: the role of liquidity risk, *Journal of Financial Economics*, 80, 309–349.

Silvapulle P., Choi J.-S. (1999), Testing for linear and nonlinear Granger causality in the stock price--volume relation: Korean evidence, *Quarterly Review of Economics and Finance*, 39, 59–76.

Stattman D. (1980), Book values and stock returns, *The Chicago MBA: A Journal of Selected Papers*, 4, 25–45.

Suominen M. (2001), Trading volume and information revelation in stock markets, *Journal of Financial and Quantitative Analysis*, 36, 545–565.

Szyszka A. (2006), Zjawisko kontynuacji stóp zwrotu na Giełdzie Papierów Wartościowych w Warszawie, *Bank i Kredyt*, 8, 37–49.

Tang T., Zou L., Li J. (2013), The high-volume return premium: evidence from the Australian equity market, *Journal of Accounting and Finance*, 13(5), 74– 93.

Waszczuk A. (2013), A risk-based explanation of return patterns – evidence from the Polish stock market, *Emerging Markets Review*, 15, 186–210.

Wójtowicz T. (2011), Efekt momentum na GPW w Warszawie w latach 2003–2010, *Managerial Economics*, 9, 63–74.

Zaremba A., Konieczka P. (2015), Are Value, Size and Momentum Premiums in CEE Emerging Markets Only Illusionary?, *Finance a úvěr – Czech Journal of Economics and Finance*, 65(1), 84–104.

Zaremba A., Szyszka A. (2016), Is there momentum in equity anomalies? Evidence from the Polish emerging market, *Research in International Business and Finance*, 38, 546–564.

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Table 1
Characteristics of the stock markets in Warsaw and Vienna

	WSE	NC	VSE
Number of equities	487.0	418.0	78.0
Market capitalization (EUR million)	255254.0	2033.0	87789.4
Average daily turnover value (EUR million)	193.7	1.6	117.7

Note: statistics in this table are based on the data from the end of 2015.
Source: yearly reports of the Warsaw Stock Exchange and the Vienna Stock Exchange.

Table 2
Average monthly returns of volume portfolios on the Warsaw Stock Exchange

	Equally-weighted portfolios			Capitalization-weighted portfolios		
	average	standard deviation	t-statistic	average	standard deviation	t-statistic
Panel A: 3-month reference period						
Low	0.28	7.90	0.34	-0.08	7.25	-0.10
Medium	1.43	7.44	1.62	0.77	5.94	1.45
High	2.55***	8.13	2.82	1.29**	7.13	2.23
High-Low	2.27***	5.05	5.92	1.37***	5.78	2.84
Panel B: 6-month reference period						
Low	0.38	8.05	0.40	-0.23	6.98	-0.30
Medium	1.46	7.43	1.65	0.78	5.93	1.45
High	2.46***	8.42	2.76	1.51***	6.98	2.69
High-Low	2.08***	5.69	4.70	1.74***	6.11	3.32
Panel C: 12-month reference period						
Low	0.54	7.58	0.61	-0.11	7.00	-0.15
Medium	1.50*	7.52	1.69	0.84	6.02	1.58
High	2.88***	9.07	2.90	1.01*	6.84	1.77
High-Low	2.34***	6.18	4.89	1.12***	5.57	2.87

Notes:
This Table reports the averages of monthly returns (in percentages) of portfolios created on the basis of comparison between firms' present trading volume and their past values form 3, 6 and 12 previous months. The Low (High) portfolio refers to portfolios of stocks from the 10^{th} bottom (top) percentiles of relative trading volume distribution on a formation day. High-Low is a zero-net portfolio that is long on stocks from the High portfolio and short on stocks from the Low portfolio.
the analysis is performed on the basis of stocks listed only on the WSE in the period from March 2002 to December 2015.
***, **, * indicate significance of the mean at the 1%, 5% and 10% level, respectively. The significance of mean monthly returns is verified by means of t-statistics with Newey-West correction on autocorrelation of returns.

Table 3

Average monthly returns of portfolios with a wider definition of extreme volume

	Equally-weighted portfolios			Capitalization-weighted portfolios		
	average	**standard deviation**	**t-statistics**	**average**	**standard deviation**	**t-statistics**
3 months	1.32***	3.65	4.89	0.91**	4.73	2.32
6 months	1.39***	4.03	4.89	0.83*	4.75	1.94
12 months	1.59***	4.46	4.35	1.23***	4.88	3.23

Note:
This Table reports averages, standard deviation and t-statistics of monthly returns (in percentages) of zero-net portfolio High-Low that is long on stocks with high relative trading volume and it is short on stocks with very low relative trading volume. The relative volume is computed on the basis of a comparison with trading activity in the previous 3, 6 and 12 months, respectively. The Low (High) portfolio refers to a portfolio of stocks from the 20^{th} bottom (top) percentile of relative trading volume distribution on a formation day. The analysis is performed on the basis of stocks quoted on the WSE form March 2002 to December 2015.
***, **, * indicate significance of the mean at the 1%, 5% or 10% level, respectively. The significance of mean monthly returns is verified by means of t-statistics with Newey-West correction on autocorrelation of the returns.

Table 4

The high-volume return premium after August 2009

	Equally-weighted portfolios			Capitalization-weighted portfolios		
	average	**standard deviation**	**t-statistics**	**average**	**standard deviation**	**t-statistics**
NC	4.35***	13.07	2.92	1.53	12.32	1.09
WSE	1.88***	3.05	5.40	1.20***	5.08	2.07
WSE + NC	2.29***	6.03	5.14	1.61***	6.03	3.03

Note:
This Table reports averages, standard deviation and t-statistics of monthly returns (in percentages) of zero-net portfolio High-Low that is long on stocks with high relative trading volume and it is short on stocks with very low relative trading volume. The analysis is performed on stocks quoted only on the NewConnect (the NC row) or only on the WSE (the WSE row). We also consider a joint sample of stocks listed on any of these markets (the WSE + NC row). The analysis is performed on the basis of data from August 2009 to December 2015.
***, **, * indicate significance of the mean at the 1%, 5% or 10% level, respectively. The significance of mean monthly returns is verified by means of t-statistics with Newey-West correction on autocorrelation of the returns.

Table 5

Average monthly returns of volume portfolios on the Vienna Stock Exchange

	Equally-weighted portfolios			Capitalization-weighted portfolios		
	average	standard deviation	t-statistics	average	standard deviation	t-statistics
Low	-0.09	6.89	-0.10	0.45	6.88	0.51
Medium	0.96	6.59	1.23	0.61	6.51	0.86
High	1.10	7.13	1.54	0.20	8.07	0.22
High-Low	1.19*	5.61	1.84	-0.25	6.18	-0.48

Note:
This Table reports averages of monthly returns (in percentages) of portfolios created on the basis of the comparison of firms' present trading volume with their past values from the six previous months. The Low (High) portfolio refers to portfolios of stocks from the 20^{th} bottom (top) percentiles of the relative trading volume distribution on a formation day. High-Low is a zero-net portfolio that is long on stocks from the High portfolio and short on stocks from the Low portfolio. The analysis is performed on the basis of stocks listed on the Vienna Stock Exchange in the period from October 2004 to December 2015.
***, **, * indicate significance of the mean at the 1%, 5% and 10% level, respectively. The significance of mean monthly returns is verified by means of t-statistics with Newey-West correction on autocorrelation of returns.

Table 6

Average monthly returns of portfolios with a 6-month reference period after August 2009

	Equally-weighted portfolios			Capitalization-weighted portfolios		
	average	standard deviation	t-statistics	average	standard deviation	t-statistics
VSE	0.65	3.96	1.55	-0.31	5.18	-0.48
90% of VSE	0.84**	4.24	2.04	0.65	4.67	1.50
80% of VSE	1.17**	4.91	2.06	0.80	4.97	1.65
70% of VSE	1.28***	5.01	2.75	1.13**	4.66	2.41

Notes:
This Table reports averages, the standard deviation and t-statistics of monthly returns (in percentages) of the High-Low portfolios with 6-month reference periods. The analysis is performed on the basis of all the stocks quoted on the VSE from August 2009 to December 2015 (the VSE row) or on the basis of 90% (80% or 70%, respectively) of the smallest stocks listed on the VSE in that period.
***, **, * indicate significance of the mean at the 1%, 5% or 10% level, respectively. The significance of mean monthly returns is verified by means of t-statistics with Newey-West correction on autocorrelation of the returns.

Table 7

Monthly returns of portfolios sorted by size, value, momentum, and relative trading volume

	Equally-weighted portfolios				**Capitalization-weighted portfolios**			
Panel A: size-volume portfolios								
	capitalization				capitalization			
	Small	Medium	Big	**S-B**	Small	Medium	Big	**S-B**
Low	0.81	0.69	0.58	**0.23**	1.05	0.73	0.28	**0.77**
Medium	2.16*	1.23	0.84	**1.32***	1.56	1.28	0.81	**0.75**
High	3.41***	1.71**	1.30**	**2.10****	2.37**	1.62*	0.91*	**1.46****
H-L	**2.60*****	**1.02*****	**0.73***	**1.87****	**1.32****	**0.89****	**0.63***	**0.69**
Panel B: value-volume portfolios								
	B/M ratio				B/M ratio			
	Low	Medium	High	**H-L**	Low	Medium	High	**H-L**
Low	0.42	0.89	1.14	**0.72**	0.19	0.50	0.87	**0.68**
Medium	1.46*	1.25	1.46	**0.00**	0.74	0.84	1.04	**0.30**
High	2.56***	1.88**	2.28**	**-0.29**	1.13*	1.02*	1.94**	**0.81**
H-L	**2.14*****	**0.99*****	**1.13***	**-1.01**	**0.95****	**0.51**	**1.08****	**0.13**
Panel C: momentum-volume portfolios								
	momentum				momentum			
	Losers	Medium	Winners	**W-L**	Losers	Medium	Winners	**W-L**
Low	0.16	0.54	1.67*	**1.51*****	-0.65	0.23	1.19	**1.85*****
Medium	0.57	1.38	2.23**	**1.67*****	-0.97	0.88	1.14**	**2.11*****
High	1.51	2.12**	2.72***	**1.21***	0.62	1.09*	2.44***	**1.81****
H-L	**1.35****	**1.58*****	**1.05*****	**-0.30**	**1.29****	**0.86***	**1.24****	**-0.05**

Notes:

This Table reports averages of monthly returns (in percentages) of portfolios containing stocks that are first sorted by size (value or momentum) and then sorted by the relative volume. Stocks sorted by the first factor are divided into three portfolios according to the 30^{th} and 70^{th} percentiles, whereas stocks sorted by the relative volume are further divided according to the 20^{th} and 80^{th} percentiles. Subsequent panels report the results for the size-volume, value-volume, and momentum-volume portfolios. Each column of the panels reports results of the high-volume return premium analysis for stocks of a similar value of the first factor. S-B (H-L and W-L) column reports differences between averages for extreme portfolios of stocks sorted by capitalization (value and momentum, respectively). Computations are performed on the basis of 165 monthly returns from April 2002 to December 2015.

***, **, * indicate significance of the mean at the 1%, 5% and 10% level, respectively. The significance of mean monthly returns is verified by means of t-statistics with Newey-West correction on autocorrelation of returns.

Table 8
Estimated values of four-factor model for volume portfolios

	Intercept	RM_t	SMB_t	HML_t	WML_t
Low	-1.1*** (0.31)	0.98*** (0.05)	0.28*** (0.06)	0.14** (0.06)	0.07 (0.05)
Medium	0.1 (0.13)	0.98*** (0.02)	0.03 (0.03)	0.09*** (0.03)	0.02 (0.02)
High	0.77** (0.38)	0.91*** (0.06)	0.12 (0.07)	0.11 (0.08)	0.01 (0.06)
High-Low	1.5*** (0.51)	-0.07 (0.08)	-0.16 (0.1)	-0.03 (0.1)	-0.06 (0.08)
$\beta_H - \beta_L$	2.6***	-1.05	-0.44	-0.17	-0.13

Note:
This Table reports estimated parameters of four-factor models of Carhart (1997). The model is estimated jointly for capitalization-weighted portfolios of stocks with the low, medium and high relative trading volume formed on the basis of a 6-month reference period. The table also reports parameter estimates of the four-factor model for the High-Low portfolio that is long on stocks with a high relative trading volume (the High portfolio) and short on stocks with the low relative trading volume (the Low portfolio). In parentheses, we report standard errors of estimates. In the last row of the table, the differences between respective parameters for High and Low portfolios are presented.
***, **, * indicates significance at the 1%, 5% and 10% level, respectively.

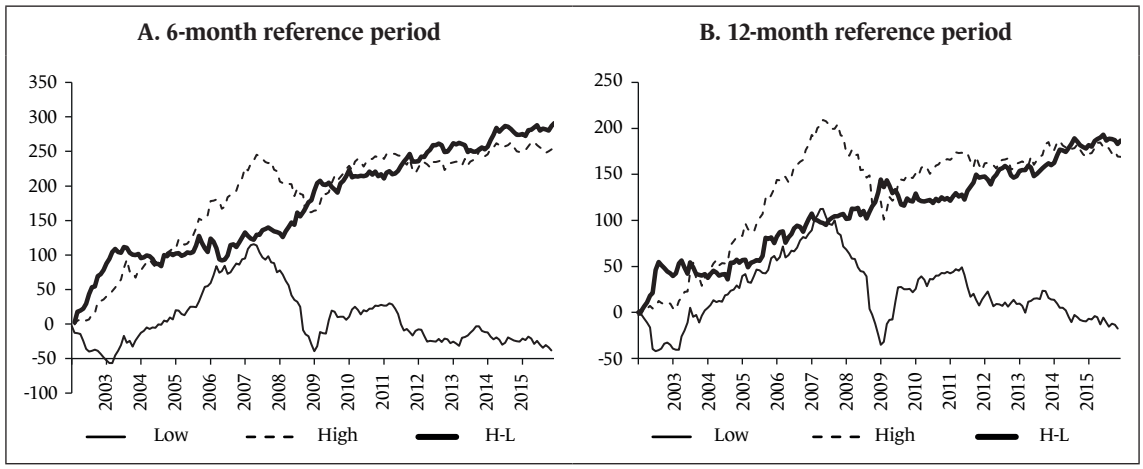
Table 9
Impact of liquidity on high-volume return premium

	Equally-weighted portfolios			**Capitalization-weighted portfolios**		
	liquidity betas			**liquidity betas**		
	Low	Medium	High	Low	Medium	High[1]
Low	0.02	0.40	0.03	-0.27	0.02	-0.63
Medium	0.54	0.85	1.27	0.79	0.04	0.29
High	1.73	1.19	1.45	1.30	0.92	1.30
High-Low	1.71**	0.78**	1.42**	1.57*	0.90*	2.09***

Note:
This Table reports averages of monthly returns (in percentages) of portfolios of stocks that are first sorted by their sensitivity to liquidity (liquidity betas) and then sorted by their relative volume. The stocks sorted by liquidity are divided into three portfolios according to the 30th and 70th percentiles, whereas the stocks sorted by relative volume are further divided according to the 20th and 80th percentiles. Within each liquidity portfolio, we also report results of the high-volume return premium analysis (i.e. the results for High-Low portfolios).
***, **, * indicate significance of the mean at the 1%, 5% and 10% level, respectively. The significance of mean monthly returns is verified by means of t-statistics with Newey-West correction on autocorrelation of returns.

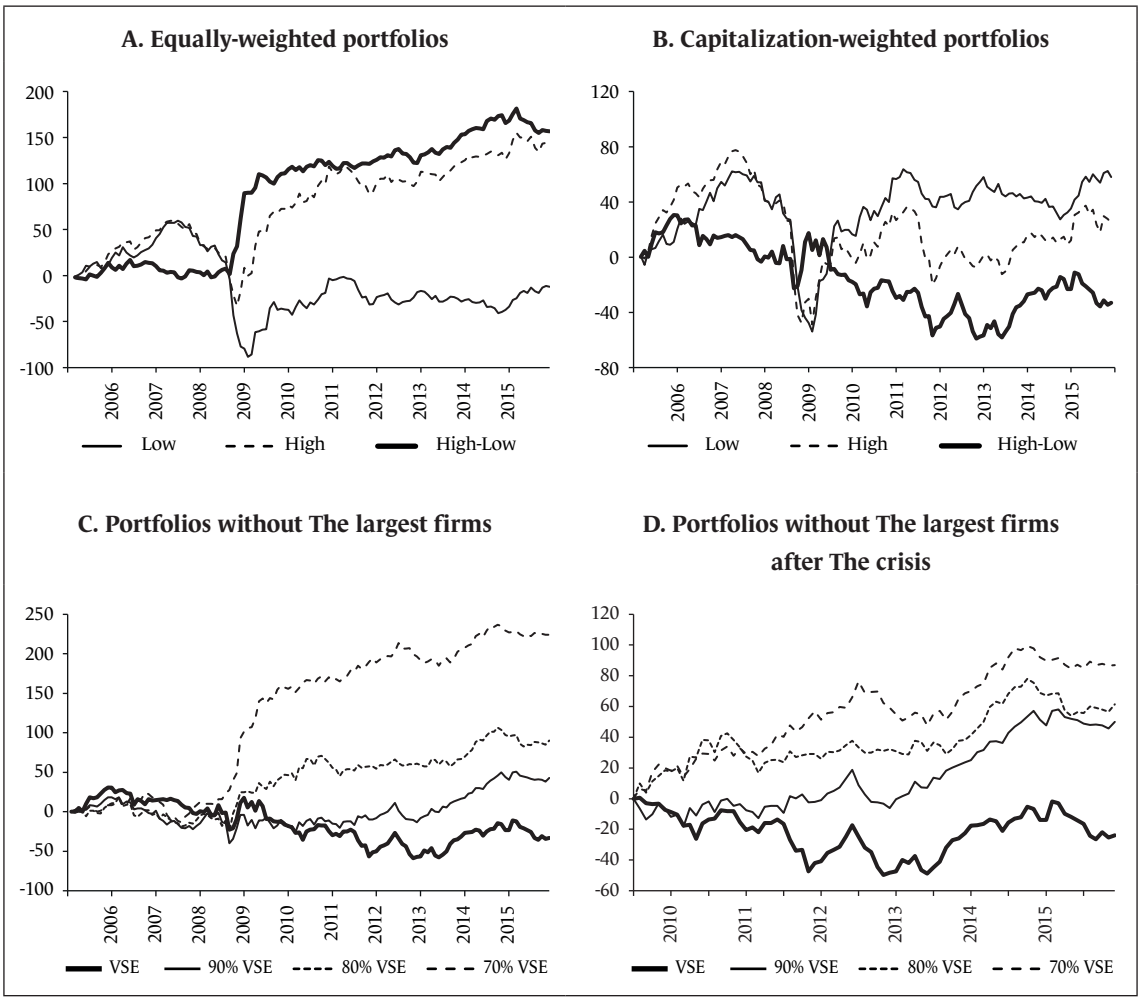
[1] Due to a relatively small number of stocks in the extreme liquidity-volume portfolios at the beginning of the sample, their monthly returns are very sensitive to outliers. The unusually high monthly returns (more than 100%) of KREZUS, SOHODEV and MIDAS in October 2006 are such outstanding observations. All these stocks are in the portfolio of stocks with high liquidity betas and a high relative volume. To ensure consistency of the analysis, we excluded these three returns from the analysis. The inclusion of these returns would increase the average returns of portfolios of stocks with high betas and high volume to 2.27% and volume premium of high beta portfolios to 2.9%. However, the difference between the premium of high and low betas portfolios would still remain insignificant.

Figure 1
Cumulative monthly returns volume portfolios on the Warsaw Stock Exchange



Notes:
These Figures show cumulative monthly average returns of the capitalization-weighted volume-based portfolios of stocks listed on the Warsaw Stock Exchange. Portfolios are created on the basis of a comparison of the trading volume at the end of each month with the trading volume from the previous six months (Panel A) or twelve months (Panel B). The Low (High) portfolio refers to a portfolio of stocks from the 10^{th} bottom (top) percentiles of the relative trading volume distribution on a portfolio formation day. H-L is a zero-investment portfolio that is long on stocks from the High portfolio and short on stocks from the Low portfolio.

Figure 2
The high volume return premium on The Vienna Stock Exchange



Notes:
These figures show cumulative monthly average returns of the capitalization-weighted volume-based portfolios of stocks listed on the Vienna Stock Exchange. Panel A and B shows cumulative average monthly returns of volume portfolios with equal and capitalization weighting, respectively. Panel C and D shows cumulative average monthly returns of the High-Low portfolios formed on the basis of 90% (80% and 70%, respectively) of the smallest firms listed on the VSE. Graphs in Panels A-C are based on data from October 2004 to December 2012, whereas graphs in Panel D concern the period from August 2009 to December 2015.