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THE INFLUENCE OF MOON PHASES ON RATES OF RETURN OF THE WARSAW STOCK EXCHANGE INDICES¹

(Summary)

The influence of the moon on human behavior has been featured in many, not only scientific publications. This paper tests the hypothesis that the one-session rates of return of index WIG20 (Warsaw Stock Exchange) in the period of 14.04.1994–30.06.2015, mWIG40 in the period 31.12.1997–30.06.2015 and sWIG80 in the period of 29.12.1994–30.06.2015, calculated for each of the following phases: full moon, new moon, first and third quarter, are statistically higher than zero (at the significance level of 95%) for WIG20 and sWIG20 when the moon was in the new phase and also for sWIG80 when the moon was in the full phase. In the second, third and the fourth part were tested null hypothesis regarding equality of one session average rates of return in two populations, for analyzed moon phases and when the moon phases falls on a specified day of the week or in the specified months.

In case of testing equality of average rates of return in two populations, the outcomes proved that the moon phases are irrelevant for one session average rates of return in two analyzed populations, but in case regarding equality of one-session average rates of return, computed for each day of the week, the result permit to reject the null hypothesis for full moon falling on Fridays (sWIG80) and for 1st quarter falling on Tuesdays (WIG20 and mWIG40). The average rates of return of the Fridays session for sWIG80 (full moon) resulted to be statistically higher than zero, while for Tuesday sessions calculated for WIG20 and mWIG40 (1st quarter) – negative.

Calculations of one-session average rates of return, regarding moon phases falling in a specified month, displayed that they are statistically higher than zero for: mWIG40 in March (full moon), WIG20 in June and mWIG40 in July (for indices both – moon in the first quarter phase) and lower than zero for: WIG20 and mWIG40 for full moon sessions in June, mWIG40 in July (new moon),

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¹ Artykuł opublikowany w ramach projektu „Popularyzacja najnowszej wiedzy ekonomicznej wśród ludzi młodych” realizowanego z Narodowym Bankiem Polskim w ramach programu edukacji ekonomicznej.

WIG20 for November and sWIG80 for October sessions (for both indices – moon in the first quarter phase). Thus, the influence of moon phases on investors operating on the Warsaw Stock Exchange has been proved.

Keywords: market efficiency; calendar effects; market anomalies; moon influence

1. Introduction

In the scientific literature, there has been widespread conviction that moon cycles affect human behavior and it is commonly believed that the abnormal human behavior peaks around the full moon. The moon cycle has been considered as an important factor in many human activities, e.g. religious ceremonies². Huston and Passerello, examining the implication of certain moon phases on human behavior, proved that human beings exhibit more depressive behavior during the full moon³. According to Barr, moon phases influence quality of human life⁴. In line with academic research, moon phases also affect economic behavior of people and investors' financial decisions⁵. In line with contemporary surveys "... a large part of the population, about 50%, believes that strange behavior peaks around the full moon"⁶ and one may use "... stock prices as a powerful aggregators of regular and recurring human behavior"⁷. The daily stock index data analyzed over decades and in many countries "... allows researchers to examine lunar cycle hypothesis on countless decisions of hundreds of millions of individuals"⁸. In the scientific

² **I. Dichev, T. Janes**, *Lunar cycle effects in stock returns*, Journal of Private Equity 2003/6, pp. 8–29.

³ **R. Houston, C. Passarelo**, *On the dynamics of a human body model*, Journal of Biomechanics 1971/9, pp. 369–378.

⁴ **W. Barr**, *Lunar revisited: the influence of the moon on the mental health and quality of life*, Journal Psychosocial Nurse Mental Health Science 2000/38, pp. 28–35.

⁵ **A. Lo, D. Repin**, *The psychophysiology of real time financial risk procession*, Sloan Working Paper 4223.01, MIT Sloan School of Management 2001; **G. Loewenstein**, *Emotion in economic theory and economic behavior*, American Economic Reviews 2000/90, pp. 426–432 and **I. Dichev, T. Janes**, *Lunar cycle effects in stock returns*, Journal of Private Equity 2003/6, pp. 8–29.

⁶ **I. Kelly, J. Rotten, R. Culver**, *The moon was full and nothing happened: A review of studies on the moon and human behavior and human belief*, in: **J. Nickel, B. Karr, T. Genoni** (ed.), *The outer edge*, Committee for the Scientific Investigation of Claims of the Paranormal (CSICOP), Amherst 1996, NY.

⁷ **I. Dichev, T. Janes**, *Lunar cycle effects in stock returns*, Journal of Private Equity 2003/6, pp. 8–29.

⁸ *Ibidem*, pp. 8–29.

literature a statement can be found that the behavioral biases can impact investors decisions, thereby may influence stock and indices rates of return⁹. Rates of return computed for full and new moon session, statistically different from zero could not be explained by announcements of macroeconomics factors or major global shocks¹⁰.

The main purpose of this paper is to analyze the influence of four moon phases on rates of return on the Warsaw Stock Exchange by means of three indices: WIG20, mWIG40 and sWIG80. The second research question of this paper is to verify the null hypothesis that the difference of one-session average rate of return calculated for the session, which falls during particular phase of the moon (full, new, 1st and 3rd quarter), and the one-session average rate of return, calculated for all sessions, which does not fall during particular moon phase, equals to zero. Tests for equality of two one-session average rates of return will be also applied whilst considering specified moon phase (full, new moon, 1st and 3rd quarter) falls on a specified day of the week and in the specified month of the year.

This is one of the first papers regarding moon influence on rates of return on the Polish financial market¹¹. This study pertains the efficiency of the capital market in Poland, and its results can be beneficial to build investment strategies by different groups of investors.

Dichev and Janes analyzed rates of return during 15 days round new and full moons for 24 major stock indices in the period of 30 years¹². They proved that the rate of return calculated for full moons was two times higher than the rate of return for new moons. In turn, Yuan et al. calculated relationship between lunar phases and stock market returns for 48 stock indices. According to these authors average rates of return calculated for full moon sessions were lower than average rates of return for new moon sessions¹³.

The return difference was around 3% to 5% between new moon and full moon and was not due to changes in stock market volatility or trading volumes.

⁹ **D. Hirshleifer**, *Investor psychology and asset pricing*, Journal of Finance 2001/56, pp. 1533–1597 and **D. Kahneman, M. Riepe**, *Aspects of investor psychology: beliefs, preferences and biases investments advisors should know about*, Journal of Portfolio Management 1998/24, pp. 52–65.

¹⁰ **L. Zacks**, *The handbook of equity markets anomalies*, Wiley & Sons, Hoboken 2011.

¹¹ **K. Borowski**, *Moon phases and rates of return of WIG index on the Warsaw Stock Exchange*, International Journal of Economics and Finance 2015/7, pp. 256–264.

¹² **I. Dichev, T. Janes**, *Lunar cycle effects in stock returns*, Journal of Private Equity 2003/6, pp. 8–29.

¹³ **K. Yuan, L. Zheng, Q. Zhu**, *Are investors moonstruck? Lunar phases and stock returns*, Journal of Empirical Finance 2006/13, pp. 1–23.

Brahman et al.¹⁴, basing their research on empirical study on seven stock markets in the period from January 1999 to December 2009, failed to reject the null hypothesis in regression analysis, however in some parts they confirmed previous conclusions of Yuan et al.¹⁵.

Gao analyzing the relationship between moon cycle and market returns for two major stock markets of China during the period of 16 years, came to the conclusion that near new moon and full moon, stock markets volatility was higher and stock market returns were lower than during other periods¹⁶. The outcome of Gao research was consistent with the earlier research conducted by Crack¹⁷.

According to Sivakumar and Sathyanarayanan impact of lunar cycles on returns of the Bombay Stock Exchange index over the period of 17 years, was quite limited¹⁸. Rotton and Kelly¹⁹ cite a working paper of Rotton and Rosenberg²⁰, who investigated relation between lunar phases and closing prices of Dow Jones Industrial Average, and found no relation after correcting Dow Jones Industrial Average prices for first autocorrelations²¹.

Liu examined average daily returns, the correlation between consecutive daily returns, and the GARCH (Generalized Auto-Regressive Conditional Heteroskedasticity) volatility for 12 stock exchanges, including G-7 markets and 5 emerging markets in Asia, indicated the existence of the lunar impact on daily stock returns although different schemes were presented on each of the analyzed markets²². Lempori investigating influence of eclipses on the rates or return on

¹⁴ **R. Brahman, C. Hooy, Z. Ahmad**, *Moon effect on Pacific basin stock market*, Indonesian Market Review 2011/3, pp. 117–126.

¹⁵ **K. Yuan K., L. Zheng L., Q. Zhu**, *Are investors moonstruck? Lunar phases and stock returns*, Journal of Empirical Finance 2006/13, pp. 1–23.

¹⁶ **Q. Gao**, *Lunar phases effect in Chines stock returns*, “International Conference on Business Intelligence and Financial Engineering”, Beijing, China 2009.

¹⁷ **T. Crack**, *A classic case of “data snooping” for classroom discussion*, Journal of Financial Education 1999/25, pp. 92–97.

¹⁸ **N. Sivakumar, S. Sathyanarayanan**, *Do Krishna Paksha (new moon phase) and Shukla Paksha (Full moon phase) affect the Indian stock market? A study of lunar cycles in the Bombay Stock Exchange*, International Journal of Indian Culture & Business Management 2009/3, pp. 281–294.

¹⁹ **J. Rotten, I. Kelly**, *Much ado about the full moon: a meta-analysis of lunar-lunacy research*, Psychological Bulletin 1985/97, pp. 296–306.

²⁰ **J. Rotten, M. Rosenberg**, *Lunar cycles and the stock market: Time-series analysis for environmental psychologists*, Unpublished Manuscript, Florida International University 1984.

²¹ **K. Yuan, L. Zheng, Q. Zhu**, *Are investors moonstruck? Lunar phases and stock returns*, Journal of Empirical Finance 2006/13, pp. 1–23.

²² **S. Liu**, *A Bayesian analysis of lunar effects on stock returns*, Working Paper 2009, Shih Hsin University, Department of Finance.

the US and Asian stock markets, in the period of 1928–2008, proved existence of below-average stock returns and trading volume declining during these events²³.

According to research conducted by Herbst the relationship between moon phases and market returns were variable and not consistent – moon cycles were not reliable in the process of predicting stock price returns and price volatility²⁴. Instead of analyzing the distance between two important price extremes not in days but with the use of moon month, Carolan introduced spiral calendar²⁵.

2. Method

The research is divided into four parts. In the first part, the following null hypothesis will be tested: the one-session average rate of return for the session, which falls during particular phase of the moon, is statistically equal to zero. Appropriate statistical tests will be conducted for the confidence levels of 95% ($\alpha = 5\%$). In case of rejection of the null hypothesis, alternative hypothesis will be adopted, which was formulated in the following way: one-session average rate of return for the session, which falls during particular phase of the moon, is statistically different from zero. The hypothesis will be tested for four moon phases: full moon, new moon, first and third quarters. If a particular phase of the moon falls on Saturday or Sunday, then the one-session rate of return was calculated for Friday and Monday sessions, respectively. The calculations were performed for the following three equity indices of the Warsaw Stock Exchange: WIG20 (blue chips index), mWIG40 (medium capitalization companies index) and sWIG80 (small capitalization companies index) in the periods of: 14.04.1994–30.06.2015, 31.12.1997–30.06.2015 and 29.12.1994–30.06.2015, respectively. All analyzed indices belong to the group of price indices and are classified as main equity indices published by the Warsaw Stock Exchange.

In the second, third and four part of this paper, the test for equality of two one-session average rates of return will be applied in the case of hypothesis testing. In the second part, the test for equality of two one-session average rates of return will be proceeded for rates of return in two populations. And so, if the first population is composed of the rates of return calculated during the session, when

²³ **G. Lempori**, *Dark omens in the sky; do superstitious beliefs affect investment decisions*, Working Paper, Copenhagen Business School 2009.

²⁴ **A. Herbst**, *Lunacy in the stock markets – what is the evidence?*, Journal of Biomechanics 2007/9, pp. 1–18.

²⁵ **C. Carolan**, *Spiral calendar*, New Classic Library, New York 1992.

the moon was in one of the four analyzed phases, then the second population determine the one-session rates of return for all remaining sessions.

In the third part, the test for equality of two one-session average rates of return will be applied where specified moon phase falls on a specified day of the week. And so, if the first population is composed of the rates of return calculated during the session, when the full moon coincided on Monday, then the second population determine the one-session rates of return for all remaining sessions during the week, e.g. on Tuesday, Wednesday, Thursday and Friday session. Similar calculations will be carried out taking into account the returns of the session, when the full moon falls on Tuesdays, Wednesdays, Thursdays and Fridays, and then for all remaining moon phases.

In the fourth part of the paper the test for equality of two one-session average rates of return, calculated in a specified moon phase, falling on a specified month, will be exploited in the process of hypothesis testing. For example, if the first population consists of returns calculated during the session, when the full moon was observed in January, then the second population determines the returns registered for all remaining sessions (months from February to December). Similar calculations will be carried out for all the other months of the year, and then for other moon phases.

According to the adopted method, the survey covers two populations of returns, characterized by normal distributions. On the basis of two independent populations of rate of returns, whose sizes equal n_1 and n_2 respectively, the hypotheses H_0 and H_1 should be tested with the use of statistics z :²⁶

$$Z = \frac{\bar{r}_1 - \bar{r}_2}{\sqrt{\left(\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}\right)}} \quad (1)$$

where:

- \bar{r}_1 – average rate of return in the first population,
- \bar{r}_2 – average rate of return in the second population,
- n_1 – number of rates of return in the first population,
- n_2 – number of rates of return in the second population,
- S_1^2 – variance of rates of returns in the first population,
- S_2^2 – variance of rates of returns in the second population.

²⁶ M. Osińska, *Ekonometria finansowa*, PWE, Warszawa 2006, pp. 43–44.

The Formula 1 can be used in the case of normally distributed populations, when the populations variances are unknown but assumed equal. The number of degrees of freedom is equal to: $df(1) = n_1 + n_2 - 2$.

Because the population variances are unknown, it might happen that the populations variances are unequal. Therefore the Formula 1 is used to calculate the z statistics, but the number of degrees of freedom should be modified according to the following formula:²⁷

$$df(2) = \frac{\left(\frac{S_1^2}{n_1} + \frac{S_2^2}{n_2}\right)^2}{\frac{(S_1^2/n_1)^2}{n_1} + \frac{(S_2^2/n_2)^2}{n_2}} \quad (2)$$

In the case of two populations, both with equal or unequal variances, the null hypothesis H_0 and alternative hypothesis H_1 regarding equality of rates of return in two populations, can be formulated as follows:

$$\begin{aligned} H_0: E(\bar{r}_1) &= E(\bar{r}_2) \\ H_0: E(\bar{r}_1) &\neq E(\bar{r}_2) \end{aligned} \quad (3)$$

In particular:

1) For the analysis of the daily rates of return, if \bar{r}_1 is the daily average rate of return in month X (the first population), then \bar{r}_2 is the daily average rate of return in all other months, except month X (the second population).

2) For the analysis of the daily rates of return for individual days of the week, if \bar{r}_1 is the daily average rate of return on day Y (the first population), then \bar{r}_2 is the daily average rate of return in all other days, except day Y (the second population).

In the second, third and fourth part of the research, the return will be carried out with the use test for equality of variances of two population rates of of

the F -statistics (so called Fisher-Snedecor statistics), where $F = \frac{S_1^2}{S_2^2}$, providing: $S_1^2 > S_2^2$ and that degrees of freedom for the numerator and denominator equal to n_1 and n_2 , respectively.

If F -test (computed for $\alpha = 0.05$) is lower than F -statistics, there is no reason to reject the null hypothesis, which can be formulated as follows:

$${}^F_0H: S_1^2 = S_2^2 \quad (4)$$

²⁷ R. Defusco, D. McLeavey, J. Pinto, D. Runkle, *Quantitative methods for investment analysis*, United Book Press, Baltimore 2001.

The alternative hypothesis may be defined by the ensuing equation:

$${}^F_1H : S_1^2 \neq S_2^2 \quad (5)$$

In all analyzed cases, the p -values will be calculated with the assumption that the populations variances are unknown, but:

- a) population variances of two populations are assumed equal – p -value(1),
- b) population variances of two populations are assumed unequal – p -value(2).

If the p -value (p -value(1) or p -value(2)) is less than or equal to 0.05, then the hypothesis H_0 is rejected in favor of hypothesis H_1 . Otherwise, there is no reason to reject hypothesis H_0 .

In the test for equality of two one-session average rates of return, when there is no reason to reject the null hypothesis concerning equality of variances of two observed returns, the p -value(1) should be compared with the critical value 0.05; otherwise the p -value(2) will be used – that explains the reason of applying p -value in the following parts of the paper: 2, 3 and 4.

3. Results

3.1. Analysis of the average rates of return

The results of testing the null hypothesis permit to draw the conclusion that the null hypothesis was rejected (for $\alpha = 5\%$) in favor of the alternative hypothesis in the following cases (in parenthesis the one-session average rates of return and standard error, respectively):

- a) WIG20 – new moon (0.2377%; 1.7900%),
- b) sWIG80 – full moon (0.2143%; 1.4199%),
- c) sWIG80 – new moon (0.2098%; 1.5999%).

In all other analyzed cases there was no reason to reject the null hypothesis in favor of the alternative one.

The results of testing the null hypothesis that one-session average rate of return was higher than zero for all three above cases, enables to draw the conclusion that the null hypothesis was rejected (for $\alpha = 5\%$) in favor of the alternative hypothesis in all three cases (in parenthesis t -statistics and critical value, respectively):

- a) WIG20 – new moon (2.1455; 1.6507),
- b) sWIG80 – full moon (2,3955; 1,6509),
- c) sWIG80 – new moon (2.0866; 1.6509).

The average rates of return for each of analyzed indices, when the moon was falling during one of four phases are presented in table 1. In the case of sWIG80,

the one session average rate of return was positive in all analyzed moon phases, while for WIG20 and mWIG40 it was negative in the 3rd and 1st quarter are reported, respectively.

TABLE 1: *One session average rates of return of analyzed indices in the specified moon phases*

	Full moon	New moon	1 st quarter	3 rd quarter
WIG20	0.0714%	0.2377%	0.0549%	-0.0614%
mWIG40	0.0291%	0.1195%	-0.0341%	0.1136%
sWIG80	0.2143%	0.2098%	0.0686%	0.0471%

Source: own calculations.

3.2. Test for equality of two one-session average rates of return in two populations

The results of testing zero hypothesis with the use of average rates of returns for two different populations enables to draw the following conclusions:

1. The null hypothesis regarding equality of variances of daily average rates of return in two populations was rejected (for $\alpha = 5\%$) in the following cases (in parenthesis the value of the fraction $\frac{S_1^2}{S_2^2}$ and F statistics, respectively):

- WIG20 – full moon (1.2617; 1.1707) and the 3rd quarter (1.2379; 1.1718),
- mWIG40 – full moon (1.2621; 1.1729),
- sWIG80 – new moon (1.2752; 1.1574).

In all other cases there was no reason to reject the null hypothesis regarding equality of variances in analyzed populations of rates of return.

2. There was no reason to reject the null hypothesis regarding equality of two average rates of return. In all analyzed cases the p -value was higher than the critical value (0.05). The p -values are presented in table 2. The p -value higher than 0.05 and lower than 0.1 was calculated during the new moon sessions in the case of WIG20 (0.0770) and for full moon sessions on the market of small capitalization companies (sWIG80, p -value = 0.0795).

TABLE 2: *The p-value for each of the analyzed indices broken into four moon phases*

	Full moon	New moon	1 st quarter	3 rd quarter
WIG20	0.9027	0.0770	0.7403	0.7223
mWIG40	0.9530	0.3532	0.3906	0.3068
sWIG80	0.0795	0.1000	0.9083	0.7390

Source: own calculations.

To conclude none of the analyzed phases of the moon affected the value of the one session average return during the observed phases with respect to returns during the remaining sessions.

3.3. Test for equality of two one-session average rates of return, when the analyzed moon phase falls on the specified day of the week

The results of testing zero hypothesis with the use of average rates of returns for two different populations permit to draw the following conclusions:

1. The null hypothesis regarding equality of variances of daily average rates of return in two populations, was rejected (for $\alpha = 5\%$) in the following cases (in parenthesis the value of the fraction $\frac{S_1^2}{S_2^2}$ and the F statistic, respectively):

a) Full moons:

- WIG20: Mondays (1.6806; 1.3588) and Thursdays (1.7056; 1.5830),
- mWIG40: Mondays (1.8384; 1.4016) and Thursdays (2.5481; 1.6775),
- sWIG80: Mondays (2.0905; 1.3678), Wednesdays (2.5510; 1.5747) and Fridays (2.1712; 1.5947),

b) New moons:

- WIG20: Fridays (1.6325; 1.3998),
- mWIG40: Fridays (1.7760; 1.4512),
- sWIG80: Tuesdays (2.0252; 1.6056),

c) First quarter:

- WIG20: Tuesdays (1.1576; 1.4645),
- mWIG40: Fridays (2.6219; 1.4512),
- sWIG80: Tuesdays (2.5687; 1.4719) and Fridays (1.9426; 1.4064),

d) Third quarter:

- WIG20: Tuesdays (2.0790; 1.6044),
- mWIG30: Fridays (1.5819; 1.4550),
- sWIG80: Mondays (1.9739; 1.3697) and Thursdays (1.3680; 1.4070),

2. The null hypothesis regarding equality of two average rates of return was rejected in the succeeding cases (one session average rate of return and p -value shown in parenthesis):

a) Full moon: sWIG80 for Fridays sessions (0.05651%; 0.0147),

b) First quarter: WIG20 (−0.6362%; 0.0222) and mWIG40 (−0.5924%; 0.0076), both for Tuesdays sessions

In all other cases there was no reason to reject the null hypothesis (for $\alpha = 5\%$) in favor of the alternative hypothesis. The p -value higher than 0.05 and lower than

0.1 was computed for mWIG40 during the Fridays sessions falling on the 1st quarter (0.0944) and for sWIG80 when the moon was on Monday in the new phase (0.0806).

The results of testing the null hypothesis that difference of one-session average rates of return was higher or lower than zero for all three cases from the point nr 2, enable to draw the conclusions that the null hypothesis was rejected (for $\alpha = 5\%$) in favor of the alternative hypothesis for (in parenthesis t -statistics and critical value):

- a) Full moon: sWIG80 (2.5844; 1.6509) for Friday sessions – the difference of one-session rates of return was higher than zero
- b) First quarter: WIG20 (-2.4564; -1.6507) and mWIG40 (-2.4564; -1.6507), both for Tuesdays sessions – the difference of one-session rates of return was lower than zero.

3.4. Test for equality of two average rates of return, when the analyzed moon phase falls during the respective month of year

The results of testing zero hypothesis with the use of average rates of returns for two different populations permit to draw the following conclusions:

1. The null hypothesis regarding equality of variances of daily average rates of return in two populations, was rejected (for $\alpha = 5\%$) in the following cases (in parenthesis the value of the fraction $\frac{S_1^2}{S_2^2}$ and F statistic, respectively):

- a) Full moons:
 - WIG20: January (2.1311; 1.6145), February (2.8550; 1.9044), May (2.6303; 1.8113) and September (2.1556; 1.6145),
 - mWIG40: February (2.9273; 2.0398), May (3.9622; 1.9913), July (2.4874; 1.9913) and September (3.2325; 1.6998),
 - sWIG80: May (1.8985; 1.8403), June (2.2459; 1.6162), September (2.0785; 1.6316), November (2.4973; 1.8712) and December (4.0666; 1.8712)
- b) New moons:
 - WIG20: February (1.9545; 1.9428), March (3.3679; 1.8395), September (1.6180; 1.6149), October (1.8994; 1.6007) and November (1.9844; 1.9046),
 - mWIG40: March (1.9998; 1.9913), April (3.6005; 1.9913), July (2.9920; 1.9913), August (1.8190; 1.6749) and September (2.1678; 1.6948),
 - sWIG80: February (2.2743; 1.6483), October (2.2765; 1.8712) and November (2.6281; 1.9436),

- c) First quarter:
- WIG20: May (2.1015; 1.5872), August (1.8641; 1.8393) and October (1.9959; 1.7857),
 - mWIG40: March (1.9636; 1.6567), July (2.7594; 1.9913) and September (1.9428; 1.6948),
 - sWIG80: February (3.0099; 1.6314), May (1.8991; 1.8711), July (4.4543; 1.8711) and October (2.1111; 1.8122).
- d) Third quarter:
- WIG20: January (1.6448; 1.6005), March (4.7649; 1.8394), June (1.6094; 1.6005), July (2.2462; 1.8394), October (1.9970; 1.6005) and December (2.6785; 1.8703),
 - mWIG40: February (2.1186; 1.6751), March (3.3279; 1.9915), April (2.5228; 1.9915), June (2.4917; 1.6951), July (2.0731; 1.9915) and December (2.3951; 2.0399),
 - sWIG80: February (3.0033; 1.6318), March (4.5388; 1.8405) and October (2.0065; 1.9055).

2. The null hypothesis regarding equality of two average rates of return was rejected in the succeeding cases (one session average rate of return and p -value shown in parenthesis):

- a) Full moon: WIG20 for June sessions (–0.6277%; 0.0224) and mWIG40 for March (0.6185%; 0.0385) and June (–0.6894%; 0.0059) sessions,
- b) New moon: mWIG40 for July sessions (–0.4227%; 0.0082),
- c) First quarter: WIG20 for June (0.9138%; 0.0251) and November (–0.8161%; 0.0154) sessions, mWIG40 for July (0.3683%; 0.0316) and sWIG80 for October (–0.4023%; 0.0329) sessions.

In all other cases there was no reason to reject the null hypothesis (for $\alpha = 5\%$) in favor of the alternative hypothesis. The p -value higher than 0.05 and lower than 0.1 was observed in the following cases:

- a) WIG20: new moon in February (0.0980), 3rd quarter in August (0.0734),
- b) mWIG40: new moon in January (0.0692) and October (0.0922), 3rd quarter in May (0.0876),
- c) sWIG80: full moon in June (0.0953), 1st quarter in November (0.0820), 3rd quarter in May (0.0725).

The results of testing the null hypothesis that difference of one-session average rates of return was higher or lower than zero for all eight cases from the point nr 2, allow us to draw the conclusions that the null hypothesis was rejected (for $\alpha = 5\%$) in favor of the alternative hypothesis for (in parenthesis t -statistics and critical value):

- a) Full moon: WIG20 for June sessions (-2.0809; -1.6507) and mWIG40 for June sessions (-2.4442; -1.6520) – the difference of one-session rates of return was lower than zero.
- b) Full moon: mWIG40 for March sessions (2.0586; 1.6520) – the difference of one-session rates of return was higher than zero.
- c) New moon: mWIG40 for July sessions (-1.9988; -1.6520) – the difference of one-session rates of return was lower than zero.
- d) First quarter: WIG20 for June sessions (2.4319; 1.6507), mWIG40 for July sessions (2.4567; 1.6520) – the difference of one-session rates of return was higher than zero.
- e) First quarter: WIG20 for November sessions (-2.1455; -1.6507), and sWIG80 for October sessions (-1.6510; -1.6509) – the difference of one-session rates of return was lower than zero.

4. Discussion

The relationship between the moon phases and rates of return on sizeable group of world stock exchanges have already been raised in scientific papers. This paper is one of the first dedicated to the study of the statistical significance of the rates of return on the Polish stock market calculated for different moon phases. The author of this article focused mostly on the relationship between rates of return during sessions close to the four moon phases (new, 1st quarter, full and 3rd quarter) whilst other authors, in their research concentrated rather on the rates of return calculated during a couple of sessions around the full or new moon.

Calculations presented in this paper indicate that the one-session average rates of return for the sessions, when the moon was in new phase for WIG20 and sWIG80 as well as for the full phase in the case of sWIG80, are statistically higher than zero. In the case of testing equality of average rates of return in two populations, the outcomes proved that the moon phases are irrelevant for one session average rates of return in two analyzed populations. In the case of testing the null hypothesis regarding equality of one-session average rates of return, computed for each day of the week, the result permit to reject the null hypothesis for full moon falling on Fridays (sWIG80) and for 1st quarter falling on Tuesdays (WIG20 and mWIG40). The average rates of return of the Fridays session for sWIG80 (full moon) resulted to be statistically higher than zero, while for Tuesday sessions calculated for WIG20 and mWIG40 (1st quarter) – negative.

Calculations of one-session average rates of return, regarding moon phases falling in a given month, are statistically:

- a) higher than zero for: mWIG40 in March (full moon), WIG20 in June and mWIG40 in July (for indices both – moon in the first quarter phase);
- b) lower than zero for: WIG20 and mWIG40 for full moon sessions in June, mWIG40 for July (new moon) sessions, WIG20 for November and sWIG80 for October sessions (for both indices – moon in the first quarter phase).

The obtained results regarding average rates of return during full moon session in the case of WIG20 and mWIG40 confirm the observations of Dichev and Jones²⁸ but outcome regarding new moon session in the case of sWIG80 reaffirm the conclusions of Yuan et al.²⁹ and Brahman et al.³⁰

The main limitation of this research is the assumption of normal distribution of returns of analyzed indices along with the use of price data gained from Reuters data source as well as the unequal intervals of observations for different equity indices. The outcome may be regarded as a part of the an ongoing discussions on the hypothesis of financial markets efficiency, which was introduced by Fama (1970) and can be used by both individual as well as by institutional investors to build investment strategies.

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WPLYW FAZ KSIĘŻYCA NA STOPY ZWROTU INDEKSÓW GIEŁDY PAPIERÓW WARTOŚCIOWYCH W WARSZAWIE

(Streszczenie)

Wpływ księżycy na ludzkie oddziaływania został przedstawiony w wielu publikacjach naukowych. W artykule tym zweryfikowana została hipoteza statystyczna, że średnia jednosesyjna stopa zwrotu następujących indeksów giełdowych (w nawiasie podany został okres analityczny): WIG20 (14.04.1994–30.06.2015), mWIG40 (31.12.1998–30.06.2015) i sWIG80 (29.12.1994–30.06.2015) obliczona w czasie sesji, kiedy księżyc znajdował się w jednej z czterech faz (nów, 1. kwadra, pełnia i 3. kwadra) jest statystycznie różna od zera (dla $\alpha = 0,05$). W drugiej, trzeciej i czwartej części artykułu testowana była hipoteza równości średnich dziennych stóp zwrotu w dwu populacjach, wtedy gdy księżyc znajdował się w jednej ze swoich faz z uwzględnieniem sytuacji, kiedy faza księżycy przypadała w określonym dniu tygodnia lub określonym miesiącu.

Otrzymane wyniki wskazują, że jednosesyjna średnia stopa zwrotu obliczona dla sesji, kiedy księżyc znajdował się w fazie nowiu i indeksów WIG20 i sWIG80, a także dla fazy pełni księżycy i indeksu sWIG80, okazała się być statystycznie większa od zera. Z kolei w przypadku testowania równości średniej jednosesyjnej stopy zwrotu w dwu populacjach stóp zwrotu, oddziaływanie księżycy nie zostało wykazane, jednak analiza jednosesyjnych stóp zwrotu obliczonych dla sytuacji, gdy dana faza przypadała w określonym dniu tygodnia, prowadziła do odrzucenia hipotezy zerowej w czasie pełni przypadających w piątki (sWIG80) i pierwszej kwadry wypadających we wtorki (WIG20 i mWIG40). Średnia stopa zwrotu indeksu sWIG80, obliczona dla sesji przypadających w czasie pełni okazała się być statystycznie większa od zera, w odróżnieniu do średniej stopy zwrotu indeksów WIG20 i mWIG40 skalkulowanych dla sesji przypadających w czasie pierwszej kwadry, która okazała się być statystycznie mniejsza od zera. Obliczenia różnicy jednosesyjnych średnich stóp zwrotu w dwu populacjach, przeprowadzone w sytuacji, gdy dana faza księżycy przypadała w określonym miesiącu roku, wykazały statystyczną istotność w następujących przypadkach: czerwcowych (WIG20) i marcowych (mWIG40) pełni, lipcowych nowiu (mWIG40) oraz pierwszych faz księżycy przypadających w czerwcu i listopadzie (WIG20), lipcu (mWIG40) i październiku (sWIG80). Średnia stopa zwrotu była statystycznie większa od zera dla pełni przypadających w marcu (mWIG40), pierwszych kwadr w czerwcu (WIG20) i lipcu (mWIG40), a niższa od zera dla sesji czerwcowych pełni (WIG20 i mWIG40), lipcowego nowiu (mWIG40), pierwszych kwadr w listopadzie (WIG20) i październiku (sWIG80). Tym samym udowodniony został wpływ oddziaływania księżycy na inwestorów operujących na Giełdzie Papierów Wartościowych w Warszawie.

Słowa kluczowe: efektywność rynku; efekty kalendarzowe; anomalie rynkowe; wpływ księżycy