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Calendar anomalies among food sector companies listed on the Warsaw Stock Exchange

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Abstract. One of the types of anomalies in the capital market are calendar anomalies. They are associated with the occurrence of various calendar relationships in the rates of return. The aim of this study is to examine whether calendar effects occur for companies in the food industry and the WIG-food index. More specifically, the article examines the occurrence of such anomalies for 14 companies in the food industry and the WIG-food index. It focuses on the effects of the day of the week, the month of the year and the half of the year. The study covers the period from December 2007 to January 2019, divided into three shorter sub-periods, and uses daily percentage logarithmic return rates. The method applied is a linear regression model, and the data was drawn from the stooq.pl website. The day of the week effect was found for Wawel in the 1st examined sub-period and for Astarta in the 2nd sub-period. The effect of the month of the year was observed for Pamapol and Seko in the 1st sub-period. The effect of the half of the year did not occur for any of the surveyed companies. Particular statistically significant variables indicate the presence of variability over time, both in the case of days of the week and months of the year. What was also observed was diminishing of the above-mentioned effects from period to period.

Keywords: stock exchange, food sector, calendar effects, regression model
JEL: C01, C12, C22, G14

Anomalie kalendarzowe branży spożywczej na Giełdzie Papierów Wartościowych w Warszawie

Streszczenie. Jednym z rodzajów anomalii występujących na rynku kapitałowym są anomalie kalendarzowe. Wiążą się one z istnieniem różnych zależności o charakterze kalendarzowym w stopach zwrotu. Celem badania omawianego w artykule jest sprawdzenie, czy efekty kalendarzowe zachodzą w przypadku spółek z branży spożywczej oraz indeksu WIG-spożywczy. Zbadano występowanie tych anomalii w 14 spółkach z branży spożywczej oraz indeksie WIG-spożywczy. Skupiono się na trzech efektach kalendarzowych: dnia tygodnia, miesiąca w roku i połowy roku. Wykorzystano dane pobrane ze strony stooq.pl, obejmujące okres od grudnia 2007 do stycznia 2019, podzielony na trzy podokresy. W badaniu wykorzystano procentowe dzienne logarytmiczne stopy zwrotu. Zastosowano model regresji liniowej. Stwierdzono występowanie efektu dnia tygodnia dla spółek Wawel w I badanym podokresie oraz Astarta w II podokresie. Efekt miesiąca w roku zaobserwowano dla spółek Pamapol i Seko w I podokre-

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sie. Efekt połowy roku nie wystąpił wśród badanych spółek. Poszczególne statystycznie istotne zmienne wskazują na istnienie zmienności w czasie zarówno dni tygodnia, jak i miesięcy w roku. Można również zaobserwować zanikanie badanych efektów z okresu na okres.

Słowa kluczowe: giełda papierów wartościowych, sektor spożywczy, efekty kalendarzowe, model regresji

1. Introduction

The concept of calendar effects is understood as the systematic occurrence of various regularities in rates of return. They can appear both for individual stocks and stock market indices. Due to the existence of numerous anomalies, they are a frequent subject of research in many markets and for various research periods. The calendar anomalies include the effects of the day of the week, the week of the month, the month of the year (especially of January and December), or the effect of the half of the year.

Studies of calendar anomalies can also be carried out in the context of informational efficiency. Their existence could contradict efficiency in a weak form. Information efficiency of the market means that the price incorporates all available information (Fama, 1970). Depending on the type of information, three forms of information efficiency are distinguished: weak, medium and strong. If the market is efficient in a weak form, then current prices reflect all the information contained in historical prices. Therefore, they cannot be used to forecast future price changes and investors cannot achieve above-average profits on the basis of historical data. It is not possible, therefore, to consistently achieve better rates of return, because prices follow the random walk process of Brealey and Myers (2006).

The research focuses on companies that are part of the food sector represented on the Warsaw Stock Exchange (WSE) by the WIG-food index. In addition to food industry companies, the research also examines the WIG-food index. It is an index published since 1998, which consists of companies from the food industry that are present on the WIG index (WIG is an index encompassing all companies from the Main Market of the Warsaw Stock Exchange). The WIG index has mechanisms which prevent any sector to claim more than 30% of it.

As studies of anomalies tend to focus on major market indices, sectoral studies are lacking in this respect. Sectoral analyses accurately reflect the situation of individual branches of the economy. The food sector, despite its relatively small share in the market, is an important element of it due to the fact that it determines internal consumption, which in turn influences the generation of GDP. Hence, the paper focuses on the food sector, but the adopted methodology can also be applied to other sectors of the economy. The aim of the research is therefore to verify whether calendar effects occur in the case of companies from the food industry and the WIG-food index. The research focused on three calendar effects: the effect of the day of the week, the effect of the month of the year and the half-year effect.

2. Literature review

Anomalies occurring in the capital market can be divided into calendar anomalies, anomalies related to delayed market reactions to incoming information, deviations related to market overreaction, and anomalies concerning the size of companies (Szyszka, 2003, p. 61). Due to the fact that the information efficiency of the market in a weak form has been the subject of numerous studies for a considerable number of years, research on anomalies, especially calendar anomalies, is an inseparable element of it (Dragota & Oprea, 2014; Muhammad & Rahman, 2010; Rossi, 2015).

The effect of the day of the week depends on the occurrence of a higher or lower average rate of return on one of the days of the week. Depending on the country, this average may fall on a completely different day. The effect of the day of the week was first observed for the American market in the studies of French (1980), Gibbons and Hess (1981), Harris (1986), Rogalski (1984) and Smirlock and Starks (1986). They pointed to the lowest rate of return on Mondays and the highest on Fridays. In the case of Japan and Australia, the lowest daily rate of return was observed on Tuesdays (Jaffe & Westerfield, 1989).

The effect of the month of the year is associated with the existence of a higher or lower rate of return in one of the months. This effect applies especially to such months as January and December, hence the literature often refers to the effect of January or December. In December, prices fall most often, after which they increase in January. The effect of the month of the year was observed for the US market by e.g. Rozeff and Kinney Jr. (1976) and Tinic and West (1984), and concerned mainly small companies. As regards the markets of other countries, this effect is described by e.g. Gultekin and Gultekin (1983), Kohers and Kohli (1991), Ritter and Chopra (1989), and Roll (1983).

Half-year effect was documented for e.g. the Japanese market. Sakakibara et al. (2013) noted that the results of return rates in the first half of the year were higher than in the second. Another variation of this anomaly was the occurrence of a lower rate of return from May to October compared to the period from November to April (Abu Zarour, 2007, pp. 68–76). Half-year effect is also called the mid-year effect. This anomaly is less frequently studied in the literature compared to the effects of the day of the week or the month of the year.

The study of calendar anomalies initiated by the aforementioned authors continues until today. Studies conducted in recent years often focus on alternative investments such as cryptocurrencies (Caporale & Plastun, 2019; Qadan et al., 2021), on African markets (Bashir & Adeleke, 2019; Obalade & Muzindutsi, 2019), or on Asian markets (Abraham, 2016; Kumar & Rachna, 2017; Singh & Das, 2020). One can also find studies for G20 (Mishra, 2017) or BRIC countries (Kinateder et al., 2019). Many of these studies are conducted using regression and GARCH models (Kumar & Rachna, 2017; Mishra, 2017; Singh & Das, 2020).

In the case of the Polish market, extensive anomaly research was carried out by e.g. Buczek (2005), Skrodzka and Włodarczyk (2004), and Szyszka (2003). Szyszka's studies for companies and indices from 1994–1999 indicated a higher, and in most cases statistically significant average for Monday. He also pointed to the regularities occurring for Tuesday. For 25 of the 29 companies, Tuesday's daily rates of return were on average negative, but not always the lowest. In the breakdown into annual sub-periods, in the most of them the highest average rates of return were observed on Mondays. However, other days were found, such as Wednesday, for which there also was a sub-period with the highest average value. Buczek's research concerned a different period, i.e. 2001–2004. It was conducted for 65 companies and the entire market represented by the WIG index. Its results show that the effect of Monday was disappearing, and Friday became the day with the highest price change. Other studies on anomalies include the works of Kompa and Matuszewska (2007) and Landmesser (2006). Depending on the research period and values adopted, the days on which the highest rates of return occurred were changing. Kompa and Matuszewska's research carried out for 6 WSE indices and 7 WIG sub-indices in the years 2002–2006 confirmed the occurrence of the Friday effect. Landmesser's research, on the other hand, carried out for four WSE indices and five companies in the years showed the effect of Monday and Friday. Calendar anomalies of one of companies from the food sector were examined by Budka et al. (2017). The research was conducted for the period 2013–2015 and analysed the effect of the day of the week and month. The results indicated that there was no anomaly for that particular company.

Due to the fact that calendar anomalies change over time, they are subject to research all the time. From among more recent studies concerning the Polish market, works by Borowski (2018), Keller (2015), Lizińska (2017) or Szymański and Wojtalik (2019) should be mentioned in this context.

The day-of-week effect for WIG20, mWIG40, sWIG80 indices was studied by Keller (2015) using regression and ARCH models. Borowski (2018) studied returns for the months of December and January using linear regression for his research. Lizińska (2017) looked for calendar anomalies (mid-month effect, January effect, turn of the month effect) using cumulative returns and comparing them with buy-and-hold returns. Szymański and Wojtalik (2019) focused on alternative market indices in Warsaw and London using regression and GARCH class models. Anomalies based on company characteristics or fundamental anomalies were studied by Zaremba and Żmudziński (2014) and Zaremba et al. (2016).

3. Research methodology

The division of the entire market into particular sectors enables investors to select the industry first, and then to choose the company which is worth investing in. The main market of the Warsaw Stock Exchange encompasses 464 companies. It would be difficult to directly select one of them. The concept of division into branches appeared at the end of 1998, when 198 companies were listed, including 132 on the primary market (Giełda Papierów Wartościowych w Warszawie, 1999). They were then grouped into 5 industries: banks, construction, IT, food and telecommunication.

The food industry is key for the Polish economy. However, this does not translate into the results of the WIG-food index, which is dominated by Ukrainian companies (accounting for almost 70% of the index). What significantly affects the value of this index is therefore the exchange rate of the Ukrainian hryvnia and financial results of Kernel, Ukrainian large food producer.

The capitalization of the food sector represents about 0.9% of the capitalization of companies from the WIG index. As of 22 March 2019, the capitalization of companies encompassed in the WIG-food amounted to 10.84 billion PLN (and the capitalization of those in the whole WIG 118.73 billion PLN). The WIG-food index currently consists of 22 companies, 14 of which (Table 1) have been there since the end of 2007. Our study concentrates on these 14 companies. They are mostly Polish businesses, but due to low capitalization (between EUR 5–50 million), their share in the WIG-food index is small. The only large Polish company listed in the WIG-food is Wawel. It has an over 15%-share in the whole index, which makes it the second largest company there, with just Kernel ahead. Kruszwica and Ambra, both medium-sized companies, should also be mentioned here, with the shares of 2.74% and 3.99% of the WIG-food index, respectively. Among the 14 surveyed companies, two are Ukrainian (including Kernel that represents over 54% of the index). Most of the analysed companies deal with food production, three of them are beverage producers, and one (Astarta), deals with agricultural production and fishing.

The research for the WIG-food index and companies from this sector was carried out in the period from December 2007 to January 2019. The secondary data was taken from the stooq.pl website. The calculations were made in Excel and Gretl.

Table 1. Analysed companies from the food sector

Company	Share in the WIG-food index in %
Ambra	3.99
Astarta	6.07
Atlantapl	0.28
Gobarto	0.87
Helio	0.30
Indykpol	2.04
Kernel	54.49
Kruszwica	2.74
Makaronpl	0.38
Mbws	0.03
Pamapol	0.25
Pepees	0.43
Seko	0.62
Wawel	15.30

Source: author's work based on data from stooq.pl.

The study of calendar effects can be carried out using various types of methods, for example statistical tests or econometric methods, including a regression model that was used in this work. The research was based on logarithmic rates of return, which were set for daily closing prices. They were an explanatory variable in the created linear regression models. In order to study the effect of the day of the week, the model based on French (1980), Gibbons and Hess (1981) and Keim and Stambaugh (1986) was applied:

$$r_t = a_{mon}x_{mon,t} + a_{tue}x_{tue,t} + a_{wed}x_{wed,t} + a_{thu}\, x_{thu,t} \; + a_{fri}x_{fri,t} + e_t, \quad (1)$$

where:
r_t – daily logarithm of rate of return at the moment;
$x_{i,t}$ – a dummy variable satisfying the condition $x_{i,t} = 1$, where t is the i-th day of the week ($i = mon, tue, wed, thu, fri$), and 0 otherwise;
$a_{mon}, a_{tue}, a_{wed}, a_{thu}, a_{fri}$ – regression coefficients for subsequent days of the week;
e_t – error term.

Model parameters (3) were estimated using the linear least square method, for which a null hypothesis was made:

$$H_0\colon a_{mon} = a_{tue} = a_{wed} = a_{thu} = a_{fri}, \quad (2)$$

to the alternative hypothesis that at least one of the parameters is different from the others. The hypothesis that there was no effect of the day of the week was verified using F-statistics on the Fisher-Snedecor distribution:

$$F = \frac{R^2/m}{(1-R^2)/(T-m-1)}. \tag{3}$$

Then, when model coefficients (1) were present, individual variables were verified. The following hypothesis was proposed:

$$H_0: a_i = 0. \tag{4}$$

where i is the day of the week.

The t statistic has (assuming true zero hypothesis) the t-Student distribution with $T-(m+1)$ degrees of freedom.

$$t = \frac{a_i}{SE_{a_i}}, \tag{5}$$

where SE_{a_i} is average error of estimation of parameter a_i.

To assess the occurrence of the effect of the month of the year, analogical reasoning was repeated. The following model was verified:

$$\begin{gathered} r_t = a_{jan}x_{jan,t} + a_{feb}x_{feb,t} + a_{mar}x_{mar,t} + a_{apr}x_{apr,t} + a_{may}x_{may,t} + \\ + a_{jun}x_{jun,t} + a_{jul}x_{jul,t} + a_{aug}x_{aug,t} + a_{sep}x_{sep,t} + a_{oct}x_{oct,t} + \\ + a_{nov}x_{nov,t} + a_{dec}x_{dec,t} + e_t, \end{gathered} \tag{6}$$

where:

$x_{jan,t}, x_{feb,t}, x_{mar,t}, x_{apr,t}, x_{may,t}, x_{jun,t}, x_{jul,t}, x_{aug,t}, x_{sep,t}, x_{oct,t}, x_{nov,t}, x_{dec,t}$ – a dummy variable satisfying the condition $x_{i,t} = 1$, where t is the i-th month of the year ($i = jan, feb, mar, apr, may, jun, jul, aug, sep, oct, nov, dec$), and 0 otherwise;

$a_{jan}, a_{feb}, a_{mar}, a_{apr}, a_{may}, a_{jun}, a_{jul}, a_{aug}, a_{sep}, a_{oct}, a_{nov}, a_{dec}$ – regression coefficients for subsequent months;

e_t – error term.

The last analysed anomaly was the effect of the half of the year, where the verified model was:

$$r_t = a_{\mathrm{I}} x_{\mathrm{I},t} + a_{\mathrm{II}} x_{\mathrm{II},t} + e_t, \tag{7}$$

where:

$a_{\mathrm{I}}, a_{\mathrm{II}}$ – regression coefficients for the relevant half of the year;

$x_{\mathrm{I},t}, x_{\mathrm{II},t}$ – a dummy variable that satisfies the condition $x_{i,t} = 1$, where t is the i-th half of the year, and 0 otherwise;

e_t – error term.

The models presented above, estimated by OLS, might yield incorrect estimations of model parameters due to the fact that they operate on the basis of financial data. Therefore, in order to take into account the presence of autocorrelation and heteroscedasticity, the study was extended by using GARCH class models for companies in which the anomaly was found. As the most commonly used model is GARCH(1,1) (Piontek, 2004), equations (1), (6) and (7) were extended by adding a lag for the rate of return and an equation describing the conditional variance σ_t^2. They took the following forms:

$$\begin{gathered} r_t = ar_{t-1} + a_{mon} x_{mon,t} + a_{tue} x_{tue,t} + a_{wed} x_{wed,t} + a_{thu} x_{thu,t} + \\ + a_{fri} x_{fri,t} + e_t, \\ \sigma_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \beta_1 \sigma_{t-1}^2, \end{gathered} \tag{8}$$

$$\begin{gathered} r_t = ar_{t-1} + a_{jan} x_{jan,t} + a_{feb} x_{feb,t} + a_{mar} x_{mar,t} + a_{apr} x_{apr,t} + \\ + a_{may} x_{may,t} + a_{jun} x_{jun,t} + a_{jul} x_{jul,t} + a_{aug} x_{aug,t} + a_{sep} x_{sep,t} + \\ + a_{oct} x_{oct,t} + a_{nov} x_{nov,t} + a_{dec} x_{dec,t} + e_t, \\ \sigma_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \beta_1 \sigma_{t-1}^2, \end{gathered} \tag{9}$$

$$\begin{gathered} r_t = ar_{t-1} + a_{\mathrm{I}} x_{\mathrm{I},t} + a_{\mathrm{II}} x_{\mathrm{II},t} + e_t, \\ \sigma_t^2 = \alpha_0 + \alpha_1 e_{t-1}^2 + \beta_1 \sigma_{t-1}^2, \end{gathered} \tag{10}$$

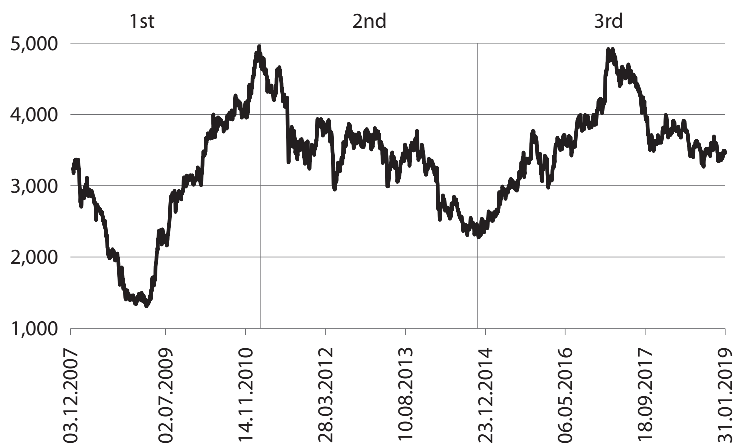
where $\alpha_0 > 0$, $\alpha_1 \geq 0, \beta_1 \geq 0$.

4. Results

The trading history of the WIG-food index (Figure) indicates that during the audited period there was a change in the stock market situation. After a period of crisis between 2007 and 2009, there was a growth, followed by a relapse of the crisis from 2011 onwards due to several factors, including problems of the eurozone. For this reason, the whole period was divided into three shorter sub-periods. These were: the

1st sub-period from 3 December 2007 to 9 March 2011, the 2nd sub-period from 10 March 2011 to 13 November 2014, and the 3rd sub-period from 14 November 2014 to 31 January 2019. In Figure, vertical lines separate individual sub-periods from each other. The first sub-period is the period of the financial crisis and just after it. The second sub-period is the time of the economic upturn, and the third one is the time characterised by the volatility of the economic situation, including a significant economic upturn. The research ends in early 2019, as the author did not want to include another crisis caused by a pandemic outbreak in the research.

Figure. Quotations of the WIG-food index in the years 2007–2019



Source: author's work based on data from stooq.pl.

Logarithmic rates of return were determined for daily closing prices of food companies and the WIG-food index. They were divided into particular days of the week and average rates of return were calculated for the three sub-periods (Tables 2–4).

The first sub-period of the research, due to the financial crisis occurring at that time, was characterized by a high volatility of price quotations and return rates. Analysing extreme values for each company, it could be observed that the highest average rates of return occurred on Wednesdays, and the lowest on Mondays and Tuesdays. In the case of the WIG-food index, the highest rates were observed on Fridays, and the lowest on Mondays. In the whole first sub-period, the most positive average rates of return occurred on Wednesdays, and the most negative ones on Mondays.

Table 2. Average daily rates of return in % results in the first sub-period

Company	Mon	Tue	Wed	Thu	Fri
Ambra	–0.1140	0.0045	–0.0386	–0.3622	0.3375
Astarta	0.0053	0.1687	0.0780	0.6395	–0.0657
Atlantapl	0.2479	–0.4658	0.2798	0.1340	–0.1072
Gobarto	–0.5151	0.1643	0.1503	–0.3820	–0.3699
Helio	0.1640	–0.1949	–0.0606	0.2868	0.2866
Indykpol	–0.0171	–0.0780	–0.2432	–0.2397	0.0504
Kernel	0.0886	0.0659	0.1419	0.2488	0.2080
Kruszwica	–0.0637	0.1432	0.0569	0.0082	0.2006
Makaronpl	–0.2156	–0.0011	–0.0533	0.3317	0.1495
Mbws	0.0412	–0.2095	0.2352	–0.5367	–0.0319
Pamapol	–0.3353	–0.1509	0.2769	–0.4142	–0.3292
Pepees	–0.2244	–0.4095	0.1654	0.1371	–0.0193
Seko	–0.0032	–0.0975	0.0699	–0.1066	–0.2197
Wawel	–0.3933	0.1771	0.1916	–0.0466	0.4800
WIG-food index	–0.0736	0.0448	0.0757	0.0239	0.1608

Source: author's work based on data from stooq.pl.

In the second analysed sub-period, where negative average rates of return prevailed, the largest number of extremely high rates of return for the surveyed companies occurred on Tuesdays, and the largest number of extremely low rates of return on Mondays. This result coincides with the maximum value of 0.39% for Tuesday and the minimum of –0.82% for Monday. However, considering the number of positive and negative returns for companies on particular days of the week, the most positive values appeared on Tuesdays and Fridays, and the most negative ones on Mondays and Wednesdays. In the case of the WIG-food index, the extremely high average rate of return occurred on Tuesdays and the lowest on Thursdays (Table 3).

Table 3. Average daily rates of return in % results in the second sub-period

Company	Mon	Tue	Wed	Thu	Fri
Ambra	–0.2833	0.2515	0.0289	–0.1730	0.2583
Astarta	–0.1985	0.3617	–0.0535	–0.5729	–0.3501
Atlantapl	–0.5970	0.3884	0.0147	0.0719	0.0328
Gobarto	–0.3200	0.1436	–0.0590	–0.2254	0.0201
Helio	–0.4096	0.1029	–0.0892	–0.2223	0.0952
Indykpol	–0.1211	–0.0345	–0.0299	0.1057	–0.0293
Kernel	–0.0341	0.0346	–0.2620	–0.2984	–0.1105
Kruszwica	0.0248	0.0534	–0.2137	–0.0408	0.0667
Makaronpl	0.1915	0.0476	–0.2853	–0.2423	0.1892
Mbws	–0.3827	0.3290	–0.0490	–0.7730	–0.0396
Pamapol	–0.8165	–0.2062	–0.1734	–0.0826	0.0204
Pepees	–0.1637	–0.1773	0.1085	–0.2154	0.3765
Seko	–0.1530	–0.2458	–0.3483	0.3753	0.1045
Wawel	0.0899	0.0833	–0.0300	0.1809	0.1081
WIG-food index	–0.0326	0.0751	–0.1670	–0.2089	–0.0597

Source: author's work based on data from stooq.pl.

In the third sub-period, the largest number of extremely high average rates of return for individual companies occurred on Wednesdays and Thursdays. Extremely low values usually occurred on Tuesdays. This did not translate into a number of positive and negative rates of return. Most positive values were observed on Fridays and most negative ones on Mondays. The maximum value for the considered companies in the whole period amounted to 0.35% and occurred on Thursdays, and the minimal value, equal to –0.38%, on Tuesdays. In the case of the WIG-food index, the highest values occurred on Tuesdays and the lowest on Wednesdays, as demonstrated in Table 4.

Table 4. Average daily rates of return in % results in the third sub-period

Company	Mon	Tue	Wed	Thu	Fri
Ambra	0.0150	0.1495	0.0927	0.0656	–0.0047
Astarta	–0.0165	0.0458	–0.0916	0.1476	0.0091
Atlantapl	–0.1326	–0.0833	–0.0808	–0.0872	0.2011
Gobarto	–0.0696	–0.0777	0.0703	0.1524	–0.0525
Helio	0.1677	–0.3847	0.2554	–0.0139	0.1511
Indykpol	–0.0289	0.0261	–0.0552	–0.0927	0.3074
Kernel	0.0163	–0.1928	0.3057	0.2479	0.0213
Kruszwica	0.2084	–0.1232	–0.0325	–0.1380	0.0665
Makaronpl	–0.2956	0.0937	–0.1721	0.3539	–0.0548
Mbws	–0.2386	–0.0301	–0.1525	–0.1808	–0.1568
Pamapol	0.1307	–0.2705	0.2542	–0.0872	0.0351
Pepees	–0.0814	0.1092	0.1225	0.1727	0.0655
Seko	–0.0793	–0.1101	–0.0499	0.2174	0.3180
Wawel	–0.0009	0.0267	0.1100	–0.0651	–0.0899
WIG-food index	0.0196	–0.0815	0.1881	0.1080	–0.0354

Source: author's work based on data from stooq.pl.

The next step was to estimate the parameters of model (1) to indicate the companies and sub-periods in which the hypothesis of the total equality of the model parameters was rejected. The research was carried out using Gretl software for the significance level 0,05. Only two such cases were found in all sub-periods examined (Table 5). All parameters of model (1) that were significantly different from each other for individual days of the week occurred for Wawel in the first sub-period and Astarta in the second sub-period.

Table 5. Cases of rejection of the null hypothesis about the significance of model (1) parameters

Company	Sub-period	*F*	*p*-value
Wawel	1st	2.7742	0.0171
Astarta	2nd	3.0133	0.0105

Source: author's work based on data from stooq.pl.

Then, individual variables of model (1) were verified. Table 6 presents the results of the statistical study of the significance of the impact of particular days of the week on the value of daily rates of return. For the 14 companies and one stock exchange index in the three sub-periods examined, individual variables of the model were relevant only in seven cases. It should be remembered, however, that the null hypothesis (2) was rejected only for two companies: Astarta in the second sub-period and Wawel in the first sub-period. In the case of these companies, statistically significant factors occurred on Thursdays (for Astarta) and on Mondays and Fridays (for Wawel). Considering all the sub-periods, it can be concluded that the most statistically significant single model variables occurred for Thursday.

Table 6. Cases of rejection of the hypothesis about the significance of individual variables ($a_{mon}, a_{tue}, a_{wed}, a_{thu}, a_{fri}$) in model (1)

Company	Sub-period	Mon	Tue	Wed	Thu	Fri
Astarta	1st	0.0053	0.1687	0.0780	0.6395*	–0.0657
Wawel	1st	–0.3933*	0.1771	0.1916	–0.0466	0.4800*
Astarta	2nd	–0.1985	0.3617	–0.0535	–0.5729*	–0.3501
Mbws	2nd	–0.3827	0.3290	–0.0490	–0.7730*	–0.0396
Pamapol	2nd	–0.8165*	–0.2062	–0.1734	–0.0826	0.0204
Kernel	3rd	0.0163	–0.1928	0.3057*	0.2479	0.0213
WIG-food index	3rd	0.0196	–0.0815	0.1881*	0.1080	–0.0354

Note. * – statistically significant value at the significance level of 0.05.
Source: author's work based on data from stooq.pl.

By performing a similar reasoning as in the case of the effect of the day of the week, model (6) was verified. The hypothesis about the total equality of the parameters of model (6) was rejected in two cases (Table 7). Parameters of model (6) significantly different from each other for individual months of the year occurred for Pamapol and Seko in the first sub-period.

Table 7. Cases of rejection of the null hypothesis about the significance of model (6) parameters in the first sub-period

Company	*F*	*p*-value
Pamapol	2.3331	0.0061
Seko	1.8196	0.0414

Source: author's work based on data from stooq.pl.

Considering individual model (6) coefficients, statistically significant parameters appeared in 19 cases (Table 8). Most of them occurred in the first sub-period. March turned out to be the month with the largest number of rejections of the null hypothesis about the lack of significance of individual parameters.

Table 8. Cases of rejection of the hypothesis about the significance of individual variables ($a_{jan}, a_{feb}, a_{mar}, a_{apr}, a_{may}, a_{jun}, a_{jul}, a_{aug}, a_{sep}, a_{oct}, a_{nov}, a_{dec}$) in model (6)

Specification	Sub-period	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Astarta	1st	–0.1549	0.2184	0.9469*	0.4988	0.4199	–0.3178	0.4705	0.1845	–0.3536	–0.2833	0.3540	0.0686
Helio	1st	–0.3245	0.3663	–0.1458	0.7518*	0.0620	–0.3031	0.6898	–0.2394	0.1812	–0.1847	0.0069	0.2299
Indykpol	1st	–0.2497	–0.1972	0.1504	0.9392*	–0.5103	–0.4246	0.1326	0.2758	–0.3379	–0.4939	–0.0282	–0.4095
Kernel	1st	0.3864	0.6489	–0.2390	0.8360*	0.6811	–0.1682	0.0560	0.0127	–0.5692	–0.6976	0.1198	0.5715
Makaronpl	1st	–0.1333	–0.0091	0.3519	0.4102	0.7013	–0.3211	–0.1588	0.0852	–0.0164	–0.3579	–0.2600	0.2282
Pamapol	1st	–1.2216*	–0.4113	1.2200*	0.2327	–0.6032	–0.4307	–0.1894	0.4690	–0.2884	–0.3861	–0.3456	–0.1410
Seko	1st	–0.5196	–0.3655	1.2374*	–0.4359	0.2206	–0.4932	0.2701	–0.0669	–0.1743	–0.1144	–0.1280	–0.1979
Wawel	1st	–0.1325	0.1557	0.3126	0.0910	0.0109	–0.3733	0.6288*	0.1869	–0.1681	0.1825	0.3534	–0.1879
WIG-food index	1st	0.0127	0.0794	0.0892	0.4321*	0.3439	–0.3223	0.1610	0.1052	–0.1142	–0.2564	0.0390	0.0198
Astarta	2nd	0.2767	0.0651	–0.5743	–0.4206	0.2292	0.0721	0.2328	–0.1250	–0.1500	–0.4328	–0.9310*	–0.2314
Atlantapl	2nd	1.0999*	0.6133	–0.2952	–0.1762	–0.0826	0.2795	0.1383	0.0037	–0.9121*	–0.0199	0.1798	–0.8630
Mbws	2nd	0.4024	–0.1783	–1.0230*	–0.3882	–0.3384	–0.3970	–0.6255	0.2843	0.2898	0.1049	–0.3504	0.1944
Seko	2nd	0.4875	0.2309	–0.0337	–0.3374	0.4084	–0.0962	–1.1579*	–0.2403	0.1514	0.0307	0.5663	–0.5016
WIG-food index	2nd	0.1244	–0.0410	–0.3514*	–0.1318	–0.1130	–0.0622	0.0618	–0.1609	–0.0310	0.0147	–0.0949	–0.1755
Atlantapl	3rd	–0.1159	–0.6301*	–0.1758	0.0374	0.2705	–0.4289	0.0603	0.1763	–0.1022	–0.1535	–0.0453	0.5592*
Gobarto	3rd	0.1122	0.1235	–0.2137	0.0386	0.3904	–0.0615	0.0526	0.2248	–0.5325*	0.2811	–0.0538	–0.2722
Kruszwica	3rd	0.0868	–0.1336	0.3199	0.1346	0.3439	–0.2188	0.1247	–0.2960	–0.4501*	0.1072	0.0963	–0.1740

Note. * – statistically significant value at the significance level of 0.05.

Source: author's work based on data from stooq.pl.

The last examined anomaly was the half-year effect. Model (7), whose parameters were verified, became the starting point. It turned out that there was no company or a sub-period in which the hypothesis of the total equality of the model parameters would be rejected. While considering individual variables of the model (Table 9), only two cases of their relevance occurred in the whole period of the study. One of them occurred in the first half of the year (Kernel, 1st sub-period), and the second, when it occurred in the second half of the year (Mbws, 3rd sub-period).

Table 9. Cases of rejection of the hypothesis about the significance of individual variables (a_{I}, a_{II}) in model (7)

Company	Sub-period	I half of the year	II half of the year
Kernel	1st	0.3557*	–0.0657
Mbws	3rd	–0.0185	–0.2762*

Note. * – statistically significant value at the significance level of 0.05.
Source: author's work based on data from stooq.pl.

The basis for further analysis of companies for which anomalies were found were the residuals of models (1), (6), (7) and the squares of their residuals. The occurrence of the first-order autocorrelation (Ljung-Box test) and the ARCH effect (verified by the LM test) resulted in the use of the GARCH(1,1) model for companies in which the anomalies were found. The results are presented in Table 10. The OLS estimation results are also included for comparison. In the case of Pamapol, Seko and Mbws, the results are not presented due to the fact none of the conditions underlying the application of the GARCH model were met.

The estimation of the models (8)–(10) gave similar results. However, the use of a conditional variance in the model resulted in smaller error estimates of individual parameters, which improved the quality of the models. Sums of alpha and beta parameters were smaller than unity but close to 1. Past information is therefore important in explaining current values.

Individual statistically significant variables indicate that there is variability over time, both in the case of days of the week and months of the year. For the Polish market, this volatility is also visible for earlier years (although to a lesser extent). Buczek (2005) emphasizes the disappearance of the effect of Monday in favour of Friday. Also in the case of the Turkish market, Balaban (1995) claims that the effect of the day of the week changes over time.

Table 10. Estimation results of models (1), (7), (8) and (10) for selected companies

Company	Sub-period and model	Results					r_{t-1}	alpha1	beta1
Day of the week									
		Mon	Tue	Wed	Thu	Fri			
Wawel	1st: (1)	−0,3933	0,1771	0,1916	−0,0466	0,4800	.	.	.
		(0,1802)*	(0,1785)	(0,1752)	(0,1845)	(0,1832)*			
	(8)[a]	−0,3575	0,1422	0,1540	0,0188	0,4079	0,0190	0,0395	0,9571
		(0,1658)*	(0,1596)	(0,1577)	(0,1678)	(0,1646)*	(0,0364)	(0,0113)*	(0,0153)*
Astarta	2nd: (1)	−0,1985	0,3617	0,0535	−0,5729	−0,3501	.	.	.
		(0,2042)	(0,2042)	(0,2015)	(0,2031)*	(0,2036)			
	(8)[b]	−0,0800	0,4532	0,0275	−0,4136	−0,0172	0,0732	0,3299	0,4396
		(0,1640)	(0,1633)*	(0,1638)	(0,1750)*	(0,1740)	(0,0407)	(0,0649)*	(0,0842)*
Half of the year									
		I		II					
Kernel	1st: (7)	0,3557		−0,0657			.	.	.
		(0,1601)*		(0,1635)					
	(10)[c]	0,3310		0,1131			−0,0782	0,1053*	0,8620*
		(0,1476)*		(0,1339)			(0,0405)		

Note. Standard errors of the parameter estimates are given in brackets. * – statistically significant value at the significance level of 0.05. a LB = 6.18*, LM(1) = 5.29*. b LB = 19.43*, LM(1) = 59.51*. c LB = 19.43*, LM(1) = 59.51*.

The observed calendar effects may result from different relationships between companies. Studies by Dudek (2008) show the influence of past price changes of a dominant company in a given industry on price changes of other companies from that industry. This could explain the observed effects of Wawel, Astarta, Kernel and Mbws.

5. Conclusions

The research concerned companies belonging to one of the industry indices, i.e. the food sector and the WIG-food index. The aim of the research was to verify whether the calendar effects occur in the case of companies from the food industry and WIG-food index. The research focused on the effects of the day of the week, the month of the year, and the half of the year. Regarding daily rates of return on the particular days of the week, the lowest of them were observed on Mondays in the 1st and 2nd sub-period. In the 3rd sub-period, the lowest rates of return occurred on Tuesdays. The highest rates of return varied depending on the period considered.

The effect of the day of the week was observed, using the regression model, for Wawel in the first sub-period and for Astarta in the second. In the case of Wawel, the results for Mondays and Fridays turned out to be statistically significant, whereas in the case of Astarta statistically significant results occurred on Thursdays. The effect of the month of the year was observed for Pamapol and Seko, both in the first sub-period. The month where statistically significant results of return rates occurred was March and additionally January (for Pamapol). The half of the year effect did not occur among the surveyed companies. It should be noted, however, that for the majority of the analysed companies, higher average rates of return occurred in the first half of the year, although they were not statistically significant. In addition, the studied effects were disappearing from period to period.

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