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Lunar effect in the times of above-average uncertainty on the financial markets: Evidence from Poland

Bartłomiej Lisicki
Department of Accounting, University of Economics in Katowice, Poland
bartlomiej.lisicki@ue.katowice.pl
ORCID 0000-0003-0268-009X

Abstract. The aim of this paper is to verify the effect of moon phases (lunar effect) on the main indices of the Warsaw Stock Exchange (WSE) in 2020-2024. In these years was possible to indicate periods of increased market volatility. It provides the basis for undertaking considerations on the possibility for observing existing dependencies on the global stock markets. Using the quotations of four main WSE indices (WIG, WIG20, mWIG40, sWIG80), daily logarithmic returns were calculated in two event windows: one-day (t_0), and three-day, covering one session day before and one after a specific moon phase (t_{-1}-t_{+1}). Based on 39 qualified new and full moons, medians of the returns differing significantly from zero were observed on the day of the new moon for all the analysed WSE indices. Moreover, the values of returns were average higher than zero on days adjacent to the new moon. However, no statistical significance was found for the median value of the returns on full moon days (except in one case, sWIG80). It is worth underlining that this research is one of the first attempts to verify the effect of moon phases in the current era of increased volatility of financial instruments on world markets in relation to the financial instrument listed on the WSE.

Keywords: efficient market hypothesis, lunar effect, behavioural finance, financial markets, stock indices.

JEL Classification: G11, G12, G17.

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1. INTRODUCTION

During research into verifying the efficient market hypothesis (Fama, 1965) certain deviations (disruptions) from its assumptions began to be noticed, which in time came to be called market anomalies (Kamaly, Tooma, 2002; Mehdian, Perry, 2002; Zielonka, 2008; Ozkan, 2021). In extant global research, several examples of groups of market anomalies have been identified (Fuksiewicz, 2021): calendar effects (seasonal anomalies), momentum strategies, fundamental anomalies (related to company market indicators), the interdependence of returns, market overreaction and underreaction, and anomalies linked to an entity's individual features.

In the last couple of decades, scientific exploration has also been undertaken into deviations from the market efficiency (anomalies) that were difficult to qualify into one of the above-mentioned groups (incl. Kamstra et al., 2003; Kramer, Weber; 2012; Kathiravan, 2021). Their occurrence was dependent on different factors from those listed above. Among these deviations are anomalies in which investors' decisions depend on the phases of the moon (Ariel, 1987; Dichev, Janes, 2003; Lingaraja, 2013; Chen, 2021; Lisicki, 2025b). This was named the lunar (moon phases) effect.

Beliefs regarding the effect of the moon on the behaviour of humans and animals have been a subject of interest for many centuries (Gierszewski, Dobrowolski, 2024). Without a doubt, human and animal physiology are subject to seasonal, lunar and circadian rhythms. Although seasonal and circadian rhythms have been fairly well described, little is known about the effects of the lunar cycle (Zimecki, 2006). Its effect has been the subject of considerations by researchers from around the world for many years, with significant dependencies being shown between lunar phases and human behaviour related to, among others, quality of sleep, fertility levels and frequency of births, the inclination to commit suicide or crimes, psychiatric disorders, and even occasional purchases (Forbes, Lebo, 1977.; Garzino, 1982; Mathew et al., 1991; Zimecki, 2006; Lagana et al., 2014; Mittal et al., 2021). Therefore, the belief that respective moon phases can affect the functioning of the financial markets and investors' decisions begins to make sense. According to the results of research by authors verifying the lunar effect, returns on investment show higher levels during a new moon than in the days accompanying a full moon (Dichev, Janes 2003; Kramer, Weber; 2012; Borowski, 2015, 2016; Lizińska, 2017; Trifan, 2021; Lisicki, 2025b).

The principal aim of this paper is to verify the occurrence of the lunar effect among the main market indices quoted on the Warsaw Stock Exchange (WSE) in the years 2020-2024. In this time period was possible to indicated particularly often subperiods, which were characterised an increased uncertainty (volatility) of prices on global financial markets (Boubaker et. al., 2023). It, in turn, undoubtedly had an effect on the decisions taken by investors on global markets (Thakur, 2020). Increased market uncertainty (volatility) motivates scientific exploration to verify the relationships occurring on financial markets (Zhang et al., 2020). It strengthens the influence of investor sentiment on market anomalies, especially under conditions of high information asymmetry. This highlights the importance of considering both sentiment and uncertainty in understanding contemporary investor behavior (Yang et al., 2025). Therefore, it would thus seem necessary to verify the occurrence of previously noted dependencies on the financial markets, allowing for confirmation (or not) of the appearance of market anomalies as examples of deviations from the efficient market hypothesis (Fama, 1965). These, in turn, may constitute certain guidelines in building future investment strategies.

It is also extremely important to verify the relatively untypical anomaly of the lunar effect on financial instruments quoted on the WSE. To the author's best knowledge, this anomaly has been verified in previous considerations by only 3 authors (Borowski, 2015; 2016; Lizińska, 2017; Fuksiewicz, 2021). However, none of these papers addressed the issue of increased uncertainty (volatility), which could have a different impact on the connections noted earlier between the moon phases and returns on the WSE. This is an additional argument for undertaking considerations to verify this type of market anomaly in question with regard to the main WSE indices in the turbulent years 2020-2024.

Achievement of the main aim of the paper is to be helped by the formulation of two principal hypotheses. Each of them will allow for the verification of the relationships occurring among the main WSE indices in the two studied moon phases: new moon and full moon. They were formulated based on the assumptions previously used by researchers to verify the effect of the moon phases (Luvey, 2010; Borowski, 2015; 2016; Trifan, 2021). They are as follows:

H1: In the periods of increased uncertainty observed in 2020-2024, it is possible to observe that average value of returns on the main WSE indices is significantly higher than zero on days adjacent to a new moon.

H2: In the periods of increased uncertainty observed in 2020-2024, it is possible to observe that average value of returns on the main WSE indices is significantly lower than zero on days adjacent to a full moon.

Obtaining knowledge on the occurrence of the anomaly contradicting the efficient market hypothesis has important implications for both researchers and investors investing funds on the WSE, as it enables them to review their existing investment strategies (Yang et al., 2025).

2. LITERATURE REVIEW

One of the effects that enjoy the greatest popularity among capital market researchers (Dragota, Oprea, 2014; Rossi, 2015; Żebrowska-Suchodolska, 2021; Lisicki, 2025a) are calendar (seasonal) effects. They constitute a broadly identifiable category covering anomalies resulting from the investor behaviours that deviate from the assumptions of the efficient market hypothesis, and which occur regularly in particular periods (Jasiniak, 2022). In addition to the typical seasonal anomalies based on the traditional calendar, in recent years attempts have been made to verify other deviations from the efficient market hypothesis (Kathiravan, 2021; Bassiouny, Kiryakos, & Tooma, 2022) that are difficult to assign to specific units of time. One of the most recognisable of these is the anomaly that conditions investor behaviour on the phases of the moon, the so-called lunar effect.

As mentioned in the introduction, many studies have been conducted on the effect of moon phases on animals, plants and human behaviour. Some human economic decisions also seem to be influenced by the lunar cycles (Lizińska, 2017). The first research into the importance of moon phases for decisions taken by investors was undertaken at the beginning of the 21st century by I. Dichev and T. Janes (2003). They studied the returns on stock market indices in more than a dozen countries and noticed a strong relationship between the behaviour of the markets and the phase of the moon. They founded that returns in a 15-day event window adjacent to a new moon were almost twice as high as those noted in a window adjacent to a full moon.

The research by I. Dichev and T. Janes caused quite a surprise and constituted the basis for further considerations in this area. In the following years, research was expanded on the relationship between moon phases and stock market returns in 48 countries. The findings indicate that stock returns are lower on the days around a full moon than on the days around a new moon. The magnitude of the annualized return difference is 3% to 5% (Yuan, Zheng, Zhiu, 2006). The lunar effect was not explained by any other incoming announcements to the financial markets. Moreover, the lunar effect is independent of other calendar-related anomalies.

In other research based on an international sample, it was shown that average returns on new moon days are higher than those during a full moon. However, the mean return on full moon days did not differ from the mean return on lunar control days (Keef, Khaled, 2011). An interesting study also indicated the link between the lunar phases and market returns (for the Chinese stock market), and came to the conclusion that near a new moon and a full moon, stock market volatility was higher and stock market returns were lower than during other periods (Gao, 2009). Interestingly, the lunar effect was also noted on the precious metals market. It was found that this effect is more visible for silver than gold or platinum (Luvey, 2010).

However, not all studies confirmed a link between lunar phases and investors' decisions (Herbst, 2007; Lee et al., 2015). No consistent, predictable influence of the moon was found on either daily returns or daily price volatility in the DJIA, either for new or full moons (Herbst, 2007). Research into a greater number of financial markets (Indonesia, Malaysia, the United Kingdom, the United States, the Philippines, Japan and Thailand) from the point of view of the coincidence between lunar phases and investment returns did not find a significant relationship. It was noted that a full moon fell relatively most frequently on a Monday, and a new moon on a Friday (Mishra, 2017).

In the next years, financial market researchers continued to attempt to verify this deviation from the efficient market hypothesis (Fama, 1965). When examining the importance of investors' biorhythms on their decisions on the Romanian financial market, a small but statistically significant influence of the lunar cycle was indicated (also with SAD effect and the fall effect). Investors become more pessimists and uncertain when facing light deficiency during fall and winter and in proximity to full moon periods, which ultimately leads to a drop in their trading activity, respectively, stock returns (Trifan, 2021). Another interesting finding was the indication that it's not just the phases of the moon that can influence investment decisions in global markets. In recent years, it has been discovered that lunar eclipses can also be a factor in excessive pessimism in analysts' market forecasts (Chen, 2021). Other studies have largely focused on the beginning of the lunar year rather than the phases of the moon and their impact on investors (e.g., Huang et al., 2022; Trung et al., 2025).The lunar effect has also been verified with regard to the WSE. Papers by only three authors have been found that address this market anomaly (Borowski, 2015; 2016; Lizińska, 2017; Fuksiewicz, 2021). In the first of these (Borowski, 2015), research was conducted into the phases of the moon based on daily returns on the broad WIG market index in the years 1991-2015. Interestingly, an attempt was also made to verify the first and third quarters of the moon. Calculations presented in this paper indicate that the average daily returns for sessions when the moon was in a new phase are statistically different from zero. Meanwhile, one-session average returns computed for each day of the week, when the moon was in one of the analysed phases (full, new, first and third quarter), did not differentiate from zero. Daily returns statistically significantly different from zero were also noted in the case of full moons in February and June, the first quarter in February and November, and the third quarter in October.

In his next study (Borowski, 2016), the same author undertook once again the verification of the lunar effect on the polish financial market. This time the anomaly was verified on the basis of the three main indices of the WSE: the WIG20, mWIG40 and sWIG80, from when they were first quoted until the end of the first half of 2015. The study also took into account possible variations in daily returns during particular lunar phases falling on various days of the week or in various months. In the case of testing the equality of average daily returns, the results proved that the lunar phases are irrelevant for one-session average returns. However, regarding the equality of one-session average returns computed for each day of the week, the results indicate that the average returns for Friday sessions for the sWIG80 (full moon) were shown to be statistically higher than zero, while for Tuesday sessions calculated for the WIG20 and mWIG40 (first quarter) – they were lower. Moreover, calculations of average daily returns, taking into account lunar phases falling in a specified month, displayed that they are statistically higher than zero for: the mWIG40 in March (full moon), the WIG20 in June and the mWIG40 in July, and lower than zero for: the WIG20 and mWIG40 for full moon sessions in June, the mWIG40 in July (new moon), the WIG20 for November and the sWIG80 for October sessions (for both indices – moon in the first quarter phase).

In the next study (Lizińska, 2017), the lunar effect on the WSE was verified on the basis of a research sample for the years 2000-2016 for three indices: the WIG, WIG20 and sWIG80 (the intention was to broaden the analysis to include the effect of company size). For each new moon (full moon) phase, a 9-day window was created around the day of the lunar phase in question. Based on the daily arithmetic returns, it was shown that returns in full moon periods were considerably lower than those achieved during new moon periods. The impact of the lunar phase was significant. However, it could also be seen to vary when the capitalisation of the companies grouped in the studied indices was taken into account. The lunar effect also coincided with other calendar anomalies such as the month effect or the effect of the first and second half of the month.

In the last of the papers found by Polish authors (Fuksiewicz, 2021), a systematic review was conducted of existing calendar anomalies in the context of the functioning of the efficient market hypothesis. No research was conducted here into the WSE, but the author himself points out that of the listed deviations

from the efficient market, a considerable proportion remain insufficiently studied with regard to the functioning of the Polish financial market. One of these deviations was the lunar effect, which justifies the considerations undertaken in this paper into its occurrence in surroundings characterised by increased uncertainty.

Similarly to research into the lunar effect on the WSE, there is only a small number of studies into its verification with regard to world markets in times of above average uncertainty. Yousop, Sipon and Yoke (2014) applied non-parametric and basic multiple linear regression analysis and showed that returns on the full moon were slightly lower compared to returns on the new moon prior to and during the financial crisis of 2008-2009. However, the results during the full moon were different for five emerging countries of the ten studied, which is not strong enough to show a relationship between the moon phase and stock returns. Similar considerations were begun in the times of above average volatility in securities on financial markets accompanying the COVID-19 pandemic (Yahya et al., 2021; Ozkan, 2021; Bassiouny, Kiryakos, & Tooma, 2022). However, none of them addressed the lunar effect described in this paper.

For this reason, it is worth taking a closer look at returns on full moon and new moon days noted for selected WSE stock market indices in the years 2020-2024. In this period, the market faced many 'black swans' (Taleb, 2010), such as the COVID-19 pandemic, the war in Ukraine and the war in the Gaza Strip, which gave rise to periods of above average uncertainty on markets.

3. METHODOLOGY

The principal aim of this paper is to verify the occurrence of the lunar effect among main stock market indices listed on the WSE in the period 2020-2024. This period saw higher than average readings of the VIX index value (Investing.com, 2024), due to the COVID-19 pandemic (2020-2022), the war in the Ukraine (2022-2024) and the war in the Gaza Strip (2023-2024). They gave rise to predictions of above-average volatility in the prices of financial instruments in the global markets. Situations of heightened uncertainty in the markets create motivations for scientific exploration that can be used to discover new correlations (or confirm existing ones) taking place in global capital markets (Naymudin et al., 2017). Moreover, it strengthens the influence of investor sentiment on market anomalies. This highlights the importance of considering both sentiment and uncertainty in understanding contemporary investor's behavior (Yang et al., 2025). These undoubtedly include the topic of market anomalies such as the lunar effect (Tauseef, 2022).

The data in this study consists of stock market quotations and the moon phase calendar over the years 2020-2024. Data for the stock market consists of the daily closing price of the four main indices listed on the WSE: the WIG, WIG20, mWIG40 and sWIG80. These indices are differentiated in accordance to the size of a company. WIG20 includes shares of 20 major and most liquid companies in the WSE. Similarly, WIG40 comprises of 40 medium sized companies listed on WSE, and WIG80 is based on 80 smaller companies (Blajer-Gołębiowska, 2012). The choice of only these indices is not accidental, because they were the exclusive subject of the studies examining the moon phases effect on the WSE in previous years (Borowski, 2015; 2016; Lizińska, 2017). The conclusions from the research conducted in this paper will enable a comparison of the impact of moon phases on the quotations of the main WSE indices in a time of above-average uncertainty in financial markets with previous years, when not so many "black swans" were recorded in such a short period (Taleb, 2010).

Historical data for daily closing prices for the selected indices were downloaded from the historical database Stooq.com (2024). Information on the precise dates of the studied moon phases (new and full moons) in the period 2020-2024 was downloaded from the website Moonphases.co.uk (2024). In the five-year study period there were 62 cases of new and full moons. However, from the perspective of this paper, it was important to distinguish those that did not occur on days characterized by above average volatility in the prices of financial instruments. This was done using the most popular measurement of volatility in the

world, the VIX 'fear index'. It measures the implied volatility of the prices of financial instruments for the next 30 days for the American S&P 500 index. VIX index value above 20 indicates above average volatility on the market (Vuong, Nguyen, Wong, 2022). Based on the VIX index (Investing.com, 2024), 39 cases of new and full moons (from the 62 cases of them in 2020-2024) were ultimately qualified for the research sample that took place on days characterized by heightened uncertainty on markets during the study period.

To verify the lunar effect, different event windows were used, covering: only the day of the new and full moon (t_0) and the day preceding and following the day of the analysed phase (t_{-1}-t_{+1}). This aimed to verify whether the lunar effect on returns for the studied indices occurred only on new moon and full moon days, or whether it extended to days adjacent to them. A similar procedure had already been used in research into this anomaly, which justifies the author adopting this course of action (Yuan, Zheng, Zhiu, 2006; Lizińska, 2017).

In each case, the daily logarithmic returns were calculated for the four WSE indices in question on the days detailed above adjacent to the day of the new or full moon, according to the formula below (1). The use of logarithmic returns for daily closing prices is an approach often used in the literature (Gajdošová, Heryán, Tufan 2011). The results were grouped according to those noted on the day of a new and a full moon.

$$R_t = \ln (P_t/P_{t-1})*100 \quad (1)$$

where:

Rt –logarithmic return on the day of the new/full moon,

Pt – closing price index on the day of the new/full moon,

Pt-1– closing price index on the preceding day of the new/full moon.

If a particular moon phase falls on a day without a trading session (e.g. Saturday, Sunday, public holiday), then the one-session return was calculated for the next possible trading session (Borowski, 2016).

In the next stage of the research procedure it was necessary to present the basic descriptive statistics of return values (mean, median, standard deviation, kurtosis, skewness, etc.). The last stage of the research procedure contains statistical verification of results with the use of statistical test.

4. EMPIRICAL RESULTS AND DISCUSSION

At the beginning of verifying the lunar effect in the selected research period (the years 2020-2024) on the main WSE indices, it is necessary to present descriptive statistics of the calculated daily returns for the 39 qualified new/full lunar phases separately. As mentioned in the Methodology section five-year research period covered 62 cases of new and full moons. However, only 39 cases of them were ultimately qualified for the research sample that took place on days characterized by heightened uncertainty on markets (based on the VIX index quotations). This research procedure coincides with achieving the main goal of this paper. These descriptive statistics of the daily returns are presented in Table 1.

Table 1

Descriptive statistics of the returns on the indicated WSE indices in the adjacent days to the full (F) and new (N) moon days

t_{-1}-t_{+1} N=117 Statistic/Index	WIG F	WIG N	WIG20 F	WIG20 N	mWIG40 F	mWIG40 N	sWIG80 F	sWIG80 N
Mean	0.10%	-0.01%	0.12%	-0.09%	0.04%	0.12%	0.09%	0.18%
Std. Error	0.15%	0.13%	0.16%	0.14%	0.13%	0.12%	0.12%	0.09%
Median	0.17%	-0.09%	0.12%	-0.24%	0.14%	0.08%	0.14%	0.22%
Std. Deviation	1.57%	1.37%	1.78%	1.57%	1.39%	1.29%	1.31%	0.93%
Mean difference (N-F)	-0.11%		-0.21%		0.08%		0.09%	
Median difference (N-F)	-0.26%		-0.36%		-0.06%		0.08%	
Kurtosis	4.76	1.23	3.48	1.25	3.63	0.85	13.18	4.39
Skewness	-0.90	-0.46	-0.59	-0.30	-0.95	-0.28	-1.96	-1.23
Min	-7.80%	-4.84%	-8.19%	-5.74%	-6.43%	-3.74%	-8.08%	-4.27%
Max	4.30%	3.11%	5.02%	3.84%	3.60%	4.21%	3.97%	2.33%
t_0 N=39 Statistic/Index	WIG F	WIG N	WIG20 F	WIG20 N	mWIG40 F	mWIG40 N	sWIG80 F	sWIG80 N
Mean	0.11%	0.37%	0.11%	0.39%	0.05%	0.31%	0.10%	0.31%
Std. Error	0.29%	0.22%	0.32%	0.25%	0.23%	0.22%	0.27%	0.20%
Median	0.21%	0.31%	0.14%	0.27%	0.25%	0.54%	0.17%	0.57%
Std. Deviation	1.80%	1.40%	2.02%	1.58%	1.41%	1.35%	1.66%	1.24%
Mean difference (N-F)	0.26%		0.28%		0.26%		0.21%	
Median difference (N-F)	0.10%		0.13%		0.29%		0.40%	
Kurtosis	8.72	1.65	6.35	1.07	11.06	1.11	15.45	4.21
Skewness	-2.13	-0.68	-1.67	-0.21	-2.69	-0.93	-3.02	-1.63
Min	-7.80%	-4.15%	-8.19%	-4.29%	-6.43%	-3.74%	-8.08%	-4.27%
Max	2.54%	2.69%	3.08%	3.84%	1.81%	2.34%	3.04%	2.33%

Source: Authors' results based on the Stooq.com Retrieved: February 20, 2025, from https://stooq.pl/q/d/?s=wig.

The highest average returns (0.39%) on new moon days were noted for the WIG20 index in the t_0 event window (covered only day of the new/full moon phase). Meanwhile, the lowest average (-0.09%) was for the same index using the t_{-1}-t_{+1} window. In the case of medians, the highest was noted on new moon days for the sWIG80 index in the window t_0 (0.57%), and the lowest for the new moon for the WIG20 index in the window t_{-1}-t_{+1} (-0.24%). By analysing the data in Table 1, it can be seen that the greatest differences in average returns between sessions connected to the new and full moon occurred in the t_0 event window, which included only the day of the studied moon phase (without adjacent days). Interestingly, both measures of average values (the mean and the median) showed higher readings in each of the studied indices on new moon days than on full moon days, which is in line with the assumption of the lunar effect (Dichev, Janes, 2003; Gao, 2009). In the case of extending the event window, the differences between the returns on new moon and full moon days decrease. It is also worth underlining that the differences in the medians between returns on new moon and full moon days (t_0 window) rise along with a decline in the market capitalisation of issuers grouped in the index. This contrasts with researchers' previous findings regarding the Polish financial market, which showed that the differences between returns during a new and full moon were lower for the index grouping smaller companies on the WSE (Lizińska, 2017).

Along with an extension of the event window (t_{-1}-t_{+1}-one day before and after the new/full moon phase), the differences in returns on days adjacent to the studied moon phases did not indicate a clear advantage of those days accompanying a new moon over the days adjacent to a full moon. There are even findings which show that average returns on full moon days were higher than those on new moon days, which somewhat contradicts the lunar effect (Herbst, 2007). These results allow an interesting conclusion to be drawn. Namely, the dependencies observed so far related to the lunar effect on investor behaviour on the Polish stock exchange in the times of heightened uncertainty could have occurred only on new moon and full moon days. Days adjacent to these phases do not show similar dependencies. However, in order to confirm this conclusion, it is necessary to conduct statistical verification of the results.

To do this it was necessary to verify whether on individual days in the adopted event windows the calculated returns significantly differed from zero. If their statistical significance is positively verified, it becomes necessary to adopt the H1 and/or H2 hypothesis presented into the Introduction. This in turn would indicate the occurrence of the lunar effect noted earlier on global financial markets (Dichev & Janes, 2003; Gao, 2009; Floros & Tan, 2013; Lisicki, 2025b) in periods of above average volatility in the prices of stocks caused by the previously mentioned 'black swans' (Taleb, 2010) on the indices quoted on the WSE.

At the beginning of the statistical verification, a necessary step was to verify the normality of the distribution of the studied returns. This test allowed us to indicate the use of a parametric or nonparametric test, respectively, verifying that the average values of the calculated returns for the WSE indices were significantly different from zero. To this case have been used: Shapiro-Wilk (1965) and Anderson-Darling tests for normality (1954). They showed that the analysed returns (in the major part of selected groups of variables) did not have a normal (or close to normal) distribution ($p<0,05$), which also confirms prior observations indicateda distribution of returns different from normal (Piasecki, Tomasik, 2013). Therefore, natural solution would seem to be to use the Wilcoxon signed-rank test, also known as the Wilcoxon single-sample test (1945) to verify the zero hypothesis that the median value of returns calculated on new moon and full moon days for selected WSE indices is equal to indicated value (zero). This is a non-parametric equivalent of parametric tests for one variables (such as single-sample t-test), whose application is only possible if the assumption of normal distribution of the studied variables is met (which was not noted in the selected research sample).

Table 2 below contains the median returns and the W test statistic, as well as the results of the Wilcoxon signed-rank for single-sample test, for daily returns for the studied WSE indices in the indicated event windows, together with their p value level of significance.

The information in Table 2 presenting the Wilcoxon signed-rank for single-sample test statistics shows for which of the studied returns for WSE indices accompanying new and full moon days there was a statistical significance indicating values considerably different from zero. It can be seen immediately that there are median values significantly higher than zero for all the studied indices on new moon days. On full moon days, statistical significance only relates to the research results calculated for the sWIG80 index. The results are similar to the findings of earlier research conducted into the lunar effect on the Polish market in the years 1991-2015 on the research sample, which covered the same main indices of the WSE (Borowski, 2015; Lizińska, 2017). Then, the authors only found an effect of the new moon on investor behaviour. In this research, there is one case of a statistically significant effect of the full moon on WSE investor behaviour (sWIG80), however, the effect of the new moon is much more clearly visible. These results are somewhat unexpected, as in prior research into the psychological motives for people's behaviour, the full moon phase was considered to have a greater effect on people than the new moon phase (Mathew et al., 1991; Zimecki, 2006; Lagana et al., 2014; Mittal et al., 2021; Gierszewski, Dobrowolski; 2024). For the sake of clarity, it should be noted that in increasing the event window to include days immediately adjacent to the studied lunar phases (t_{-1}-t_{+1}), statistically significant returns were found only for the new moon for one index

(sWIG80). These results may show that in times of heightened volatility on markets, WSE indices may be susceptible to the lunar effect only on the day of the current phase. Wherein the effect of the day of the new moon is particularly noticeable. These results differ from those noted earlier for the WSE (Borowski, 2016), which showed that the single session average on days of particular lunar phases was not significantly different from zero.

Table 2

Wilcoxon signed-rank for single-sample test statistics for daily returns for the selected WSE indices in the days adjacent to full (F) and new (N) moon days

Index/ test statistic	Median	W	z	p value
t_{-1}-t_{+1} N=117 (39 cases x 3 days event widnow each of them)				
WIG F	0.17%	3027	-1.15	0.249
WIG N	-0.09%	3431	-0.06	0.956
WIG20 F	0.12%	3123	-0.89	0.372
WIG20 N	-0.24%	3196	-0.69	0.487
mWIG40 F	0.14%	3028	-1.15	0.249
mWIG40 N	0.08%	2956	-1.35	0.178
sWIG80 F	0.14%	2785	-1.54	0.123
sWIG80 N	0.22%	2299	-3.13	0.002***
t_0 N=39				
WIG F	0.21%	322	-0.95	0.343
WIG N	0.31%	256	-1.87	0.061*
WIG20 F	0.14%	328	-0.87	0.387
WIG20 N	0.27%	272	-1.64	0.097*
mWIG40 F	0.25%	301	-1.24	0.214
mWIG40 N	0.54%	256	-1.87	0.061*
sWIG80 F	0.17%	264	-1.74	0.083*
sWIG80 N	0.57%	221	-2.37	0.018**

Source: Authors' results.

These results can be explained as an expression of reinforcement of the investors' sentiment on market anomalies, which is especially noticeable under conditions of increased market volatility (Yang et al., 2025). Based on this finding, it can be assumed that the full explanatory power of market anomalies observed on the global stock markets occurs only during a specific period related to its type (day, week, month etc.). After this period ends, the market returns to "normality" without demonstrating significant variability in the analyzed returns. However, to confirm the value of the obtained results in the time of increased volatility on financial markets are is necessary for verifying this anomaly for the Polish market on a broader sample (e.g., sector indices, shares of individual issuers).

Also of interest is the result which shows that median returns are negatively correlated with an increase in the capitalisation of companies grouped in particular indices. The lowest statistically significant median was for the index including the 20 largest companies on the WSE – the WIG20 (0.27%). Meanwhile, the highest was noted for the sWIG80 index, which includes 80 small companies (0.57%). Moreover, in the case of the latter, daily returns statistically significant from zero were only noted on full moon days. The average value was positive (0.17%), but was considerably lower than the value noted on new moon days. The results show that in a turbulent economic environment, it is small companies that can be particularly susceptible to the lunar effect, which contrasts with the results of research into the WSE in times of greater predictability on financial markets (Lizińska, 2017).

The results presented above provide positive verification for the hypothesis H1 and negative verification for the hypothesis H2 proposed at the beginning of this paper. In the period of heightened volatility of the prices of stocks observed in the years 2020-2024, the lunar effect can be observed among

stock indices on the WSE, manifesting itself in statistically significant median of the daily returns higher than zero on new moon days (H1). However, on full moon days, median of the returns were not found to be statistically significant for major part of the research sample (H2). The results confirm conclusions reached in the majority of prior studies (Dichev, Janes, 2003; Gao, 2009). Moreover, among emerging markets, to which Poland belongs, this effect has been observed considerably more often for the new moon than the full moon (Floros, Tan, 2013; Borowski, 2015, Lizińska, 2017). However, the 'black swans' that have affected markets in recent years and have led to above average volatility on markets have resulted in certain changes in the lunar effect on the WSE, manifested in previously unnoted statistically significant daily returns on new moon days, but not on days adjacent to them (Borowski, 2016), and a negative correlation between daily returns on lunar phase days and the market capitalisation of companies listed on the studied indices (Lizińska, 2017). This is an interesting starting point for further considerations on this anomaly in the context of the Polish stock market.

5. CONCLUSION

One of the categories of deviations from the efficient market hypothesis (Fama, 1965) is the anomaly which depends investor behaviour on the phases of the moon (Ariel, 1987; Dichev, Janes, 2003; Borowski, 2015; 2016). According to the results of research by authors verifying this effect in earlier years, returns on investments were at a higher level during the new moon than on days accompanying a full moon (Kramer, Weber; 2012; Yousop, Sipon, Yoke, 2014). The principal aim of this paper was to verify the occurrence of this anomaly among selected indices quoted on the WSE in the years 2020-2024. This time period was characterised by heightened uncertainty (volatility) of prices on the global financial markets, which could have been of importance with regard to the further development of the selected market anomaly. The author's aim was to use the example of the WSE to verify whether the heightened volatility of the prices of financial instruments disrupted the previously noted dependencies relating to the lunar effect on investor behaviour.

Based on the prices of main WSE stock market indices (WIG, WIG20, mWIG40 and sWIG80, which were the only financial instruments verified in terms of the moon phases effect in recent years and with respect to which earlier research results it is possible to apply certain comparisons in this paper in the years 2020-2024, daily logarithmic returns were calculated in two event windows: one-day, covering only the day of the analysed lunar phase (t_0), and three-day, covering respectively one session day before and one after a specific lunar phase (t_{-1}-t_{+1}). Importantly, included in the research sample were only those full moon and new moon days (39 cases out of 62 each) which occurred in exact periods of heightened volatility of market prices, verified by values of the VIX fear index exceeding the cut-off value of 20 separating the standard volatility from above-average volatility (Investing, 2024).

The research results in times of heightened uncertainty allow for verification of the main hypotheses stated at the beginning of the paper:

H1: In the periods of increased uncertainty observed in 2020-2024, it is possible to observe that average value of returns on the main WSE indices is significantly higher than zero on days adjacent to a new moon.

H2: In the periods of increased uncertainty observed in 2020-2024, it is possible to observe that average value of returns on the main WSE indices is significantly lower than zero on days adjacent to a full moon.

In the times of increased volatility of stock prices observed in the years 2020-2024, the lunar effect can be observed among the main WSE indices, manifesting itself in the occurrence of statistically significant higher than zero daily returns on new moon days (only). This allows to accept the main hypothesis H1 proposed at the beginning of the paper. Nevertheless, this effect was not confirmed by the occurrence of median of returns significantly lower from zero among the studied indices on full moon days (except for one case, sWIG80 index). Therefore, it was necessary to reject the proposed main hypothesis H2. In

addition, it can be seen that widening the event window to include days adjacent to the day of a specific lunar phase did not, in the majority of cases, show significantly different returns, which contrasts with previous results obtained from verifying the lunar effect on the WSE (Borowski, 2016) on the same research sample. Somewhat surprising is also the negative correlation between the size of listed issuers with the strength of the lunar effect, which was not found earlier for the WSE (Lizińska, 2017). This provides the basis for further considerations into the occurrence of non-standard market anomalies on the WSE stock market (such as the lunar effect studied here), which are considerably less often verified than the more well-known classic calendar anomalies (Lisicki, 2018; Szymański, Wojtalik, 2020; Żebrowska-Suchodolska, 2021).

The research implications of this study for the extant body of research warrant further consideration into biases in the assumptions of the efficient market hypothesis (not only using the example of calendar anomalies). As can be seen from the research presented so far, increased market volatility has not caused such biases to disappear. They have continued to occur in the indicated research sample, and should be understood on the one hand as a real deviation from the principles presented by E. Fama (1965). On the other hand, they should be seen as an investment opportunity for achieving above-average profits (Pera, 2019).

Nevertheless, this paper has some limitations, one of which is the interdisciplinary nature of the research. The author has made an attempt to include the psychological impact on investor behaviour, while the results are focused to a greater degree on researchers of financial markets than those involved in psychology. Another limitation is the small research sample, which focuses only on a narrow group of the main indices quoted on the WSE. The author's intention was above all to draw attention to the essence of a relatively untypical anomaly that has been studied extremely rarely with regard to the Polish stock market, and verifying its presence on the same sample used by earlier researchers (Borowski, 2015; 2016; Lizińska, 2017). Such research was aimed at determining whether, in an times of above-average volatility on global markets on the WSE, it was possible to observe previously detected dependencies regarding deviations from the efficient market hypothesis (Fama, 1965). In further research, the author wishes to address the topic using a broader sample of financial instruments listed on the WSE, such as, sector indices or shares of individual issuers. That research procedure will constitute an extension to and possible confirmation of the results about lunar effect of the research presented in this paper and would also be beneficial for examining the robustness of them

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