

# PRACE NAUKOWE

Uniwersytetu Ekonomicznego we Wrocławiu

# RESEARCH PAPERS

of Wrocław University of Economics

Nr 428

## Wrocław Conference in Finance: Contemporary Trends and Challenges



Publishing House of Wrocław University of Economics  
Wrocław 2016

Copy-editing: Marta Karaś  
Layout: Barbara Łopusiewicz  
Proof-reading: Barbara Cibis  
Typesetting: Małgorzata Czupryńska  
Cover design: Beata Dębska

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Wrocław 2016

**ISSN 1899-3192**  
**e- ISSN 2392-0041**

**ISBN 978-83-7695-583-4**

The original version: printed

Publication may be ordered in Publishing House  
Wydawnictwo Uniwersytetu Ekonomicznego we Wrocławiu  
ul. Komandorska 118/120, 53-345 Wrocław

tel./fax 71 36-80-602; e-mail: [econbook@ue.wroc.pl](mailto:econbook@ue.wroc.pl)  
[www.ksiegarnia.ue.wroc.pl](http://www.ksiegarnia.ue.wroc.pl)

Printing: TOTEM

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## Introduction

One of the fastest growing areas in the economic sciences is broadly defined area of finance, with particular emphasis on the financial markets, financial institutions and risk management. Real world challenges stimulate the development of new theories and methods. A large part of the theoretical research concerns the analysis of the risk of not only economic entities, but also households.

The first Wrocław Conference in Finance WROFIN was held in Wrocław between 22nd and 24th of September 2015. The participants of the conference were the leading representatives of academia, practitioners at corporate finance, financial and insurance markets. The conference is a continuation of the two long-standing conferences: INVEST (Financial Investments and Insurance) and ZAFIN (Financial Management – Theory and Practice).

The Conference constitutes a vibrant forum for presenting scientific ideas and results of new research in the areas of investment theory, financial markets, banking, corporate finance, insurance and risk management. Much emphasis is put on practical issues within the fields of finance and insurance. The conference was organized by Finance Management Institute of the Wrocław University of Economics. Scientific Committee of the conference consisted of prof. Diarmuid Bradley, prof. dr hab. Jan Czekaj, prof. dr hab. Andrzej Gospodarowicz, prof. dr hab. Krzysztof Jajuga, prof. dr hab. Adam Kopiński, prof. dr. Hermann Locarek-Junge, prof. dr hab. Monika Marcinkowska, prof. dr hab. Paweł Miłobędzki, prof. dr hab. Jan Monkiewicz, prof. dr Lucjan T. Orłowski, prof. dr hab. Stanisław Owsiak, prof. dr hab. Wanda Ronka-Chmielowiec, prof. dr hab. Jerzy Różański, prof. dr hab. Andrzej Sławiński, dr hab. Tomasz Słoński, prof. Karsten Staehr, prof. dr hab. Jerzy Węclawski, prof. dr hab. Małgorzata Zaleska and prof. dr hab. Dariusz Zarzecki. The Committee on Financial Sciences of Polish Academy of Sciences held the patronage of content and the Rector of the University of Economics in Wrocław, Prof. Andrzej Gospodarowicz, held the honorary patronage.

The conference was attended by about 120 persons representing the academic, financial and insurance sector, including several people from abroad. During the conference 45 papers on finance and insurance, all in English, were presented. There were also 26 posters.

This publication contains 27 articles. They are listed in alphabetical order. The editors of the book on behalf of the authors and themselves express their deep gratitude to the reviewers of articles – Professors: Jacek Batóg, Joanna Bruzda, Katarzyna Byrka-Kita, Jerzy Dzieża, Teresa Famulska, Piotr Fiszeder, Jerzy Gajdka, Marek Gruszczyński, Magdalena Jerzemowska, Jarosław Kubiak, Tadeusz Kufel, Jacek Li-

sowski, Sebastian Majewski, Agnieszka Majewska, Monika Marcinkowska, Paweł Miłobędzki, Paweł Niedziółka, Tomasz Panek, Mateusz Pipień, Izabela Pruchnicka-Grabias, Wiesława Przybylska-Kapuścińska, Jan Sobiech, Jadwiga Suchecka, Włodzimierz Szkutnik, Mirosław Szreder, Małgorzata Tarczyńska-Łuniewska, Waldemar Tarczyński, Tadeusz Trzaskalik, Tomasz Wiśniewski, Ryszard Węgrzyn, Anna Zamojska, Piotr Zielonka – for comments, which helped to give the publication a better shape.

*Wanda Ronka-Chmielowiec, Krzysztof Jajuga*

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## **THE DAY RETURNS OF WIG20 FUTURES ON THE WARSAW STOCK EXCHANGE – THE ANALYSIS OF THE DAY OF THE WEEK EFFECT**

### **DZIENNE STOPY ZWROTU KONTRAKTÓW FUTURES NA WIG20 NA GPW W WARSZAWIE – ANALIZA EFEKTU DNIA TYGODNIA**

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DOI: 10.15611/pn.2016.428.25

JEL Classification: G10, G12

**Abstract:** The aim of the study was to investigate the day of the week effect on daily returns and volatility for the Warsaw Stock Exchange, based on the open-to-close and min-to-max returns, in comparison with close-to-open returns of WIG20 futures. The research provided evidence on day of the week effect pattern in futures returns and volatility on the Polish market. In the analysed period (January 2009 – July 2015), the highest daily returns were observed on Mondays, whereas the highest volatility of returns were observed on Thursdays and Mondays.

**Keywords:** calendar effect, futures, returns, volatility.

**Streszczenie:** Celem pracy było zbadanie występowania efektu dnia tygodnia na rynku kontraktów futures na indeks WIG20 notowanych na Giełdzie Papierów Wartościowych w Warszawie. Analizie poddano kształtowanie się logarytmicznych dziennych stóp zwrotu i ich zmienności w okresie od otwarcia do zamknięcia sesji oraz między minimum i maksimum cenowym na danej sesji w porównaniu z okresem od zamknięcia do otwarcia kolejnej sesji. W badaniu wykorzystane zostały szeregi dziennych stóp zwrotu kontraktów na WIG20 w okresie od 1 stycznia 2009 r. do 1 lipca 2015 r. Badania wykazały, iż najwyższeienne stopy zwrotu były notowane w analizowanym okresie w poniedziałki, natomiast najwyższą zmiennością stopy zwrotu charakteryzowały się w czwartki i w poniedziałki.

**Słowa kluczowe:** efekty kalendarzowe, kontrakty futures, stopy zwrotu, zmienność.

## **1. Introduction**

According to Fama's efficient market hypothesis (EMH), prices on traded assets fully reflect the available information. It is not possible then to generate excess returns by



using historical data. Most studies of capital market efficiency prove, however, that there are some deviations (anomalies) from this theory such as, for instance, calendar effects. These can be defined as constant seasonal patterns and systematic variations of returns, depending on time of the day, week or month. The most popular calendar anomalies are the following: the day of the week effect, the weekend effect, the month effect, the turn-of-the-month effect, the holiday effect.

Calendar anomalies could be treated as a sign of capital market inefficiency. Still, proponents of the efficient market hypothesis have often reiterated that there might be other reasons for this situation. According to some of them, anomalies are random and inconstant in character. The hypothesis can be confirmed (or denounced) by studies of various markets and in different time periods, which will verify whether these correlations occur constantly and regardless of an analysed market or time period.

One other explanation of calendar effects can be the impact of such factors as the organization of quotations (the system of placing stock orders) or the influence of the environment (e.g. tax regulations) [Szyszka 1999]. Some others claim that a market can be inefficient because of the so called marketing game which may result in, for instance, the irrationality of investors' decisions, the unreliability of statements provided by companies and variable availability of information [Buczek 2005].

The purpose of this study is to investigate the occurrence of the day of the week effect on the futures market for the WIG20 index on the Warsaw Stock Exchange. The analysis focuses on the fixing of log returns and their volatility in the period from open to close and from minimum to maximum price in a given session comparing with a period from close to open of another session. The study uses the series of daily returns WIG20 contracts for the period from 1 January 2009 to 1 July 2015.

## **2. A survey of selected studies of the day of the week effect**

The day of the week effect consists in significant variations in the level of returns occurring on various days of the week. Initially, studies of the day of the week effect focused on the stock market, but later this phenomenon was also observed on other markets: currency market, interest rate market and derivatives market.

The research of the American market in the 70's and 80's indicates that the level of Monday and Friday returns is significantly different from other days of the week, curiously enough, Monday returns were usually negative and Friday ones positive, proving the existence of the weekend effect [Cross 1973; French 1980; Hirsch 1987; Lakonishok, Smidt 1988]. These findings made the researchers seek answers to the question of when Monday negative returns occur: whether in the period from Friday close to Monday open or during a Monday session.

One of the researchers, Rogalski [1984], by decomposing daily returns of two major American indices into trading and non-trading returns, found out that negative returns from Friday close to Monday close occur during the non-trading hours. This

hypothesis has been confirmed by Smirlock and Starks [1986] for the period of 1974–1983, at the same time, they observed a reverse correlation for the period of 1963–1973. Later studies proved significant statistical volatility of daily returns (from open to close) and overnight returns (from close to open). What is worth noting is that the mean day returns on the American market were most often negative, whereas the overnight returns were usually positive and the standard deviation of overnight returns was significantly lower than the day returns, no matter which day of the week it was [Cliff et al. 2008].

The occurrence of the day of the week effect has also been confirmed for the volatility of returns. Analysing the S&P500 index for the period of 1973–1997, Berument and Kiyamaz [2003] observed the highest volatility of returns on Fridays, which they explained with the fact that news is usually released on these days. The lowest volatility, in turn, was observed on the American market on Tuesdays [Berument, Kiyamaz 2003]. Studies of other countries not always confirmed these findings.

The day of the week effect was also studied with reference to the Polish market. This subject was the point of concern for, among others, Tarczyński [1997], Szyszka [1999, 2003, 2007], Piontek [2000], Buczek [2005], Landmesser [2006], Ślepaczuk [2006], Witkowska and Kompa [2007], Sojda [2008], Grotowski [2008], Borowski [2013], Fiszeder and Kozuchowska [2013]. The most frequently observed effects were significantly higher mean returns on Mondays and Fridays, and negative returns on Tuesdays. Higher returns on Mondays have been explained as an effect of a late reaction to quotations on the American stock market, which finishes after a close in Poland. Another explanation, which is often provided, is a more intense activity of individual investors on Monday sessions.

Even initial studies of the Polish market helped confirm the existence of the day of the week effect, although the findings differed from those for foreign markets whose Monday sessions were normally characterized by negative returns. Szyszka's [1999, 2003] research revealed that, in the period of 1994–1999, the mean Monday returns on the stock market and major indices on the Warsaw Stock Exchange were positive and, most frequently, much higher than those occurring on other days of the week, whereas Tuesday returns were negative. Apart from that, the highest mean returns were most often observed on Mondays. These effects, however, were not economically significant because of transaction costs.

The above anomalies were not confirmed by Buczek [2005], who, investigating the returns of all stocks in the continuous trading system and WIG index for the period of 2001–2004, proved the existence of the highest mean returns on Fridays.

In turn, Landmesser [2006], who investigated this effect for the period of 2002–2005, proved the occurrence of these anomalies both in Monday and Friday returns. She also observed higher volatility of Monday returns. Also, Witkowska and Kompa [2007], investigating the returns of 12 listed companies and 2 major indices for the period of 2002–2005, confirmed the occurrence of significantly positive Monday and Friday returns.

Other anomalies have been discovered by Grotowski, who taking into account the fixing of the returns of 4 indices and 30 selected companies on the Warsaw Stock Exchange for the period from the middle of 1999 to the middle of 2007, pointed to the existence of Thursday and Friday effect. He observed that it is on these days, that the returns are higher on the level which is statistically significant [Grotowski 2008].

Next researchers, who analysed more contemporary periods, normally confirmed the existence of patterns which had already been observed during Monday sessions. Basing their conclusions on their research for the period between January 2000 and January 2011, Fiszeder and Kożuchowska [2013] revealed that the estimates of mean returns are positive on Mondays and Fridays, and negative on Tuesdays. Still, significantly positive returns were observed only on Mondays for the WIG20 index [Fiszeder, Kożuchowska 2013]. Also on Mondays, the highest (positive) mean returns for the WIG index were observed for the period between the beginning of quotation to the middle of 2012 [Borowski 2013].

The analysis also investigated the correlations between day and overnight returns on various days of the week. The research conducted by Rozkrut and Tarczyńska-Luniewska [2010] has revealed the highest returns and their highest volatility during Friday sessions (from open to close). Echaust's study of the single stock and index futures contracts on the Warsaw Stock Exchange for the period of 2007–2012 shows that the mean overnight returns are positive and higher than daily returns. What is more, they are also characterized by lower risk measured by the standard deviation [Echaust 2013].

### 3. Methodology and results of research

In the current analysis of the time series of returns on the futures market for the WIG20 index, day log returns for particular days of the week from open to close of a session and from minimum to maximum price of a session are used. They are compared with returns from close to open of another session. As a result, what has been done is a decomposition of day returns measured from close to close into *day* (open to close) and *overnight* (close to open) *returns*. The standard deviation is used as a measure of volatility. To measure the direction and the strength of the correlation between day and overnight returns, and between the returns and their volatility, the Pearson product-moment correlation coefficient is employed. The stationarity of the series of returns is investigated with the use of the ADF test and the normality of distribution with the Jarque-Bera test.

The study encompasses all contracts marketed in the period of 2009–2014 and expiring before July 2015 (which was determined by the moment the current research was conducted) beginning with the FW20H10 contract and finishing with the FW20M1520 contract. In effect, 25 series of contracts were investigated, which resulted in 5784 observations. Since the period in question could be characterized with several visible trends, it is divided into three sub-periods: one period of growth

(18 February 2009 – 28 April 2011), one period of downturn (29 April 2011 – 24 May 2012), one period when a sideways trend dominated the market (25 May 2012 – 30 June 2015).

In order to evaluate the fixing of returns, the analysis investigates basic descriptive statistics. The findings are presented in Tables 1, 2 and 3. Bold values denote mean returns that are statistically significant at the 5% level. The independent two-samples (Welch's t-test) t-tests are used to test the statistical significance of mean returns. To be specific, mean return on each weekday (Monday to Friday) was compared with mean return on other four weekdays. For example, to test the Monday effect, the t-statistic was calculated as follows [Li, Liu 2011]:

$$t = \frac{\bar{R}_{Mon} - \bar{R}_{NonMon}}{\sqrt{\frac{S_{Mon}^2}{n_{Mon}} + \frac{S_{NonMon}^2}{n_{NonMon}}}}$$

where:  $\bar{R}_{Mon}$  – the mean return on Monday,  $\bar{R}_{NonMon}$  – the mean return on the weekdays other than Monday,  $S_{Mon}^2$  – the variance of Monday returns,  $S_{NonMon}^2$  – the variance of Non-Mondays returns,  $n_{Mon}$  – the observation numbers of Monday returns,  $n_{NonMon}$  – the observation numbers of Non-Monday returns.

The mean return from open to close for the whole period is negative (−0.0348). At the same time, the mean return from close to open is positive (0.0154), which is the result of the positive overnight return. The highest mean return from close to close was observed on Mondays. It was positive (on the level of 0.1056) and significantly higher than on other days of the week, which confirms earlier findings of the research conducted on the Polish market. At the same time, the highest frequency of occurrence of positive close to close returns was observed on Mondays. In the

**Table 1.** Summary statistics of the close-to-close returns

From close to close	Min	Max	Mean	Median	Std. dev.	% posit.*	% neg.	Skewness	Kurtosis
Entire sample	−8.2461	6.5763	0.0154	0.0000	1.2632	51.86	48.14	−0.3563	4.2741
Monday	−6.4165	6.3599	<b>0.1056</b>	0.0787	1.3040	54.55	45.45	−0.1761	2.5941
Tuesday	−4.4793	5.6670	0.0355	0.0809	1.1860	54.39	45.61	0.1049	2.0047
Wednesday	−7.9392	4.7104	−0.0314	0.0000	1.2529	50.88	49.12	−0.3821	4.7230
Thursday	−8.2461	6.5763	<b>−0.0599</b>	−0.0748	1.4420	47.89	52.11	−0.8031	6.0955
Friday	−4.7939	4.2193	0.0296	0.0000	1.1009	51.63	48.37	−0.0923	2.1709

Note: \*Positive values include zero value.

Source: Author's own study.

**Table 2.** Summary statistics of the open-to-close returns

From open to close	Min	Max	Mean	Median	Std. dev.	% posit.*	% neg.	Skewness	Kurtosis
Entire sample	-9.4456	5.8108	-0.0348	-0.0409	1.1356	49.17	50.83	-0.4764	4.8960
Monday	-6.3379	4.7590	<b>0.0224</b>	-0.0350	1.0911	49.87	50.13	-0.2731	3.0004
Tuesday	-4.7551	5.1109	0.0180	0.0416	1.0572	53.08	46.92	0.0218	2.4331
Wednesday	-9.4456	5.8108	-0.0574	-0.0790	1.1987	47.78	52.22	-0.9032	9.8028
Thursday	-6.1578	4.1921	<b>-0.1593</b>	-0.1224	1.2712	45.45	54.55	-0.7018	3.3122
Friday	-4.6236	4.4512	0.0017	-0.0360	1.0309	49.66	50.34	0.0430	2.6549

Note: \*Positive values include zero value.

Source: Author's own study.

**Table 3.** Summary statistics of the close-to-open returns

From close to open	Min	Max	Mean	Median	Std. dev.	% posit.*	% neg.	Skewness	Kurtosis
Entire sample	-3.1554	3.2061	0.0465	0.0434	0.5697	59.82	40.18	-0.3348	4.4311
Monday	-2.8283	2.0362	<b>0.0176</b>	0.0360	0.5184	58.11	41.89	-0.4543	3.6214
Tuesday	-2.3393	2.4169	0.0260	0.0408	0.5132	57.49	42.51	-0.2038	2.9984
Wednesday	-3.1191	2.9622	<b>0.0998</b>	0.0855	0.5652	62.77	37.23	0.2570	5.0678
Thursday	-3.1554	1.8745	0.0279	0.0460	0.5465	61.17	38.83	-1.0858	0.0000
Friday	-3.1416	3.2061	0.0624	0.0822	0.6880	59.63	40.37	-0.3265	3.3253

Note: \*Positive values include zero value.

Source: Author's own study.

case of open to close returns, the highest mean return was observed on Mondays, importantly enough it was on a much lower level (0.0224). Apart from Mondays, positive day returns were observed on Tuesdays and Fridays.

The mean returns from open to close for particular days of the week were relatively low in comparison with the returns from close to close, which means that most of the profit was generated during night-time, that is from closing to opening of another session. In the whole analysed period, the mean overnight returns were positive for each day of the week (the highest ones on Wednesday night) with nearly a half lower volatility in relation to day returns. As a result, the occurrence of investment risk premium can be confirmed during a non-trading period.

Overnight returns could be characterized by a significantly lower standard deviation than day returns. The highest volatility of returns from close to close was observed on Thursdays, mainly as a result of high day volatility, and on Mondays, which was the

effect of increased overnight volatility between Friday and Monday. High volatility on Mondays was already observed in earlier studies of the Polish market.

The research proved no correlation between the mean day returns and mean overnight returns for any day of the week separately or all days of the week put together, and between day returns: from open to close and minimum to maximum. No correlation was also found between the level of mean returns and their volatility (with the exception of returns from minimum to maximum, whose correlation with volatility was 0.5458) and between volatility of returns and the trading volume.

The analysed distributions of day returns proved to be stationary with a distribution significantly different than normal (on the 5% level of significance). It is also confirmed by the skewness and kurtosis values. The distributions of returns were left-skewed, mostly for Wednesday and Thursday returns from open to close and from close to close. In turn, Tuesday and Friday distributions of returns from open to close and from close to close were almost symmetrical. In the analysed period, skewness and kurtosis of day returns were higher than for overnight returns.

**Table 4.** Summary statistics of the open-to-close returns for bullish market, bearish market and horizontal market

From open to close		Min	Max	Mean	Median	Std. dev.	Skewness	Kurtosis
Entire sample	period 1	-6.3379	5.8108	-0.0115	-0.0386	1.2164	-0.0493	2.3889
	period 2	-9.4456	5.1523	-0.1135	-0.0882	1.4685	-0.9011	5.4280
	period 3	-5.3852	3.5553	-0.0204	0.0000	0.9340	-0.2510	2.8127
Monday	period 1	-6.3379	4.7590	<b>0.1836</b>	0.1550	1.1177	-0.8211	6.5227
	period 2	-2.9867	4.3475	-0.0367	-0.0697	1.4094	0.1688	-0.0314
	period 3	-5.1460	2.8827	-0.0484	-0.0814	0.9266	-0.2949	2.5970
Tuesday	period 1	-4.7551	5.1109	-0.0127	0.0678	1.3289	0.0256	2.2284
	period 2	-3.1682	2.9317	-0.0064	-0.0214	1.0347	-0.0257	0.8259
	period 3	-2.8220	3.1047	<b>0.0447</b>	0.0417	0.8652	0.1362	0.6458
Wednesday	period 1	-3.2899	5.8108	0.0717	0.0000	1.1767	0.3827	1.6190
	period 2	-9.4456	5.1523	-0.1955	-0.2979	1.8164	-1.4416	7.7533
	period 3	-2.6737	2.4693	-0.0827	-0.0422	0.8765	-0.0204	0.5276
Thursday	period 1	-4.6281	4.0750	<b>-0.2524</b>	-0.3361	1.2842	0.2201	1.1605
	period 2	-6.1578	4.1921	-0.2828	-0.1569	1.6868	-0.8612	2.1819
	period 3	-5.3852	3.4515	-0.0619	0.0000	1.0662	-1.0471	4.9121
Friday	period 1	-4.4938	4.4512	-0.0521	-0.0180	1.1076	-0.1680	2.3523
	period 2	-4.6236	3.4938	-0.0385	-0.0400	1.2014	-0.2605	2.9157
	period 3	-3.0325	3.5553	<b>0.0449</b>	-0.0389	0.9157	0.5569	1.8059

Note: Period 1 – bullish market, period 2 bearish market, period 3 horizontal market.

Source: Author's own study.

**Table 5.** Summary statistics of the min-to-max returns

From min to max	Min	Max	Mean	Median	Std. dev.	% posit.	% neg.	Skewness	Kurtosis
Entire sample	0.00	10.4275	1.4026	1.1924	0.9129	100.00	0.00	2.5967	12.8379
Monday	0.00	6.3379	<b>1.3349</b>	1.1566	0.8246	100.00	0.00	1.8872	6.3527
Tuesday	0.00	7.1079	<b>1.3562</b>	1.2003	0.8127	100.00	0.00	2.1285	8.2668
Wednesday	0.00	10.4275	1.4264	1.2346	0.9257	100.00	0.00	3.5150	24.4010
Thursday	0.00	8.8425	<b>1.5230</b>	1.2645	1.0831	100.00	0.00	2.6776	11.0888
Friday	0.00	6.6782	1.3730	1.1401	0.8811	100.00	0.00	1.9066	5.1242

Source: Author's own study.

Descriptive statistics of day returns for particular sub-periods were presented in Table 4. They confirm the existence of the highest day returns on Mondays, but only for a bull market. In the period between 25 May 2012 and 30 June 2015 Tuesday and Friday returns were positive.

The analysis of fixing of day returns from min to max (Table 5) proves that the volatility of prices from min to max was the highest on Thursdays with, simultaneously, the highest volatility of these returns in comparison with other days of the week.

#### 4. Conclusions

Empirical studies of the WIG20 futures market on the Warsaw Stock Exchange confirmed the occurrence of the Monday effect on the Polish market. In the analysed period, the mean returns were significantly positive and higher than on other days of the week. It is one of the characteristic features confirmed by many other studies.

High Monday returns can be explained by the fact that important macroeconomic information from around the world and listed company disclosures are published between Friday closing and Monday opening. That is why investors can react to the news no sooner than on Monday. This is also the reason of high volatility of Monday returns. What is more, unprofessional investors (mainly individual ones) can make a more careful analysis then, which results in their increased activity during Monday sessions. High returns on Mondays are also the effect of a long non-trading period. These returns are, in fact, three-day returns since they result from the freezing of funds for the weekend.

The current analysis also reveals that, in the whole analysed period, the mean overnight returns are positive, no matter which day of the week it is, with nearly a half lower volatility in comparison with day returns. The highest volatility of analysed returns is observed on Thursdays. It seems to be difficult, though, to point to the reason of this pattern, even though it was also observed on other markets (e.g. in Great Britain) [Berument, Kiyamaz 2003].



It must be remembered that taking advantage of presented anomalies is impossible in practice, mainly because of high transaction costs. Additionally, what must be taken into account is that the disclosure of such patterns leads to shifting them to other periods.

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