THE DISTRIBUTION OF DAILY RETURNS ON MAIN STOCK MARKET INDEXES IN CENTRAL AND EAST EUROPE

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Abstract: *This study examined the distribution of daily returns on the main stock market indices of Central and Eastern Europe in the period from 31 December 2008 to 31 December 2018. The main goal was to determine whether the stock market indices in the region followed normal distributions A Shapiro-Wilk test proved the indices did not have normally distributed daily returns. Moreover, 9 of the 15 indices achieved negative skewness in the given period. The three indices with skewness values closest to zero were MOEX, HEX and WIG20, and of the 15 indices, each index had a high positive kurtosis. This indicated that all 15 indices were leptokurtic, and they had higher peaks around the mean value and had fatter-tailed distributions than the normal distribution. The three indices with the lowest kurtosis values were UX100, WIG20 and HEX.*

The second goal was to determine whether calendar market anomalies (day of the week and day of the month effects) existed in these market indices. It was found that 12 of the 15 indices had the lowest daily returns, during the first two days of the week (Monday and Tuesday). Day of the week effects were not observed for the indices MOEX, UX100 and WIG20; thus, the three indices were efficient. Following this research, day of the month effects were examined. For 13 of the 15 indices, superior results were observed at the beginnings and ends of months.

Finally, the third goal was to determine the most developed markets in Central and Eastern Europe. Next, this study examined the distributions of the daily returns during the week. Overall, after an analysis of the Shapiro-Wilk, skewness, kurtosis, day of the week effect and day of the month effect data, it was concluded that the most efficient indices were WIG20, MOEX, UX100 and HEX.

Key words: *investing, daily returns, market indexes*

JEL codes: *E22, O52, G11, C10, G14*

1. Introduction

Many financial methods and models are based on the assumption that daily returns on stocks are normally distributed. The normal distribution of returns is an important concept of the efficient market hypothesis (EMH), created by Fama (1970). Fama classifies forms of market efficiency into three groups: weak, semi-strong and strong. In the strong form, the EMH states that stock returns are serially uncorrelated and have a constant mean.

The assumption that daily returns on stocks are normally distributed indicates that financial markets are efficient and investors are unable to achieve abnormal returns. However, empirical evidence shows that this is not true. It has been observed that most financial time series are leptokurtic (Mandelbrot, 1963), which means they are characterised by higher concentrations of probability mass in their centres and in their tails of distribution than Gaussian distributions (Alfarano et al., 2015). Fama (1965) conducted the first extensive study of financial asset returns in the context of stable distribution. He concluded that Gaussian or normal distributions are not adequate representations of stock price changes.

Thus, this study aimed to examine the distributions of daily returns on the main stock market indices of Central and Eastern Europe. The main goal was to determine whether the stock market indices in the region followed normal distributions. However, there were also three other goals. The first was to analyse the skewness and kurtosis of each daily return distribution for the selected indices. The second was to determine whether calendar market anomalies (day of the week and day of the month effects) existed in these market indices. Finally, the third was to determine the most developed markets in Central and Eastern Europe.

The second concerns the day of the week effect, a calendar anomaly that has been observed in many stock markets all over the world. It has been extensively studied in recent decades, with a special focus on equity markets. French (1980) conducted research on the New York Stock Exchange and noticed substantial differences in stock returns on different days of the week. The daily returns were significantly higher on Fridays than on the other weekdays, and returns on Mondays were significantly lower than any other day (this is called the Monday effect). Gibbon and Hess (1981) confirmed these findings and found that Monday's stock returns are, on average, significantly negative. The authors proposed several explanations for this phenomenon but did not find empirical evidence in support of any of their hypotheses. Harris (1986) argued that Monday's negative stock returns could be explained by the first 45 minutes of the day's trading session, when stocks fall the most rapidly. In contrast, Smirlock and Starkas (1986) concluded that the Monday effect is caused by a fall between the end of each Friday session and the beginning of each Monday session.

Lakonishok and Smidt (1988) analysed the daily returns of the Dow Jones Industrial Average Index between 1897 and 1986, and confirmed the presence of the day of the week effect in the index behaviour. Jeffrey, Westerfield and Ma (1989) found that the Monday effect strongly correlates with the Friday effect, and Bagnoli, Clement and Watts (2004) noticed that investors are less active on Fridays; the latter concluded that investors are likely to be influenced by the weekend. Moreover, it was found that the day of the week anomaly tends to revert; the effect sometimes becomes negative on Friday and positive on Monday (Brusa et al., 2000).

The third goal stated above concerns the distributions of daily returns in a month. Some of the first research concerning such distributions was conducted by Ariel (1987). He divided a month into two equal parts and noted that average returns were much higher in the first part of the month than in the last. Later, Lakonishok and Smidt (1988) noticed statistically significant high returns at the ends and beginnings of months. This research was confirmed by Cadsby and Ratner (1992). They found that the effect of higher returns at the beginnings and ends of months could be observed in Canada, the United Kingdom, Australia, Switzerland and Germany. The effect was also observed by Aziz and Ansari (2018) in 11 out of 12 Asian countries. As aforementioned, the EMH suggests that in an efficient market, it is not possible to achieve abnormal returns, and returns are normally distributed. However, the existence of market anomalies, such as the day of the week and the day of the month effects, shows that markets are inefficient.

This section reviewed extant literature. In the following section, the methodology used for this study is presented. Section three focuses on the normality of the distributions of the daily returns on the selected indices. The fourth and fifth sections examine market anomalies, the day of the week effect, and the day of the month effect, respectively. Finally, in the sixth section, the main conclusions of this study are presented.

2. Methodology and Data

The research examines daily returns on selected stock market indexes in Central and East Europe. The selected indexes are described below. All of these indexes were adjusted for dividend so that dividends were added back to the value of the index. The time frame of the research is a period between December, 31 2008 and December, 31 2018.

The selected indexes are:

Athex Composite - the main stock market index from Greece. It was launched on 31 December 1980 and has 60 constituents.

BET - the main stock market index from Romania. It was launched on 31 October 2000 and has 10 constituents.

BUX – the main stock market index from Hungary. It was launched on 2 January 1991 and has 25 constituents.

HEX - the main stock market index from Finland. It was launched on 2 January 1995 and has 25 constituents.

OMX Riga - the main stock market index from Latvia. Base date of the index is December 31, 1999. OMX Riga has 18 constituents.

OMX St.30 - the main stock market index from Sweden. Base date of the index is September 30, 1986. OMX Stockholm 30 has 30 constituents.

OMX Tallinn - the main stock market index from Estonia. Base date of the index is January 3, 2000. OMX Tallinn has 16 constituencies.

OMX Vilnius - the main stock market index from Lithuania. Base date of the index is January 3, 2000. OMX Tallinn has 20 constituencies.

PX - the main stock market index from Czech Republic. Base date of the index is 5 April 1994. PX has 50 constituents.

MOEX - the main stock market index from Russia. Base date of the index is 22 September 1997. MOEX has 50 constituents.

SAX - the main stock market index from Slovakia. The index was developed on September 14, 1993. The SAX index formula is flexible and allows for participation of various companies in the index, as well as changes in the number of companies, proportional to changes in their tradeability, or in the case of a new company entering the capital market.

SOFIX - the main stock market index from Bulgaria. Base date of the index is October 20, 2000. The index has 15 constituents.

UX - the main stock market index from Ukraine. Base date of the index is March 26th, 2009. The index has 15 constituencies. The index has 6 constituents.

UX100 - the main stock market index from Turkey. Borsa Istanbul 100 Index base date is January 1986. The index has 100 constituents.

WIG20 - the main stock market index from Poland. Base date of the index is 16 April 1994. The index has 20 constituents.

The shape of a distribution bell can be examined using skewness and kurtosis, while the normal distributions of daily returns can be tested using a Shapiro-Wilk test. Skewness is a measure of the asymmetry of a probability distribution of a real valued random variable in regards to its mean. A skewness value can be positive, negative or undefined. It can be calculated using a coefficient of skewness (Pearson, 1895):

$$Skewness = \frac{\frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^3}{S^3(x)}$$

Where,

$\bar{x} -$ is the mean

$S -$ is the standard deviation

$n -$ is the number of data points

Kurtosis is a measure of the probability distribution of a random variable; specifically, it examines the tail of the distribution. It can be calculated as follows (Kenney & Keeping, 1951):

$$\text{Kurtosis} = \frac{\frac{1}{n}\sum_{i=1}^{N}(x_i - \bar{x})^4}{S^4(x)} - 3$$

where,

$\bar{x} -$ is the mean

$S -$ is the standard deviation

$n -$ is the number of data points

The distribution is tested using a Shapiro-Wilk test as follows (Shapiro & Wilk, 1965):

$$W = \frac{\left(\sum_{i=1}^{n} a_i x_{(i)}\right)^2}{\sum_{i=1}^{n}(x_i - \bar{x})^2}$$

where,

$x_{(i)}$ is the ith order statistic, i.e., the ith − smallest number in the sample;

$\bar{x} -$ is the mean

$a -$ the coefficients is calculated

$$(a_1, \ldots, a_n) = \frac{m^T V^{-1}}{C}$$

where C is a vector norm:

$$C = \|V^{-1}m\| = (m^T V^{-1} V^{-1} m)^{1/2}$$

and the vector m is as follows:

$$m = (m_1, \dots, m_n)^T$$

H0: The variable from which the sample was extracted follows a normal distribution.

Ha: The variable from which the sample was extracted does not follow a normal distribution.

These two hypothesis are tested using significance level alpha=0.01

3. Normal distribution testing

Table 1 below presents arithmetic average daily returns, standard deviations, skewness, kurtosis and Shapiro-Wilk tests for the selected 15 indexes.

Tab. 3 Normality of the distribution of daily returns on selected stock market indexes.

Index (Country)		Arithmetic Average	Standard Deviation	Skewness	Kurtosis	Shapiro-Wilk	Null Hypothesis
Athex Comp	Greece	-0.0206%	2.1300%	-0.0817	5.0762	0.9536	Rejected
BET	Romania	0.0445%	1.3017%	-0.5017	13.3556	0.8430	Rejected
BUX	Hungary	0.0564%	1.3972%	0.2249	3.9656	0.9624	Rejected
HEX	Finland	0.0256%	1.2595%	-0.0652	3.1270	0.9662	Rejected
OMX Riga	Latvia	0.0570%	1.2176%	1.1347	12.5534	0.8832	Rejected
OMX St.30	Sweden	0.0360%	1.2443%	-0.1515	3.2525	0.9642	Rejected
OMX Tallinn	Estonia	0.0610%	0.9897%	1.1412	17.0054	0.8641	Rejected
OMX Vilnius	Lithuania	0.0534%	0.9019%	0.4777	30.3991	0.7699	Rejected
PX	Czech Rep	0.0115%	1.1420%	-0.0844	4.6517	0.9447	Rejected
MOEX	Russia	0.0653%	1.5301%	-0.0602	6.2004	0.9280	Rejected
SAX	Slovakia	0.0039%	1.2078%	-0.7794	19.9933	0.8198	Rejected
SOFIX	Bulgaria	0.0249%	0.9541%	0.4673	6.9045	0.9112	Rejected
UX	Ukraine	0.0517%	1.9426%	0.2841	9.8035	0.8930	Rejected
UX100	Turkey	0.0592%	1.4570%	-0.3124	2.9164	0.9734	Rejected
WIG20	Poland	0.0182%	1.3096%	-0.0787	2.9870	0.9688	Rejected

Source: own calculation based on Bloomberg

The highest average daily returns that were achieved in the given period were by the indices MOEX (0.0610%), OMX Tallinn (0.061%) and UX100 (0.0592%). The lowest daily results were for Athex Composite (-0.0206%), SAX (0.0039%) and PX (0.0115%). However, these results are expressed in local currencies; thus, they are incomparable. Moreover, the results did not take differences in inflation levels into account.

The highest standard deviations were for Athex Comp (2.1300%), UX (1.9426%) and MOEX (1.5301%). These indices achieved the highest risk measures due to specific events. That is, Greece’s economy experienced a financial crisis, and Russia and the Ukraine’s stock exchanges experienced political pressure. In contrast, the lowest standard deviations were for

OMX Vilnius (0.9019%), SOFIX (0.9541%) and OMX Tallinn (0.9897%). These indices achieved the lowest standard deviations as they were infrequently traded in (OMX Vilnius and OMX Tallinn).

A majority of the indices in the given period, that is, 9 of the 15 indices, achieved negative skewnesses. A negative skewness means that the tail of the left side of a distribution is longer, or fatter, than the tail on the right side. The means and medians of the negatively skewed daily returns of the nine indices were less than the modes of the indices. The indices with the lowest skewnesses were MOEX (-0.0602), HEX (-0.0652) and WIG20 (-0.0787). In contrast, the indices with the highest skewnesses were OMX Tallinn (1.1412), OMX Riga (1.1347) and SAX (-0.7794).

All the indices had high positive kurtosises. This indicated that all the indices were leptokurtic, had higher peaks around their mean values and had fatter tails than normal distributions. The highest kurtosises were achieved by OMX Vilnius (30.3991), SAX (19.9933) and OMX Tallinn (17.0054). The lowest kurtosises were achieved by UX100 (2.9164), WIG20 (2.9870) and HEX (3.1270).

Analyses of Shapiro-Wilk tests allowed for the rejection of null hypotheses in favour of an alternative hypothesis. The conclusion was that the daily returns on the stock market indices of Central and Eastern Europe did not follow normal distributions. The closest to normal distributions were for the indices UX100 (0.9734), WIG20 (0.9734) and HEX (0.9662). Overall, it was concluded that the indices WIG20 and HEX had the daily return distribution closest to normal distributions. This could indicate that the Polish and Finnish markets are the most efficient.

4. The day of the week effect

Table 2 presents the average daily returns on the stock market indices by weekday. Bolded values indicate a statistical significance with a p of less than 0.10. The framed values for each index show the lowest average daily returns on weekdays. For example, the index Athex Composite (from Greece) achieved a -0.2610% average daily return on Mondays. The value is framed, which means that it was the lowest average daily return on Mondays. Moreover, the value is bolded; thus, it is statistically significant with a p of less than 0.10.

Tab. 2 The average daily returns on selected stock market indexes in weekdays

Index (Country)		Mondays	Tuesdays	Wednesdays	Thursdays	Fridays
Athex Comp	Greece	**-0.2610%**	-0.0348%	0.0545%	0.0277%	0.0979%
BET	Romania	-0.0524%	-0.0360%	0.0337%	0.1866%	0.0867%
BUX	Hungary	0.1543%	-0.0276%	0.0943%	0.0544%	0.0101%
HEX	Finland	-0.0112%	0.0105%	**0.0985%**	0.0130%	0.0155%
OMX Riga	Latvia	-0.0717%	0.0054%	0.1685%	0.0741%	0.1040%
OMX St.30	Sweden	-0.0093%	0.0269%	0.0722%	0.0201%	0.0702%
OMX Tallinn	Estonia	0.0045%	-0.0263%	0.1391%	0.0635%	0.1245%
OMX Vilnius	Lithuania	0.0261%	0.0014%	0.0939%	0.0551%	0.0908%
PX	Czech Rep	0.0175%	-0.0732%	0.0771%	0.0594%	-0.0238%
MOEX	Russia	0.0915%	0.0861%	0.0890%	0.0246%	0.0354%
SAX	Slovakia	-0.0314%	-0.0330%	0.0376%	-0.0019%	0.0474%
SOFIX	Bulgaria	-0.0695%	-0.0289%	0.0498%	0.0640%	0.1071%
UX	Ukraine	0.0705%	0.0147%	0.0377%	0.0290%	**0.1096%**
UX100	Turkey	**0.1413%**	0.0395%	0.0573%	0.0474%	0.0104%
WIG20	Poland	0.1132%	0.0028%	0.0541%	-0.0012%	-0.0784%

*Bold font indicates statistical significance p < 0.10

** Framed red numbers indicate maximum values

Source: own calculation based on Bloomberg

For 6 out of 15 countries, the main indices achieved their weakest results on Mondays. However, for Greece (Athex Composite), the results were statistically significant. Thus, the Monday effect existed only in Greece. Moreover, for 12 out of 15 countries, the lowest daily returns were observed on the first two days of the week.

The reason for the first part of the week being weaker for these indices is a delay in the analysis of bad information. In the most efficient markets, the day of the week effect is not observed. In less efficient markets, the Monday effect is observed. However, it is possible that in very inefficient markets, the effect can be observed on the first two days of the week. The Monday effect is caused by the publication of bad information after each Friday session. During the weekend, markets analyse the bad information, which is then reflected in stock prices on the following Monday session. However, in very inefficient markets, this information is not analysed on the weekend, but on Monday. Thus, the bad information is reflected in stock prices on Tuesday. Therefore, one can conclude that the Russian (MOEX), Turkish (UX100) and Polish (WIG20) markets are efficient. It should be noted that these markets are the biggest markets in Central and Eastern Europe, so a correlation between capitalisation and information efficiency may exist.

5. The day of the month effect

Table 3 shows the average daily returns on the stock market indices by the parts of months. The months were divided into six parts: day 1–5, day 6–10, day 11–15, day 16–20, day 21–25 and day 26–31. As months differ in length, the last group varied significantly by three days (in February) and six days (in January, March, May, July, August, October and December).

Tab. 3 The average daily returns on selected stock market indexes in different parts of a month

Index (Country)		1-5	6-10	11-15	16-20	21-25	26-31
Athex Comp	Greece	-0.0366%	0.0191%	-0.0838%	0.0273%	-0.0546%	**0.0993%**
BET	Romania	0.1011%	0.0789%	0.0079%	0.0493%	**-0.0304%**	0.0831%
BUX	Hungary	0.1250%	0.0789%	0.0627%	-0.0135%	-0.0280%	0.1345%
HEX	Finland	0.0386%	0.0896%	-0.0136%	0.0601%	-0.0159%	0.0026%
OMX Riga	Latvia	0.0640%	0.0816%	0.0397%	**0.1984%**	-0.0519%	0.0676%
OMX St.30	Sweden	-0.0505%	0.0623%	0.0310%	0.0555%	0.0506%	0.0774%
OMX Tallinn	Estonia	**0.0966%**	0.0786%	0.0827%	0.0423%	0.0496%	0.0393%
OMX Vilnius	Lithuania	0.0242%	0.0555%	0.0542%	0.0182%	0.0480%	**0.1090%**
PX	Czech R.	0.0093%	0.0276%	0.0162%	-0.0472%	0.0023%	**0.0885%**
MOEX	Russia	0.1652%	0.1269%	0.0203%	-0.0249%	-0.0489%	0.1573%
SAX	Slovakia	0.0625%	-0.0732%	0.0021%	0.0142%	-0.0847%	0.0746%
SOFIX	Bulgaria	-0.0104%	0.1016%	-0.0093%	-0.0799%	0.0859%	0.1263%
UX	Ukraine	0.0210%	0.0461%	0.0537%	-0.0704%	-0.0263%	**0.3054%**
UX100	Turkey	0.0514%	-0.0423%	0.0712%	0.0820%	-0.0153%	0.1319%
WIG20	Poland	0.0323%	0.0227%	0.0356%	**-0.0553%**	0.0460%	0.0536%

*Bold font indicates statistical significance p < 0.10

** Framed green numbers indicate maximum values

Source: own calculation based on Bloomberg

The bolded values in the table indicate a statistical significance with a p of less than 0.10. The framed values for each index show the highest average daily returns in given parts of the months. For example, Athex Composite achieved the highest daily returns in the last parts of the months (days 26–31); thus, the number 0.0993% is framed. Moreover, the return for the period was statistically significant with a p of less than 0.10, so the number is bolded. The table shows that 10 out of 15 indices achieved the highest average daily returns in the last parts of the months. The abnormal returns in the last parts of the months can be explained by the activities of portfolio managers of investment funds. The managers are under constant pressure from investors to perform well. The managers usually report to their clients (investors), on monthly, quarterly or yearly bases. Thus, the managers buy illiquid companies in order to artificially increase the values of assets. The distortion of market prices results in the growth of stock market indices.

A second explanation for the abnormal returns in the last parts of the months is inflows of money. Many employees in Central and Eastern Europe received their salaries on a monthly basis. At the end of each month, they received their salaries, and part of the money went to their investment accounts, e.g., some employees contributed to pension funds or saved money for other occasions. Increased inflows of money on stock exchanges boosted demand for stocks. The demand caused the growth of stock prices, and consequently raised the value of each stock market index. However, in other countries, employees received their salaries at the beginning of each month, so the highest results were observed in the first parts of the months.

Meanwhile, the highest average daily returns in the middle parts of the months may signal that a stock market is efficient. Overall, 13 out of 15 stock market indices achieved superior results at the beginnings or ends of the months. Only HEX and OMX Riga achieved the highest average daily returns in the middle parts of the months. Thus, one could hypothesise that these two indices were efficient.

6. Conclusions

This study focused on the distributions of daily returns on the main stock market indices of Central and Eastern Europe. The normality of each daily return distribution was examined, and Shapiro-Wilk tests proved that all the examined indices were not normally distributed. Moreover, 9 of the 15 indices achieved negative skewnesses in the given period. The indices with the lowest skewnesses were MOEX, HEX and WIG20. Moreover, all the indices had high positive kurtosises. This indicated that all the indices were leptokurtic and had higher peaks in regards to the mean value and fatter tails than normal distributions. The indexes with the lowest kurtosises were UX100, WIG20 and HEX.

The study then examined the distributions of the daily returns by week and by month. In 12 out of 15 countries, the lowest daily returns were observed on the first two days of the week (Monday and Tuesday); thus, the day of the week effect was observed for most of the indices. However, the day of the week effect was not observed for MOEX, UX100 and WIG20. Thus, the indices were efficient. Moreover, overall, 13 out of the 15 stock market indices achieved superior results at the beginnings or ends of the months. HEX and OMX Riga achieved the highest average daily returns in the middle parts of the months. These indices were the most efficient ones as market anomalies were not observed in them.

Overall, after analyses of Shapiro-Wilk tests, skewnesses, kurtosises, day of the week effects and day of the month effects, one could conclude that the most efficient indices were WIG20, MOEX, UX100 and HEX. It should be noted that among these indices, the most efficient one was WIG20. Recently, the Polish market has been classified as developed by FTSE Russell (www1). This research confirmed that the polish market has the highest information efficiency among the main Central and Eastern European markets. This high information efficiency correlates with the level of development of the market. As a result, the change in status from developing market to developed market might be correct. However, more research is needed to confirm this.

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