Eurasian Journal of Business and Management, 3(2), 2015, 12-37
DOI: 10.15604/ejbm.2015.03.02.002

EURASIAN JOURNAL OF BUSINESS AND MANAGEMENT

http://www.eurasianpublications.com

ANALYSIS OF SELECTED SEASONALITY EFFECTS IN THE FOLLOWING AGRICULTURAL MARKETS: CORN, WHEAT, COFFEE, COCOA, SUGAR, COTTON AND SOYBEANS

Krzysztof Borowski
Corresponding Author: Warsaw School of Economics, Poland.
Email: krzysztof.borowski@sgh.waw.pl

Malgorzata Lukasik
Warsaw School of Economics, Poland. Email: malgorzata.lukasik@nbp.pl

Abstract

The commodity market has been becoming one of the main popular segments of the financial markets among individual and institutional investors in recent years, due to downward trend on the stock exchanges. Likely to the equity market, the problem of anomalies in the commodities market is becoming an interesting phenomenon, particularly in the segment of the agricultural market. This paper tests the hypothesis of monthly, the day-of-the week and weekend effects of seven agricultural commodities quoted in the period of 01.01.1994 - 31.12.2014. Calculations presented in this paper indicate the absence of the monthly effect on coffee market and the existence of monthly effect in the case of another six analyzed agricultural commodities: corn, wheat, sugar, cocoa, cotton and soybeans. In the analyzed period, no occurrence of day-of-the-week effect was proven for corn, cotton and soybeans. The day-of-the-week effect was registered on the markets of: wheat, coffee, sugar and cocoa and the weekend effect was observed only on the cocoa market.

Keywords: Market Efficiency, Commodity Market, Corn, Coffee, Cocoa, Sugar, Cotton, Soybeans

1. Introduction

According to Efficient Market Hypothesis (EMH), introduced by Fama (1970) the security prices fully reflect all available information. This theory has been subjected to many analyses and has become a main source of disagreement between academics and practitioners. The latter tends to reject the EMH while the academics support it. Current definitions of EMH differ from that formulated by Fama (1970). According to them the efficiency of markets prevents systematic beating of the market, usually in a form of above-average risk-adjusted returns. Because of the fact, that stock market anomalies breach the EMH, they are the subject to a lot of empirical research.

The problem of the financial markets efficiency, especially of equity markets, has become a main topic of number of scientific works, which has led to a sizable set of publications

examining this issue. In many empirical works dedicated to the time series analysis of rates of return and stock prices, statistically significant effects of both types were found, i.e. calendar effects and effects associated with the size of companies. These effects are called "anomalies", because their existence testifies against market efficiency. Discussion of the most common anomalies in the capital markets can be found, among others, in Simson (1988) or Latif *et al.* (2011).

One of the most common calendar anomalies observed on the financial markets are:

A) Day-of-the-week Effect – different distributions of expected rates of return can be observed for different days of the week (Keim and Stambaugh, 1984). Strong evidence of the day-of-the-week effect has been found by many academics in major markets, Gibbons and Hess (1981). The day-of-the-week effect in the US market was also presented, among others, in the works of: Jaffe *et al.* (1989), French (1980), Lakonishok and Maberly (1990). The evidence for UK market was examined by: Theobald and Price (1984), Jaffe and Westerfield (1985), Board and Sutcliffe (1988), Agrawal and Tandon (1994), Peiro (1994), Mills and Coutts (1995), Dubois and Louvet (1996), Coutts and Hayes (1999). Peiro (1994), and Kramer (1996) provided evidence of negative Monday and Tuesday returns for Frankfurt exchange. In works of Solnik and Bousquet (1990), Agarwal and Tandon (1994), there was found an evidence of negative Tuesday rates of return in Paris market, while Condoyanni *et al.* (1987) and Peiro (1994) demonstrated negative Monday and Tuesday rates or return on the same market and Barone (1990) in Milan. Research regarding rates of return on other market was performed in works of Kato *et al.* (1990), and also by Sutheebanjard and Premchaiswadi (2010). On the Polish market, findings regarding the day-of-the-week effect were conducted among others by: Buczek (2005) and Szyszka (2007).

B) Monthly Effect – achieving by portfolio replicating the specified stock index, different returns in each month. The most popular monthly effect is called “January effect”, i.e. the tendency to observe higher average rate of return of stock market indices in the first month of the year. For the first time, this effect was observed by Keim (1983), who noted that the average rate of return on stocks with small capitalization is the highest in January. In the case of large and mid-capitalization companies the effect was not so perceptible. Although January was the best single month in UK, the period from December to April consisted of months, which on average produced positive returns (Rozeff and Kinney, 1976; Corhay *et al.* 1988). Bernstein (1991), taking into consideration the behavior of the US equity market in the period from 1940 to 1989, gave the interdependence between rates of returns in each month. Modern researches, e.g. Gu (2003) and Schwert (2002) show that in the last two decades of the twentieth century, phenomenon of the month-of-the-year effect was much weaker. This fact would suggest that the discovery and dissemination of the monthly effect in world financial literature contributed to the increase of market efficiency.

C) Other Seasonal Effects- in the financial literature, the following calendar effects can be found:

1. The weekend effect – Cross (1973) found that markets tend to raise on Fridays and fall on Mondays. His findings generated a flood of research (Lakonishok and Levi, 1982; Jaffe and Westerfield, 1985; Condoyanni *et al.* 1987; Connolly 1991; Abraham and Ikenberry, 1994). In the literature two ways of computing weekend rates of return are implemented. In the first approach, Friday close and Monday open prices are used, while in the second example Friday close and Monday close prices are employed.
2. The holiday effects – markets before holidays or other trading breaks tend to rise. In the US there is a number of studies looking at this issue, e.g., Fields (1934), Ariel (1987 and 1990), Lakonishok and Smith (1988) and Cadsby and Ratner (1992)
3. Within-the-month effect – positive rates of returns only occur in the first half of the month (Ariel,1987; Kim and Park,1994).
4. Turn-of-the month effect – average rate of return calculated for the last day of the month and for three days of the next month, was higher than the average rate of return calculated for the month, for which the rate of return of only one session, was taken.

Lakonishok and Smidt (1988) found that the four days at the turn-of-the-month averaged a cumulative rate of increase of 0.473% versus 0.0612% for and average four days. The average monthly increase was 0.349%, i.e., the DJIA went down during non-turn-of-the-month period.

Commodity market is one of the segments of the financial market, characterized by high heterogeneity of assets compared to the stock or bond markets (Johnson and Soenen, 1997). It is often perceived as a separate asset class, which in turn leads to low correlation of commodity market rates of return in comparison to h returns on the stock orbonds markets.The consequence of this fact is the possibility of constructing more diversified investment portfolio compared to a portfolio solely consisting of shares orbonds. Another factor in favor of investing in the commodity market is the ability to protect the investment portfolio from the negative effects of inflation.This type of invest or preferences in building an investment portfolio are clearly visible in the period of increased inflation (Gorska and Krawiec, 2013). Another factor encouraging investors to carry out investments in the commodity market can be the threat of currency devaluation or the outbreak of armed conflict.

In the world literature, in contrast to the stock market, relatively little attention has been dedicated to the occurrence of the seasonality effects on the agricultural commodity market. This fact was one of the reasons encouraging the authors to undertake empirical studies.The aim of this article is to examine the prevalence of selected seasonality effects on the markets of the following agricultural products: corn, wheat, coffee, sugar, cocoa, cotton, soybeans. Analysis of the seasonality effects will apply to monthly returns, returns over various days of the weekand so called weekend effect. In the process of analyzing weekend effect, close prices on Friday and open prices on Monday will be used. Statistical tests were conducted for agricultural commodities on the basis of Bloomberg prices for the period from 01.01.1994 to 31.12.2014. The prices for each of analyzed commodities are expressed in the following units: in USD/bu for corn, wheat, soybeans, in USD/lb for coffee, sugar and cotton and in USD/mt for cocoa.

2. Literature Review

In the scientific literaturea statement can be found that the stock market is some how predestined to record number of anomalies, whereas the foreign exchange is the most effective of all the markets (Froot and Thaler, 1990). It is worth noting that the number of scientific papers dedicated to commodity market efficiency is lower than those relating to the stock market. Numerous research has examined the price efficiency of agricultural markets. However, many of the studies differ with respect to the analyzed commodity, the covered time period and implemented method of analysis, and the type of data employed in the research (Garcia *et al.* 1988).

Tests of price market efficiency in a weak form were conducted among others by Bigman *et al.* (1983), Kofi (1972), Leath and Garcia (1983), Spriggs (1981) and Tomek and Gray (1970). All of these studiesfocused onthe following agricultural commodities: wheat, corn, soybeans (Bigman *et al.* 1983), wheat, corn, soybeans, cocoa, coffee (Kofi, 1972), corn (Leath and Garcia, 1983), corn (Spriggs, 1981), corn, soybeans and potatoes (Tomek and Gray, 1970). In turn, test of price market efficiency in a semi-strong form were performed by Canarella and Pollard (1985), Just and Rausser (1975), Rausser and Carter (1983) and regarded markets of: wheat, corn, soybeans, soybean oil (the two first papers) and markets of soybean and soybean oil (the third paper).

The price inefficiency of some agriculture commodity markets was proved by (Garcia *et al.* 1988):

a) Bigman *et al.* (1983) – wheat, corn and soybeans,
b) Bigman and Goldfarb (1985) – wheat, corn, soybeans,
c) Brinegar (1970) - wheat, corn, rye,
d) Helms *et al.* (1984) – soybeans, soybean oil,
e) Hunt (1974) – wool,
f) Martell and Helms (1978) – wheat, corn, oats, soybeans, soybean oil,
g) Stevenson and Bear (1970) – cottonseed oil and soybeans.

There are, however, works proving thesis of the effectiveness of selected commodity market segments:

a) Labys and Granger (1970) – corn, oat, rye, wheat, lard,
b) Larson (1960) – corn.

The third group of scientific works prove thesis of the mixed nature of the effectiveness of different types of commodity markets:

a) Cargill and Rausser (1972) - corn, oat, rye, soybeans, wheat,
b) Cargill and Rausser (1975) - corn, oat, rye, soybeans, wheat,
c) Gordon (1985) – wheat, corn, rough rice, soybeans, cotton, orange juice, soybean oil
d) Labys and Granger (1970) – cottonseed oil, corn, cocoa, lard, soybeans, soybean oil, cotton, rye, oat, wheat, rubber,
e) Martell and Philipatos (1974) – wheat and soybeans,
f) Smidt (1965) – rye and soybeans.

On the basis of above mentioned research, we may formulate the hypothesis that the markets were relatively efficient prior to 1973. Due to the increasing turbulence in the 1970s, the market inefficiency was observed in the period from 1973 to 1979. The period from 1979 to 1987 was hypothesized to be more efficient than the period from 1973 through 1979 (Garcia *et al.* 1988). Fortenberry and Zapata (1993) evaluated the relationship of the North Carolina corn and soybean markets with respect to CBOT – no strong evidence was found to reject the efficiency hypothesis. Aulton *et al.* (1997) investigated the efficiency of agricultural commodities in UK markets. They found wheat market as efficient. Sabuhoro and Larue (1997) demonstrated with the use of cocoa and coffee futures prices, that there was noevidence to rejectthe null hypothesisconcerning theeffectivenessof both markets. Result indicated by Mckenzie and Holt (1998), on the basis of future and spot prices of some agricultural commodities in the period of 1966 – 1995, proved that corn and soybean futures markets are both efficient and unbiased in the long-run, but short-run inefficiencies were found to exist in each market.

Wang and Ke (2005) studied wheat and soybean futures markets in China. The results suggest that future market of wheat was inefficient, which might be caused by overspeculation and government intervention on this market. Lokare (2007) found an evidence concerning sugar and cotton markets in India, but Sahoo and Kumar (2009) concluded that the commodity futures markets of soybean oil was efficient in the same country. Ali and Gupta (2011) examined the efficiency of the futures markets of twelve agricultural commodities quoted at NCDEX with the use of Johansen's cointegration analysis. They proved that there was a long-term relationship between futures and spot prices for all of the selected commodities except wheat and rice. Sehgal *et al.* (2012), during the analysis of ten agricultural prices in the period of June 2003 – March 2011 quoted on NCDEX, observed that all commodity markets were efficient except one (turmeric).

Zunino *et al.* (2011) applied information theory methods to the commodity markets and ranked them finding that silver, copper and cotton were the most efficient commodities in the analyzed period. Kim *et al.* (2011b) with the use of the random matrix theory and network analysis found that stock and commodity markets were well decoupled except oil and gold, showing signs of inefficiency. The analysis of Korean agricultural market with the application of detrended fluctuation analysis proved its inefficiency (Kim *et al.* 2011a). Lee *et al.* (2013) found that returns in October for corn, April for soybeans and August for wheat futures dominate returns of other months.

Kristoufek and Vosvrda (2013) introduced the Efficiency Index to rank the commodity according to their efficiency. Authors analyzing daily futures prices of 25 commodities, registered the strongest anti-persistence concerning cocoa, oats and orange juice. There were sugar, copper, palladium and platinum among commodities with a signs of persistence. On the other hand, cotton and natural gas were classified as the closest to the efficient market value. With the use of Efficiency Index, calculated for all of analyzed commodities, the most efficient of the commodities turned out to be heating oil, followed by WTI crude oil. Cotton, wheat and coffee came after these with the smaller level of efficiency. Kellard *et al.* (1999) analyzed the efficiency of several commodities traded in different markets, including soybeans on the CBOT, finding a long-run equilibrium relationship but a short-run inefficiency for most of the markets.

In summary, there has not been consensus about the efficiency of agricultural commodities. One reason for the heterogeneous results is the different test setups and the second a single-market perspective (Otto, 2011).

3. Data and Methods

The test for equality of two average rates of return will be applied in the case of hypothesis testing. According to the adopted methodology, the survey covers two populations of returns, characterized by normal distributions. On the basis of two independent populations of rate of returns, which sizes are equal n_1 andn_2 respectively, the hypotheses H_0 and H_1 should be tested with the use of statistics *z* (Osinska, 2006):

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

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.

The null hypothesis H_0 and alternative hypothesis H_1 can be formulated as follows:

$$H_0: E(r_1) = E(r_2)$$
$$H_1: E(r_1) \neq E(r_2)$$

In particular:

a) For the analysis of the monthly rates of return, if$\bar{r}_1$ is the average rate of return in month *X*, then $\bar{r}_2$is the average rate of return in all other months, except month *X*, on the agricultural commodity market.
b) For the analysis of the rates of return on individual days of the week, if$\bar{r}_1$ is the average rate of return on day *Y*, then $\bar{r}_2$ is the average rate of return in all other days, except day *Y*, on the agricultural commodity market.
c) For the analysis of weekend effect, if$\bar{r}_1$ is the average rate of return calculated with the use of Friday close and Monday open prices, then $\bar{r}_2$is the average rate of return calculated for other day open and close prices (Tuesday open/Monday close, Wednesday open/Tuesday close, Thursday open/Wednesday closeand Friday open/Thursday close) on the agricultural commodity market.

In all analyzed cases, *z*statistic and thep-value is calculated. If thep-value is less than or equal to 0.05; then the hypothesis H_0 is rejected in favor of the hypothesis H_1.Otherwise, there is no reason to reject hypothesis H_0.

3. Analysis of Results

3.1. Analysis of Monthly Effect

The prices of analyzed agricultural commodities in the period from 01.01.1994 to 31.12.2014 are presented in Figure 1.

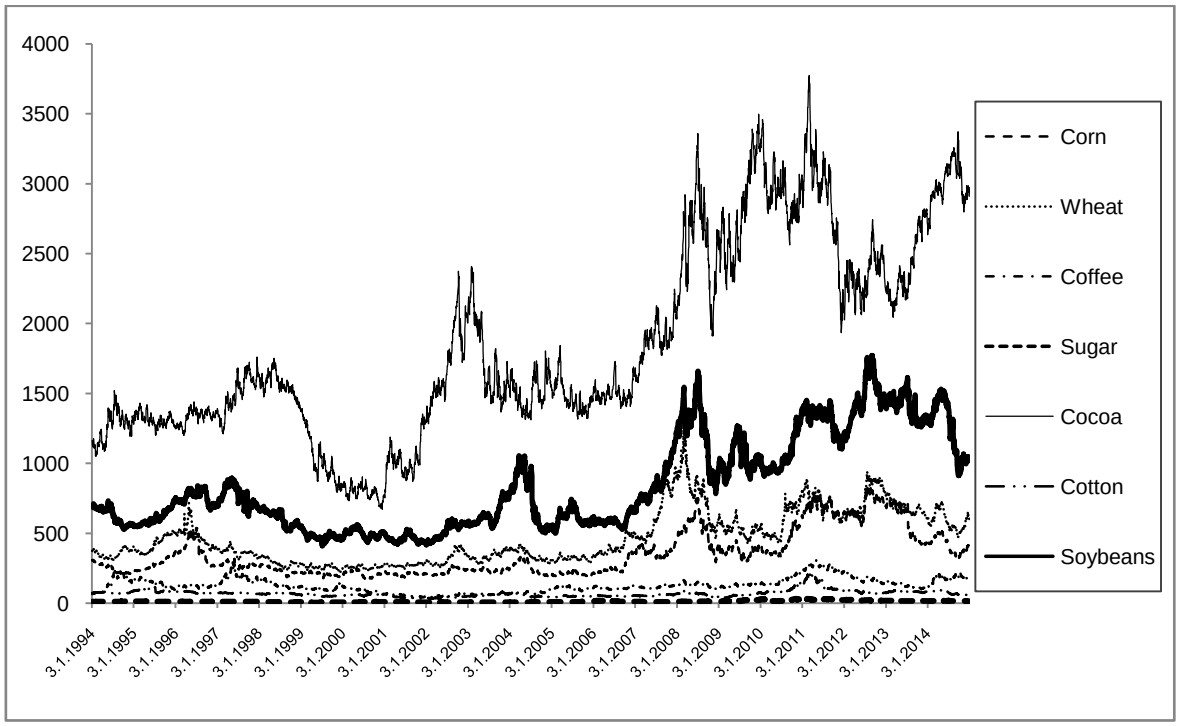

Figure 1. The daily agricultural commodity prices in the period from 01.01.1994 to 31.12.2014

Source: own calculations

Notes: Prices are presented in USD/bu for corn, wheat, soybeans, in USD/lb for coffee, sugar and cotton, in USD/mt for cocoa.

The monthly average rates of return for each commodity and for each month is visible in Apendix – Table 6. The highest monthly rate of return equal to 5.31% was observed on the sugar market in June, and the lowest one (-4.96%) on the soybean market in September. The monthly average rates of return higher than 3 percent were registered 6 times (cocoa in January – 3.11%, coffee in February – 3.05%, sugar in June – 5.31% and in July – 3.70%, corn in December – 5.20% and cotton in December – 4.01%). The monthly average rates of return lower than minus 3% were registered 10 times: twice on the corn market (June, July), twice on the sugar market (March, April) and twice on the soybean market (July, September) and once in case of all other commodities (wheat – June, coffee – June, cocoa – October, cotton – July).
The number andpercentage ofpositive and negativemonthlyreturnson the agricultural commodity market for each month, is presented in Table 1.

In the analyzed period, the positive monthly returns on the corn market, were the most frequently observed in December-in 76.19% of all observations - see Figure 2.The second and third months in which the positive returns were most frequentwere: February and August – both at 61.90% of all observations. In turn, the months with the highest percentage of negative monthly returns resulted to be: November (71.43%), April and Juneboth at 66.67% of all observations.

Inthe analyzed period,on the wheat market, the positive monthly returns occurred more frequently in July –71.43% of all observations - see Figure 3. This month were followed by months of September, October and December, in which the positive monthly rates were noted in 57.14% of all observations. On the other hand, negative monthly rates of return occurred most frequently in the month ofJune (71.43%) and also in February and March (66.67%).

Table 1. The number and percentage of positive and negative monthly returns on the markets of: corn, wheat, coffee, sugar, cocoa, cotton and soybeans

	Commodity	January	February	March	April	May	June	July	August	September	October	November	December
Number of positive returns	Corn	12	13	12	7	11	7	9	13	9	12	6	16
	Wheat	9	7	7	9	10	6	15	11	12	12	9	12
	Coffee	12	9	9	10	7	8	11	11	11	9	11	13
	Sugar	10	11	7	6	10	15	15	9	9	13	10	12
	Cocoa	10	12	12	12	9	13	11	11	13	5	10	13
	Cotton	12	12	10	8	8	13	12	10	8	13	12	14
	Soybeans	12	12	13	12	11	11	7	10	7	13	15	9
Nuber of negative returns	Corn	9	8	9	14	10	14	12	8	12	9	15	5
	Wheat	12	14	14	12	11	15	6	10	9	9	12	9
	Coffee	9	12	132	11	14	13	10	10	10	12	10	8
	Sugar	11	10	14	15	11	6	6	12	12	8	11	9
	Cocoa	11	9	9	9	12	8	10	10	8	16	11	8
	Cotton	9	9	11	13	13	8	9	11	13	8	9	7
	Soybeans	9	9	8	9	10	1	14	11	14	8	6	12
Percentage of months with positive rates of return	Corn	57.14	61.90	57.14	33.33	52.38	33.33	42.86	61.90	42.86	57.14	28.57	76.19
	Wheat	42.86	33.33	33.33	42.86	47.62	28.57	71.43	52.38	57.14	57.14	42.86	57.14
	Coffee	57.14	42.86	6.38	47.62	33.33	38.10	52.38	52.38	52.38	42.86	52.38	61.90
	Sugar	47.62	52.38	33.33	28.57	47.62	71.43	71.43	42.86	42.86	61.90	47.62	57.14
	Cocoa	47.62	57.14	57.14	57.14	42.86	61.90	52.38	52.38	61.90	23.81	47.62	61.90
	Cotton	57.14	57.14	47.62	38.10	38.10	61.90	57.14	47.62	38.10	61.90	57.14	66.67
	Soybeans	57.14	57.14	61.90	57.14	52.38	91.67	33.33	47.62	33.33	61.90	71.43	42.86
Percentage of months with negative rates of return	Corn	42.86	38.10	42.86	66.67	47.62	66.67	57.14	38.10	57.14	42.86	71.43	23.81
	Wheat	57.14	66.67	66.67	57.14	52.38	71.43	28.57	47.62	42.86	42.86	57.14	42.86
	Coffee	42.86	57.14	93.62	52.38	66.67	61.90	47.62	47.62	47.62	57.14	47.62	38.10
	Sugar	52.38	47.62	66.67	71.43	52.38	28.57	28.57	57.14	57.14	38.10	52.38	42.86
	Cocoa	52.38	42.86	42.86	42.86	57.14	38.10	47.62	47.62	38.10	76.19	52.38	38.10
	Cotton	42.86	42.86	52.38	61.90	61.90	38.10	42.86	52.38	61.90	38.10	42.86	33.33
	Soybeans	42.86	42.86	38.10	42.86	47.62	8.33	66.67	52.38	66.67	38.10	28.57	57.14

Source: own calculations

December was the month, in which the highest percentage of positive monthly returns was recorded on the coffee market (61.90%) (Figure 4). The second highest percentage of positive returns took place in January (57.14%). On the other hand, the most negative rates of return occurred in the month of May (66.67%) and in June (61.90%).
Regarding the sugar market, the highest percentage of monthly positive returns was recorded in June and July (71.43% of observations in both months) (Figure 5). The negative rates of returns were most common in April (71.43%), followed by March (66.67%).

On cocoamarket, monthly positive returns took place most frequentlyin June, September and December (61.90% of all observations) (Figure 6). In the months of February, March and April they occurred in 57.14% of all observations. The negative monthly rates of return were achieved on cocoa market most frequently in October (76.19%) and February (57.14%). December was the month, in which the highest percentage of positive monthly returns was recorded on the cotton market (66.67%) (Figure 7).The second highest percentage of positive returns was registered in June and October (61.90% in both months). On the other hand, the most negative rates of return occurred in April, May and September (61.90% of all observations).

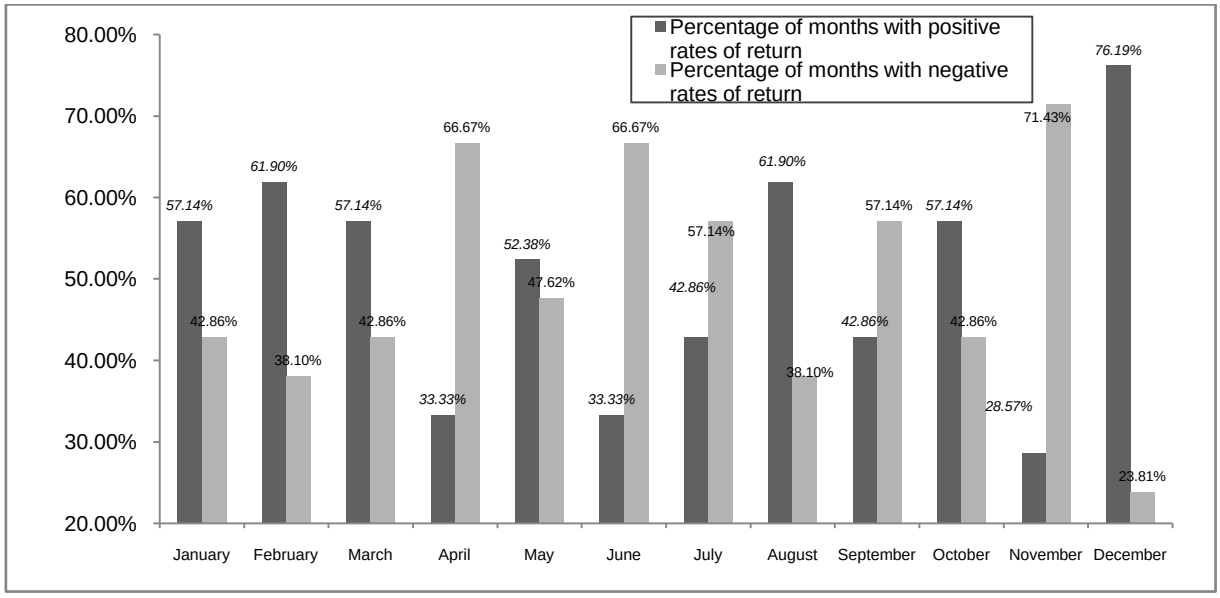

Figure 2. The percentage of monthly positive and negative returns in each month-corn
Source:own calculations

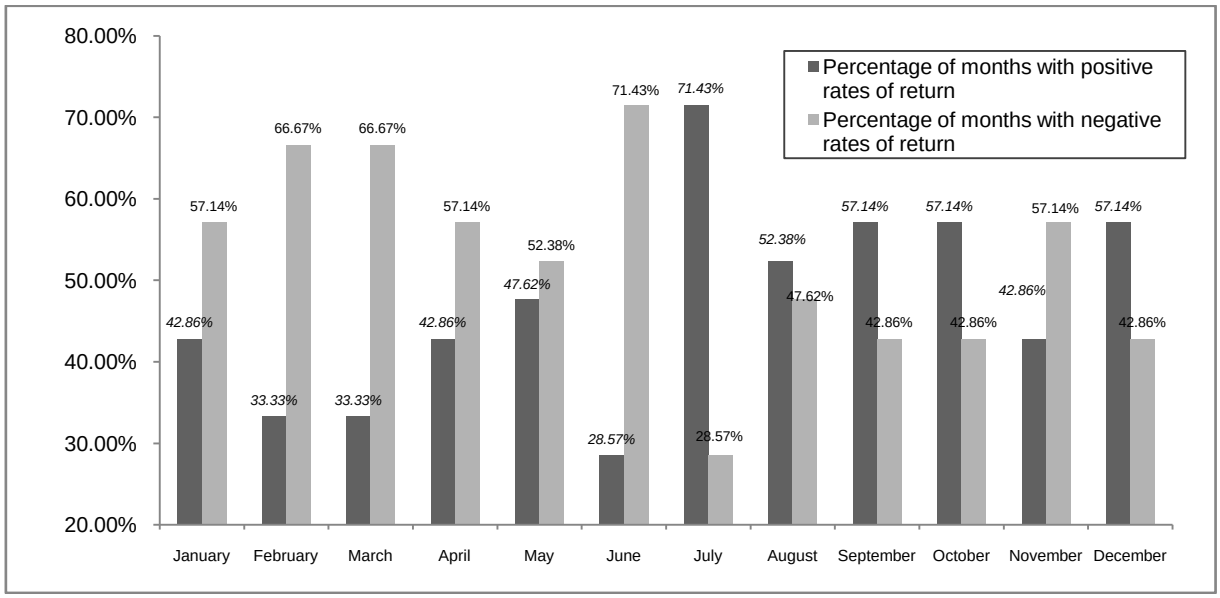

Figure 3. The percentage of monthly positive and negative returns in each month- wheat
Source: own calculations

Regarding the soybean market, the highest percentage of monthly positive returns were recorded in November (71.43%), followed by March (61.90%) (Figure 8). The negative rates of returns was most common in the months of July and September (66.67% of all observation in each month).

In December, on the market of all analyzed agricultural commodities, the percentage of positive returns higher than 50%, was the greatest. On the other hand, in January and October the percentage of positive returns was greater than 50% on the market of 5 out of 7 commodities, but in February, June, July and November only on the market of 4 out of 7 commodities. The percentage of negative monthly rates of return was greater than 50% on the market of 5 out of 7 agricultural commodities in the months of April and May (Figure 9).

The results obtained in the process of testing statistical hypotheses for the monthly returns on analyzed agricultural commodity markets, are presented in Table 2.

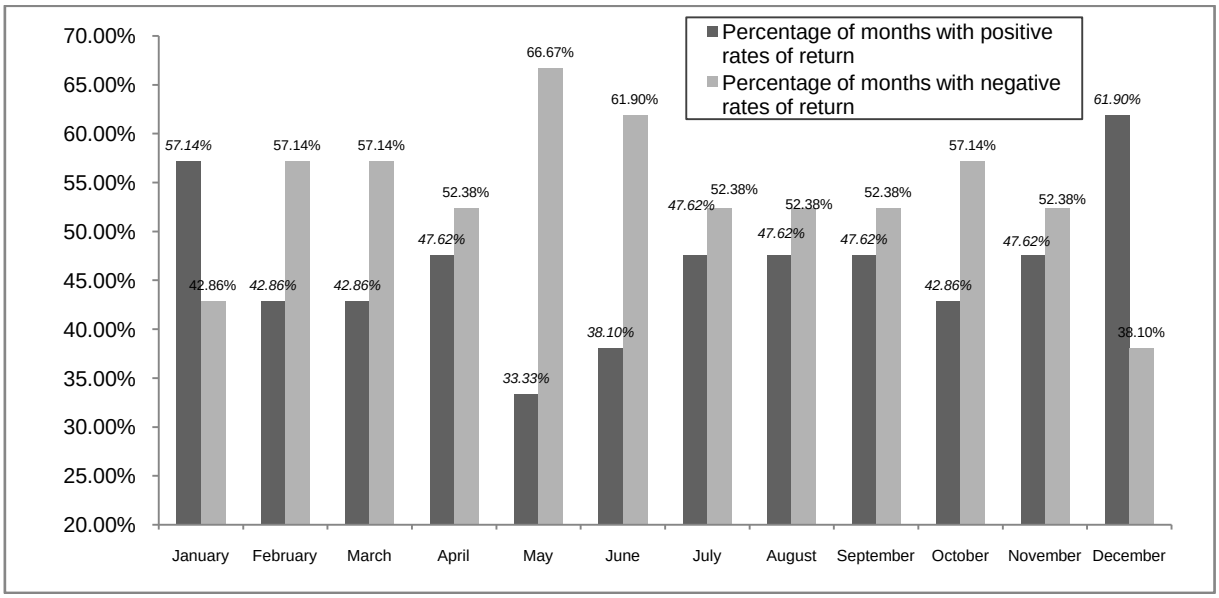

Figure 4. The percentage of monthly positive and negative returns in each month-coffee
Source: own calculations

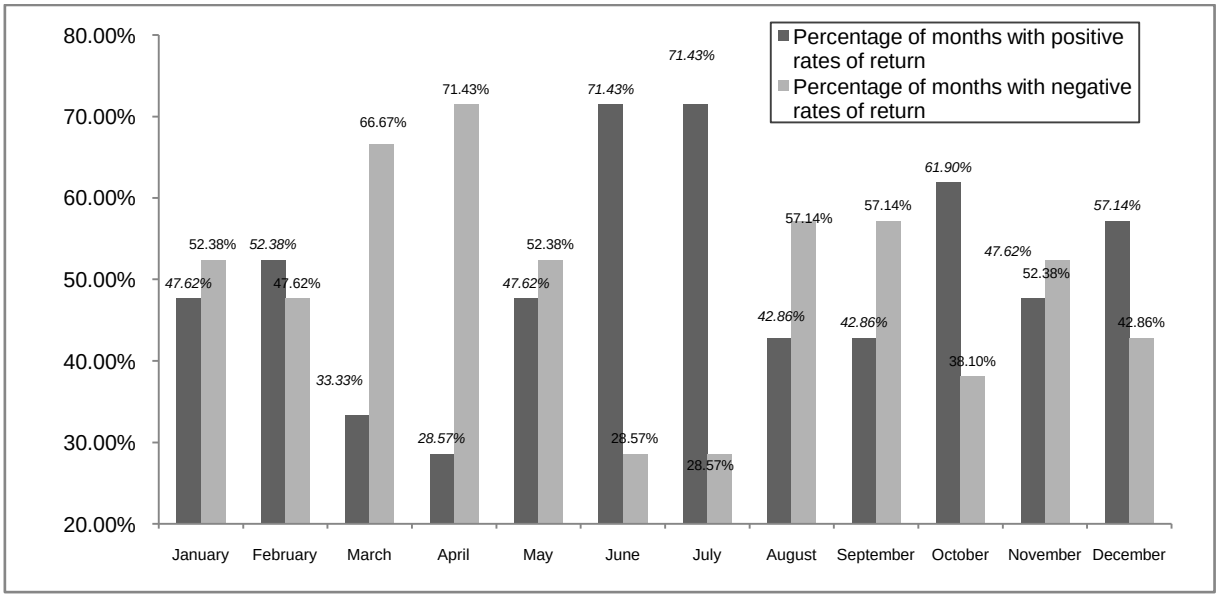

Figure 5. The percentage of monthly positive and negative returns in each month - sugar
Source: own calculations

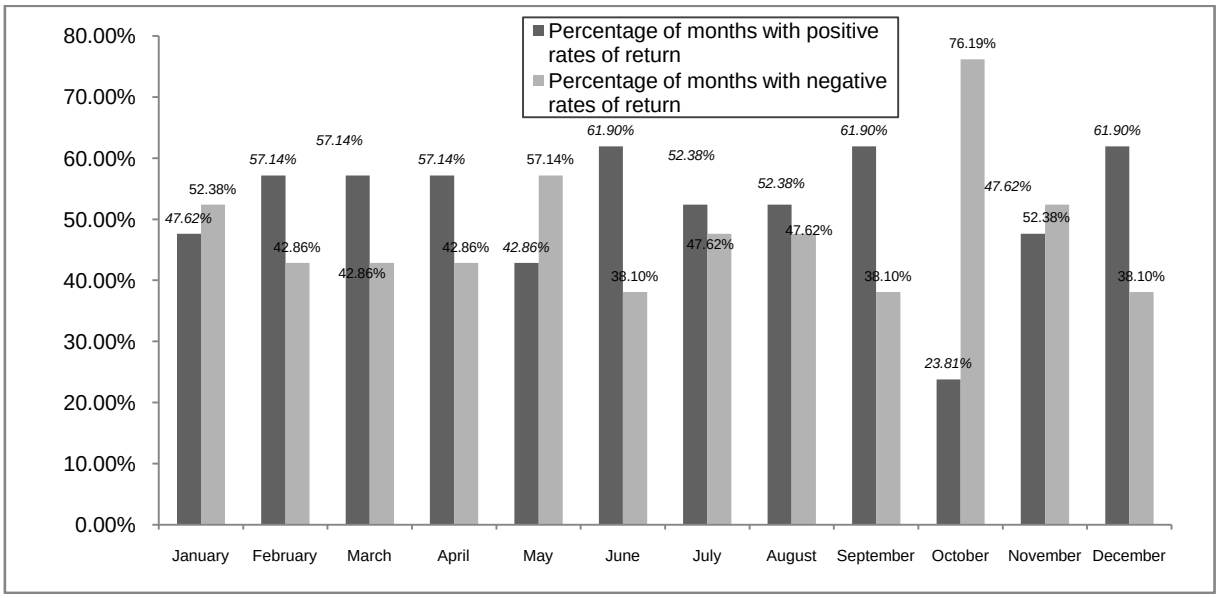

Figure 6. The percentage of monthly positive and negative returns in each - cocoa
Source: own calculations

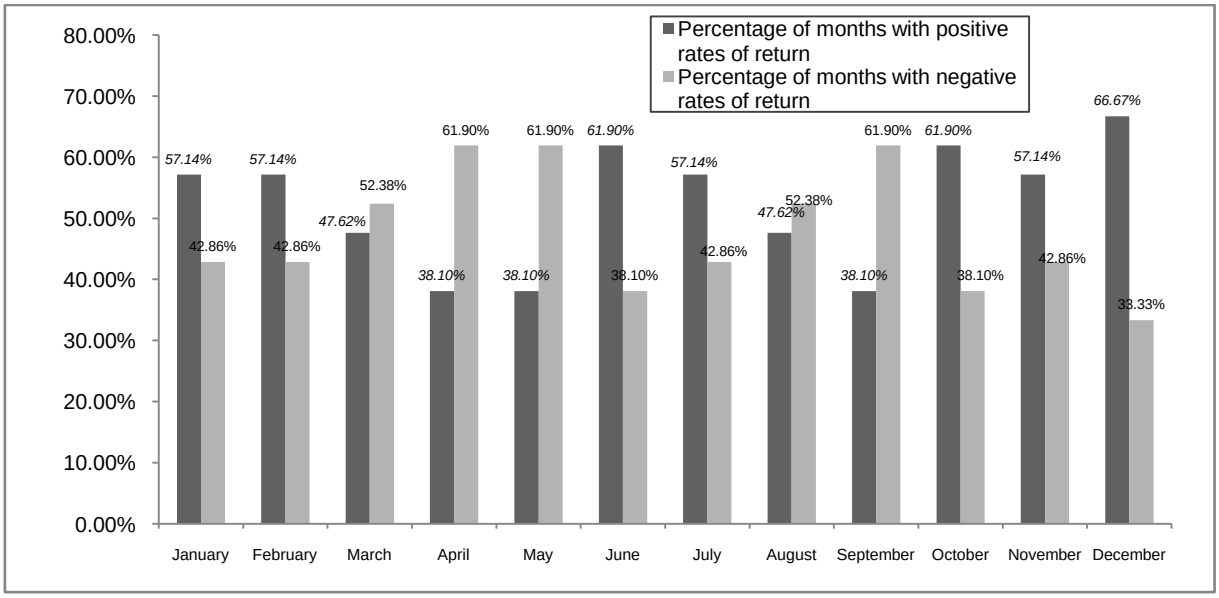

Figure 7. The percentage of monthly positive and negative returns in each month- cotton
Source: own calculations

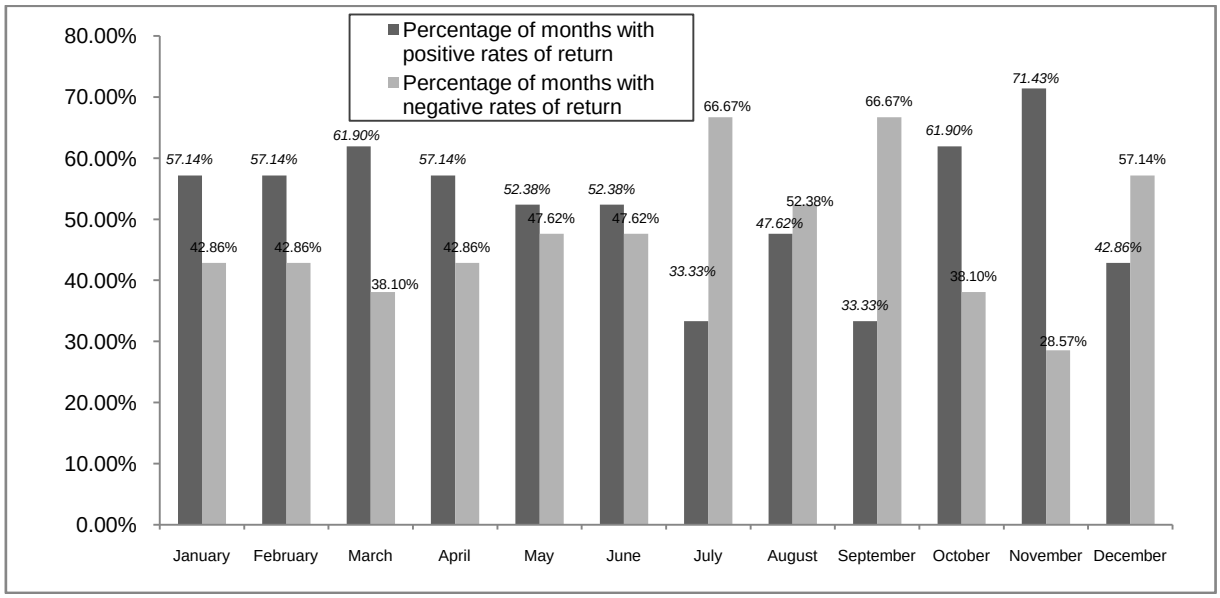

Figure 8. The percentage of monthly positive and negative returns in each month-soybeans
Source: own calculations

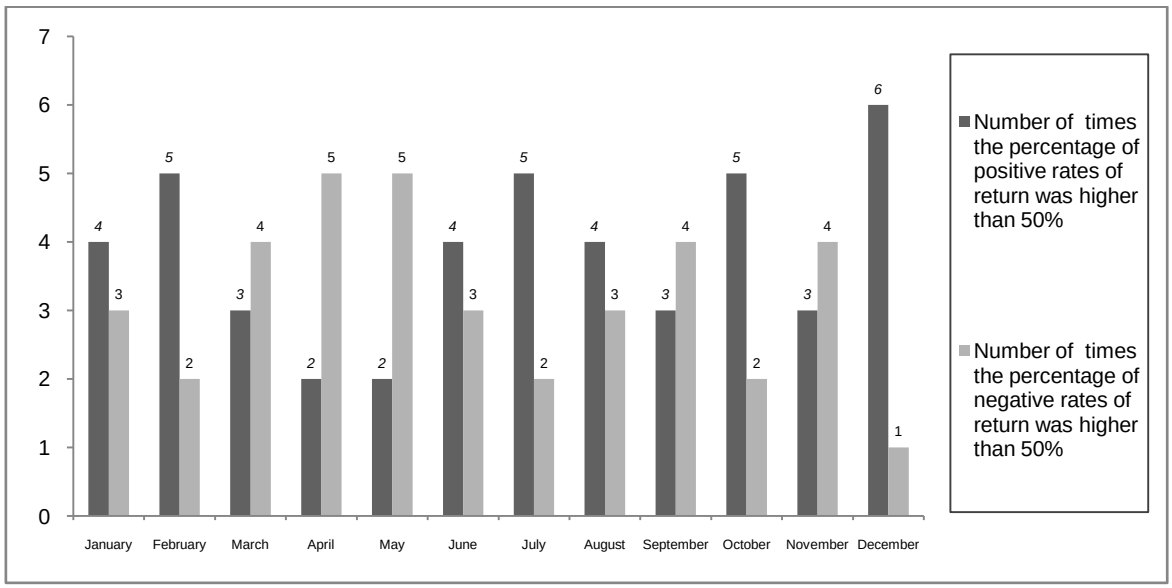

Figure 9. Number of times when the percentage of positive and negative rates of return was higher than 50% concerning all analyzed agricultural commodities markets
Source: own calculations

Table 2. The results of testing the null hypothesis for the monthly returns on the agricultural commodity market

	Corn	Wheat	Coffee	Sugar	Cocoa	Cotton	Soybeans
January	0.262393 0.793018	-1.10375 0.269702	1.212084 0.22548	-0.08319 0.933699	1.460917 0.144038	1.511597 0.130636	-0.12495 0.900567
February	1.895201 0.058066	-0.77386 0.439016	1.292757 0.196095	-0.80149 0.422847	0.569509 0.569011	1.047544 0.294849	2.089529 0.03666
March	0.897884 0.369247	-0.24156 0.809125	-0.56166 0.574345	-2.13586 0.032691	-0.74797 0.454479	-0.16811 0.866498	0.797739 0.425022
April	-0.28891 0.772649	-0.15578 0.876204	0.610662 0.541423	-2.15123 0.031458	-0.15203 0.879167	-0.76036 0.447041	1.63719 0.101591
May	0.238607 0.81141	0.212409 0.831788	0.163465 0.870152	-0.39644 0.691777	-1.18575 0.23572	-1.09943 0.271581	-0.059 0.952951
June	-2.18269 0.029059	-1.86733 0.061856	-1.47261 0.140857	2.605622 0.009171	1.333056 0.182513	-0.32111 0.748129	0.535973 0.591977
July	-1.62673 0.103795	2.551587 0.010723	-0.03556 0.971634	1.580536 0.113984	0.153104 0.878316	-1.60329 0.108871	-2.29934 0.021485
August	0.319828 0.749099	0.641888 0.520946	0.003133 0.997501	-1.12211 0.261814	-0.17183 0.863574	0.700465 0.483637	-0.53049 0.595771
September	-1.0922 0.274746	0.914286 0.360567	-1.16922 0.242314	0.117685 0.906317	0.525 0.599583	-0.87449 0.381849	-2.77284 0.005557
October	1.355672 0.175204	-0.65101 0.515037	-0.49342 0.621717	0.604584 0.545455	-2.79894 0.005126	0.279391 0.779945	1.250015 0.211294
November	-0.97899 0.327585	-0.68 0.496505	0.434032 0.664265	0.393627 0.693856	0.094744 0.924518	-0.08859 0.929405	1.351639 0.176491
December	3.318384 0.000905	1.056145 0.290902	0.689486 0.490518	1.286835 0.198152	0.861675 0.388866	2.410904 0.015913	0.66197 0.50799

Source: own calculations

Notes: The first value in the cell represent test statistic for z, and the second is the p-value

The results permit to draw the following conclusions:

1. In the case of corn, the null hypothesis was rejected in favor of the alternative hypothesis for the months of June and December. This fact indicates the occurrence of the effect of the month on the analyzed market. The December p-value was even lower than 0.001; what can be interpreted as a strong monthly effect in comparison to June, for which the p-value reached the level of 0.029. Regardingall of the remaining months, the null hypothesis was not rejected, which indicates that month of the year effect did not occur. It is worth to mention that p-value calculated for monthly rates of return in February was equal to 0.058, and was close to the significance level (0.05).

2. In the case of wheat, the null hypothesis was rejected in favor of the alternative hypothesis for July. The p-value calculated for this month reached the level of 0.01. For all of the remaining months, the null hypothesis was not rejected, which indicates that the effect of month of the year did not occur. In June the p-value was slightly higher (0.062) than the significance level (0.05)

3. In the case of coffee, there was no reason to reject the null hypothesis for each of the analyzed month. This indicates that the effect of month of the year did not occur in the analyzed period.

4. In the case of sugar, the null hypothesis was rejected in favor of the alternative hypothesis for the months of March, April and June. The June p-value was even lower than 0,01; what can be interpreted as a strong monthly effect in comparison with March and April, for

which the p-value reached was a little bit higher than 0.03. For all of the remaining months, the null hypothesis was not rejected, which indicates that the effect of month of the year did not occur.

5. In the case of cocoa, the null hypothesis was rejected in favor of the alternative hypothesis for October, when the calculated p-value was slightly higher than 0.005. For all of the remaining months, the null hypothesis was not rejected, which indicates that the effect of month of the year did not occur.

6. In the case of cotton, the null hypothesis was rejected in favor of the alternative hypothesis for the month of December, when the p-vale was lower than 0.02. For all of the remaining months, the null hypothesis was not rejected, which indicates that the effect of month of the year did not occur.

7. In the case of soybeans, the null hypothesis was rejected in favor of the alternative hypothesis for February, July and September. The low p-value calculated for September was a little bit higher than 0.005, what signalizes the strong monthly effect taking place in that month. For all of the remaining months, the null hypothesis was not rejected, what indicates that the effect of month of the year did not occur.

4.2. The Analysis of the Day-of-the-Week Effect

Average rates of return for each day of the week and average rates of return calculated with the use of Monday open and Friday close prices are shown in the Appendix in the Table 7. Information regarding number andfrequency ofpositive and negativerates of return, computed for each day of the week, divided into markets of analyzed agricultural commodities,are included in Table 3.

The highestaverage dailyrate of returnfor all analyzed agricultural commodities was observed on the market of corn on Wednesdays (0.24%), and the lowest on the market of coffee on Fridays (-0.83%). Regarding the corn market, the highest daily rate or return was observed on Wednesdays, and the lowest on Tuesdays. On the wheat market Friday sessions characterized the highest daily average rate of return equal 0.01%, while the lowest were noted on Tuesday sessions. On the coffee market the highest and lowest daily average rates of return took place on Wednesdays (-0.01%) and Fridays (-0.83%), respectively. In the case of sugar and cocoa the lowest daily average rates or return were registered on Monday session, while the highest on Wednesdays for sugar (0.21%) and on Tuesdays for cocoa (0.16%). On Monday sessions the lowest and the highest daily average returns were registered on the cotton and soybeans market reaching -0.40% and 0.20% respectively. The highest daily average rates of return on cotton market and the lowest for soybeans were calculated for Wednesdays (-0.09%) and Thursdays (0.08%) respectively. On Mondays and Tuesdays daily average rates of return turned out to be negative in 5 out of 7 analyzed agricultural commodities. On other sessions they were negative in 4 out of 7 examined commodities.

The corn market experienced positive daily returns mostly on Mondays (52.21%), followed by 51.37% on Wednesdays. The negative daily rates of return were reported more often on Fridays (50.66%) and Tuesdays (50.62%) (Figure 10). On the wheat market frequency of negative daily returns was higher than 50% for all days of the week except Friday (48.79%), and the highest was found to be on Tuesdays (54.61%). Positive daily rate of return was recorded mostly on Fridays (51.21%) (Figure 11).

Table 3. The number and percentage of positive and negative rates of returns on the markets of: corn, wheat, sugar, cocoa, cotton and soybeans for each day of the week in the analyzed period

	AgriculturalCommodity	Monday	Tuesday	Wednesday	Thursday	Friday
Number of positivereturns	Corn	555	518	544	528	522
	Wheat	519	487	529	509	548
	Coffee	507	529	514	529	470
	Sugar	523	516	549	518	547
	Cocoa	474	572	543	534	472
	Cotton	528	488	545	491	538
	Soybeans	577	578	577	540	577
Nuber of negativereturns	Corn	508	531	515	530	536
	Wheat	566	586	547	561	522
	Coffee	580	551	565	554	614
	Sugar	533	554	515	548	523
	Cocoa	605	507	526	536	590
	Cotton	553	593	533	582	535
	Soybeans	504	504	501	533	497
Percentage of months with positive rates of return	Corn	52.21%	49.38%	51.37%	49.91%	49.34%
	Wheat	47.83%	45.39%	49.16%	47.57%	51.21%
	Coffee	46.64%	48.98%	47.64%	48.85%	43.36%
	Sugar	49.53%	48.22%	51.60%	48.59%	51.12%
	Cocoa	43.93%	53.01%	50.80%	49.91%	44.44%
	Cotton	48.84%	45.14%	50.56%	45.76%	50.14%
	Soybeans	53.38%	53.42%	53.53%	50.33%	53.72%
Percentage of months with negative rates of return	Corn	47.79%	50.62%	48.63%	50.09%	50.66%
	Wheat	52.17%	54.61%	50.84%	52.43%	48.79%
	Coffee	53.36%	51.02%	52.36%	51.15%	56.64%
	Sugar	50.47%	51.78%	48.40%	51.41%	48.88%
	Cocoa	56.07%	46.99%	49.20%	50.09%	55.56%
	Cotton	51.16%	54.86%	49.44%	54.24%	49.86%
	Soybeans	46.62%	46.58%	46.47%	49.67%	46.28%

Source: own calculations

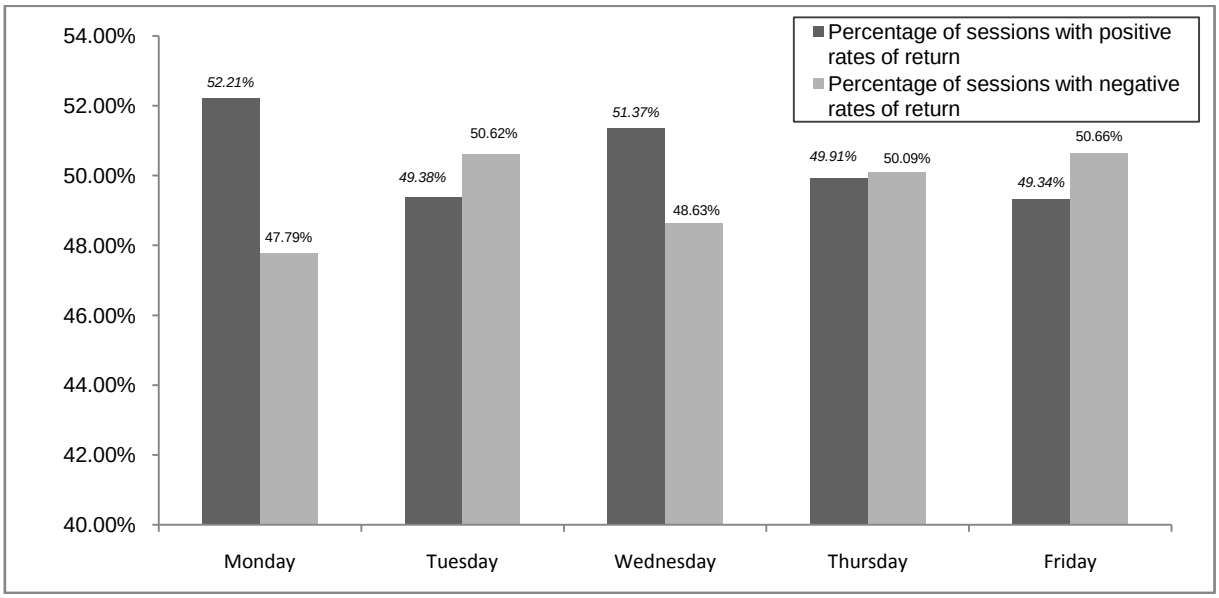

Figure 10. The frequency of positive and negative daily returns over various days of the week for corn
Source: own calculations

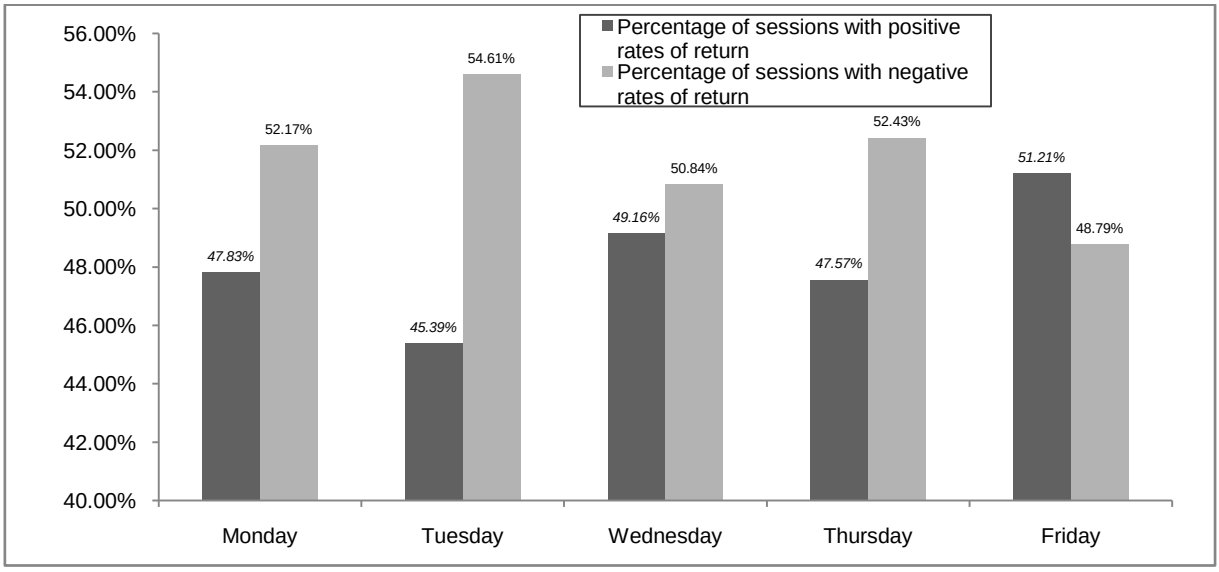

Figure 11. The frequency of positive and negative daily returns over various days of the week for wheat
Source: own calculations

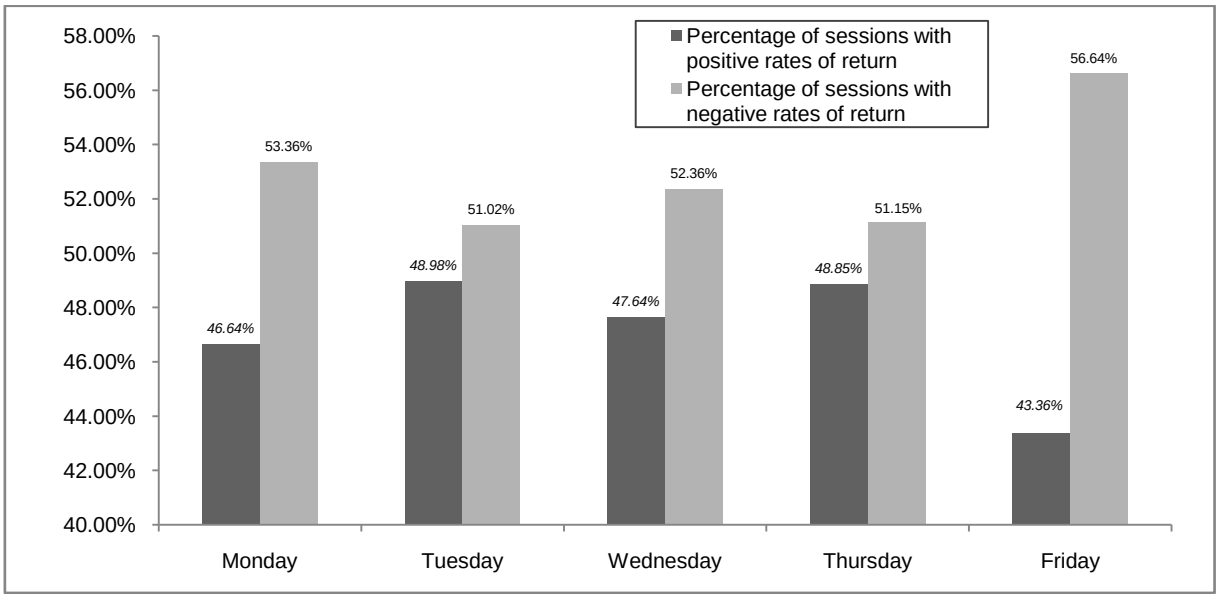

Figure 12. The frequency of positive and negative daily returns over various days of the week for coffee
Source: own calculations

On the coffee market frequency of negative daily rates of return for individual days was higher than 50% and the highest value was recorded on Fridays (56.64%). The highest positive daily rate of return was registered on Tuesdays (48.98%) (Figure 12).

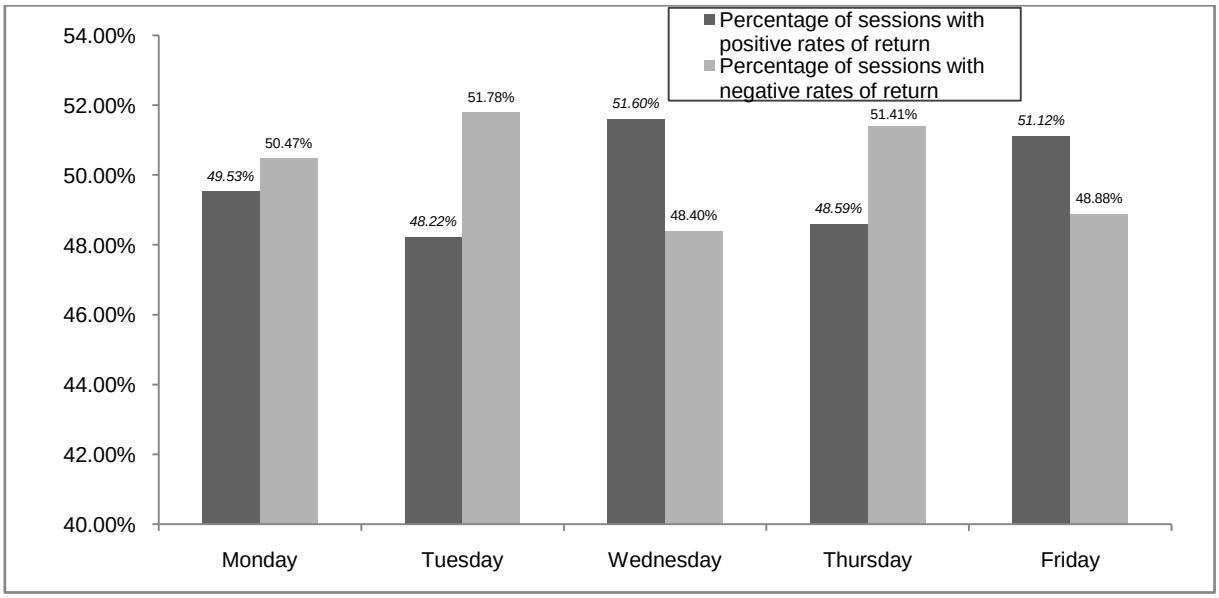

Figure 13. The frequency of positive and negative daily returns over various days of the week for sugar
Source: own calculations

On the sugar market, frequency of positive daily returns proved to be the highest on Wednesdays (51.60%) (Figure 13). In addition,on Fridayspositivedaily rates of return were reportedin 51.12% of all observations. Negative daily rates of return dominated sessions on Tuesdays in 51.78% and on Thursdays in 51.41% of all observations.

On the cocoa market, positive daily returns were recorded mostly on Tuesdays (53.01%), followed by Wednesdays (50.80%) (Figure 14). On the other hand, negative rates of return were most common during Monday and Friday sessions - in 56.07% and 55.56% of all observations respectively.

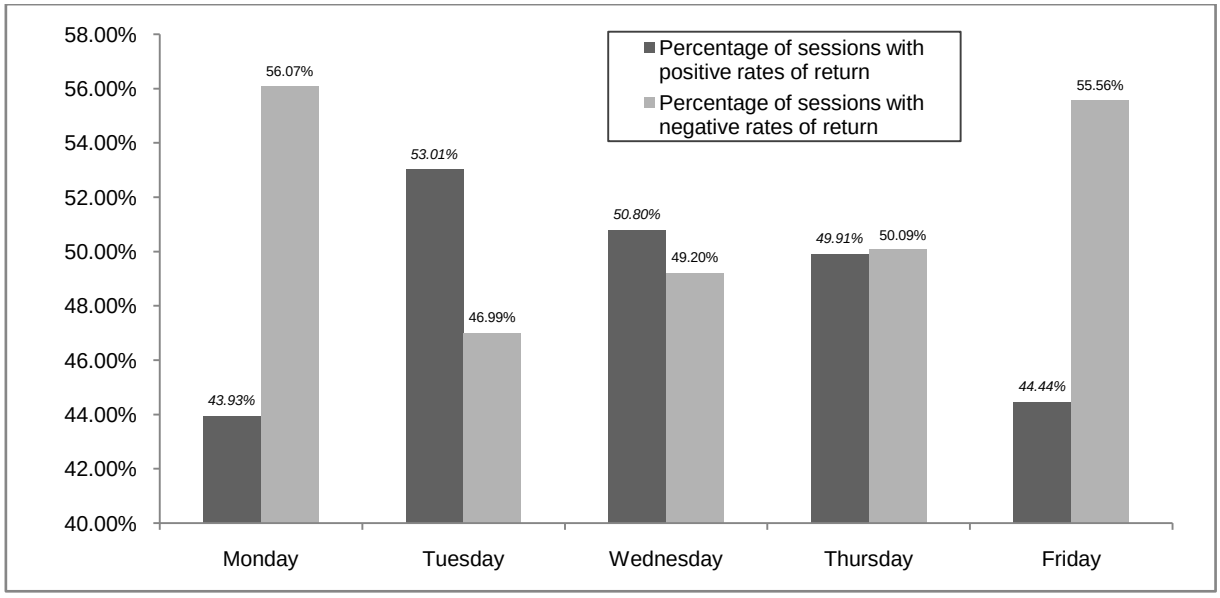

Figure 14. The frequency of positive and negative daily returns over various days of the week for cocoa
Source: own calculations

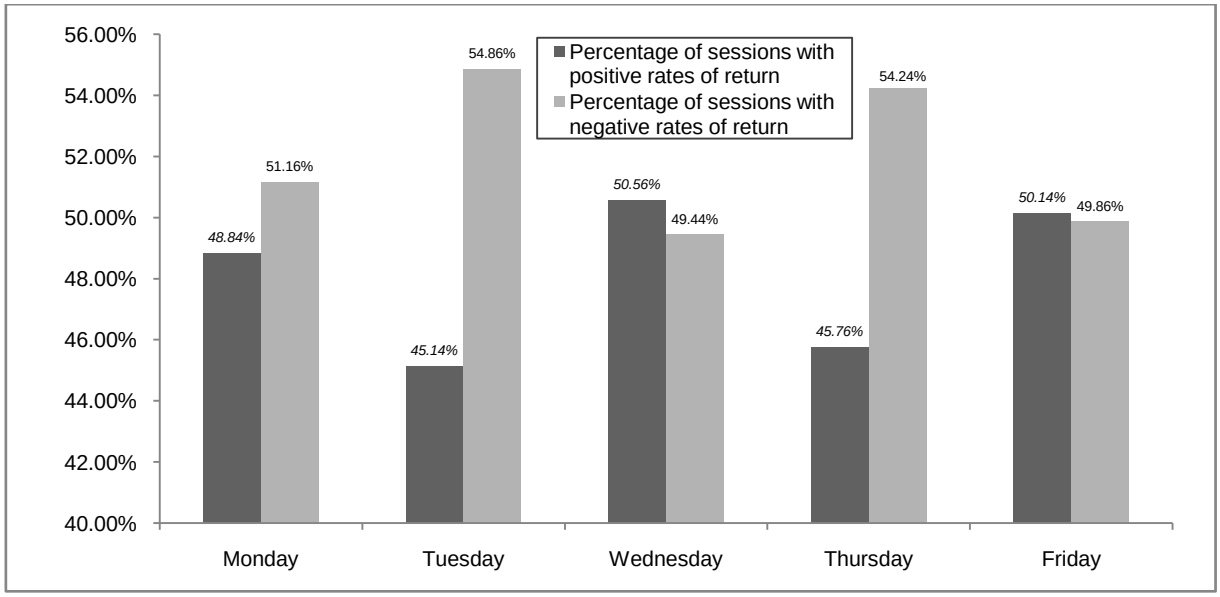

Figure 15. The frequency of positive and negative daily returns overvariousdays of the week for cotton
Source: own calculations

On the cotton market the positive daily rates of return were observed more frequently on Wednesdays (50.56%) and Fridays (50.14%). On the other hand, the negative daily rates of return dominated Tuesday and Thursday sessions – in 54.86% and 54.24% respectively (Figure 15).

On the soybeans market frequency of positive daily rates of return were registered for all days of the week, and was the highest on Fridays (53.72%) and Wednesdays (53.53%). The highest percentage of negative daily rates of return dominated Thursday session and was equal 49.67% of all observations (Figure 16).

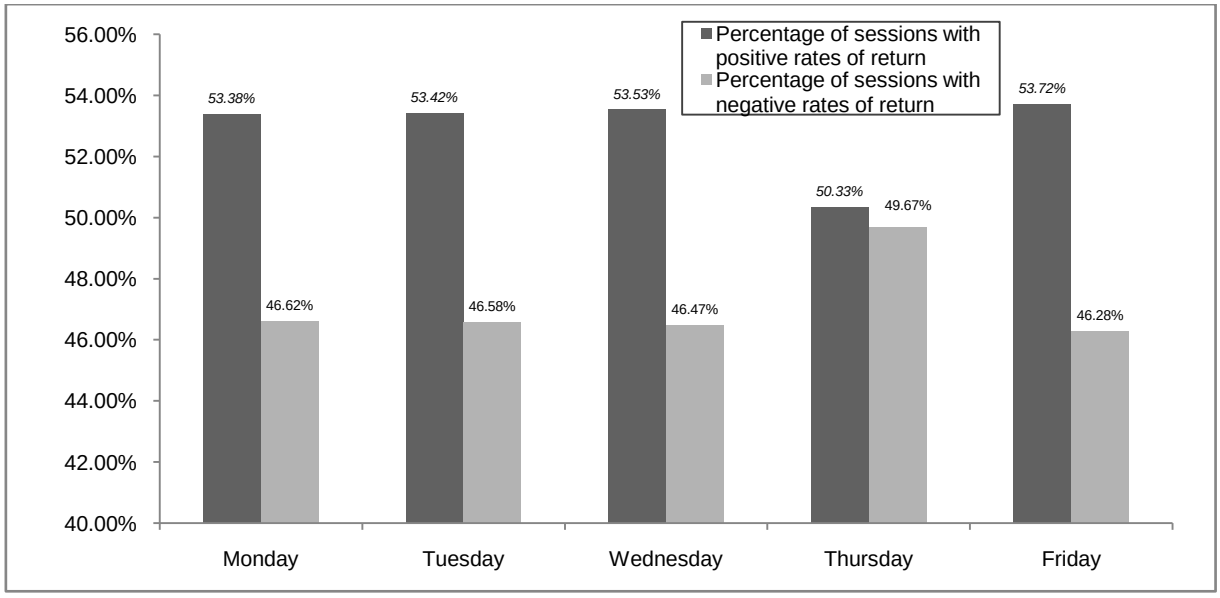

Figure 16. The frequency of positive and negative returns over various days of the week for soybeans

Source: own calculations

The results of testing statistical hypotheses for the daily rates of returns for different days of the week during analyzed period, are presented in Table 4.

Table 4. The results of testing the null hypothesis for the day-of-the week rates of return on the agricultural market

	Corn	Wheat	Coffee	Sugar	Cocoa	Cotton	Soybeans
Monday	0.633214 0.526594	0.205914 0.836858	0.753988 0.450856	-1.96438 0.049486	-2.68856 0.007176	-0.80718 0.419564	0.524348 0.600036
Tuesday	-0.45919 0.646096	-1.97289 0.048508	2.412162 0.015858	-0.45752 0.647296	3.371394 0.000748	-0.74671 0.45524	0.399766 0.689329
Wednesday	1.775635 0.075793	0.497283 0.61899	2.64968 0.008057	1.783115 0.074568	1.267637 0.204928	1.545919 0.122124	0.218856 0.826762
Thursday	-0.16646 0.867795	-1.28249 0.199672	0.336927 0.736172	-0.87784 0.380028	1.856536 0.063377	-0.66851 0.503807	-0.53168 0.594946
Friday	-0.5762 0.564479	0.841432 0.400106	-2.21889 0.026494	0.547823 0.583813	-1.28319 0.199425	0.244255 0.807033	-0.21454 0.830126

Source: own calculations

Notes: The first value in the cell represent test statistic for z, and the second is the p-value

The results of testing H_0 hypothesis permitto presentthe following conclusions:

1. Regarding corn, there was no reason to reject the null hypothesis for each analyzed day of the week. The p-value for Wednesdaysession is equal to 0.076; and slightly differs from the assumed level of significance (0.05).
2. Regarding wheat the null hypothesis was rejected in favor of the alternative hypothesis for Tuesday sessions. This fact indicates the occurrence of day-of-the-week effect on the analyzed market. The p-value calculated for daily rates of return on Tuesdays is a little bit lower than the level of significance (0.05). This fact can provide for a weak day-of-the-week effect.
3. In the case of coffee the null hypothesis was rejected in favor of the alternative hypothesis for Tuesday, Wednesday and Friday sessions. This fact indicates the occurrence of the day-of-the-week effect on the analyzed market. The p-value calculated for rates of return on Wednesday is lower than 0.01. This fact can be interpreted as a strong prove for the occurrence of the-day-of-the-week effect.
4. In the case of sugar the null hypothesis was rejected in favor of the alternative hypothesis for Monday sessions, but p-value is slightly lower than the level of significance (0.05). This fact indicates the occurrence of day-of-the-week effect on the analyzed market, but the magnitude of this ineffectiveness is rather small. P-value for Wednesdays is a little bit higher than the level of significance (0.05).
5. Regardingcocoa the null hypothesis was rejected in favor of the alternative hypothesis for Monday and Tuesday sessions. This fact signalizes the occurrence of the day-of-the-week effect on the analyzed market. Taking into consideration p-value for each of these sessions, we may conclude that the day-of-the-week-effect was the strongest for Monday and Tuesday sessions respectively. The p-value for Thursdaysession is equal to 0.063; and slightly differs from the assumed level of significance (0.05).
6. Regarding cotton, there was no reason to reject the null hypothesis for each analyzed day of the week.
7. Regarding soybeans, there was no reason to reject the null hypothesis for each analyzed day of the week.

4.3 The Analysis of the Weekend Effect

Analysis of rates of return calculated with the use of the Monday's open and Friday's close prices for each agricultural commodity and the result of statistical testing of null hypothesis leads to the data presented in Table 5.

Table 5. The results oftestingthe null hypothesisfor the weekend rates of returnon the agricultural commodity market

Corn	Wheat	Coffee	Sugar	Cocoa	Cotton	Soybeans
-0.27101 0.78638	1.350057 0.176998	-0.24646 0.805324	0.880758 0.378449	-3.30106 0.000963	-0.28695 0.774147	-1.95985 0.050014

Source: own calculations

Notes: The first value in the cell represent statistic test for z, and the second is the p-value

The results obtained during testing the null hypothesis allow to formulate the following conclusions:

1. Regarding corn, wheat, coffee, sugar, cottonand soybeans there were no reasons to reject the null hypothesis. The p-value for soybeans differs from the assumed level of significance (0.05).
2. Regarding cocoa, the null hypothesis was rejected in favor of the alternative hypothesis. The fact, that p-value for cocoa differs heavily from the significance level (0.05), can be interpreted as a weekend effect with strong magnitude.

The average overnight weekend rates of return were positive in 4 out of 7 analyzed commodities and the highest value were obtained for coffee (0.47%), followed by wheat

(0.26%), cotton (0.25%) and sugar (0.16%). The most negative overnight rate of return was registered on the market of soybeans (-0.30%). Regarding cocoa and corn market, the overnight weekend rate of return turn out to be negative and equal: -0.05% and -0.04% respectively.

5. Conclusion

In recent years, there has been observed an increased interest in the commodity market, including precious metals, both institutional and individual investors. Investment strategies implemented in the commodity market by its participants, heavily resemble those of the stock and currency markets. However it should be mentioned that particular characteristics are assigned to the agricultural commodity market such as stock level or marginal unit cost. It is also important to note that, despite the physical diversity, this asset class is often characterized by a high degree of price correlation (Fabozzi *et al.* 2008).

The aim of this study was to determine the prevalence of selected effects of seasonality on the following agricultural commodities: corn, wheat, coffee, sugar, cocoa, cotton and soybeans. Analysis of the effects of seasonality included an examination of monthly returns, returns over various days of the week and so called weekend effect. The main limitation ofthis study isthe assumptionof normal distributionof return rates of analyzed commoditiesas well as the use of price data gained from Bloomberg data source.

Calculations presented in this paper indicate the absence of the monthly effect on coffee market. The existence of seasonality effect occurred in case of another six analyzed agricultural commodities: corn (June, December), wheat (July), sugar (March, April and June), cocoa (October), cotton (December) and soybeans (February, July and September). January, May and November were the months when no seasonal effect was observed on the market of seven analyzed agricultural commodities.

In the analyzed period no occurrence of day-of-the-week effect was proved concerningcorn, cotton and soybeans. The day-of-the-week effect was registered on the markets of: wheat (Tuesdays), coffee (Tuesdays, Wednesdays and Fridays), sugar (Mondays) and cocoa (Mondays and Tuesdays). In turn, the weekend effect was observed only on the cocoa market – for another six analyzed agricultural commodities, this kind of effect was not detected.

The results obtained in the article,regarding the monthly effect were consistent with those of:

a) Bigman *et al.* (1983), Bigman and Goldfarb (1985), Martell and Helms (1978), Cargill and Rausser (1972), Cargill and Rausser (1975) – on the markets of: wheat, corn and soybeans,
b) Brinegar (1970) – on the markets of: wheat and corn,
c) Helms *et al.* (1984) and Stevenson and Bear (1970) – on the market of soybeans,
d) Gordon (1985) – on the markets of: wheat, corn, soybeans, cotton,
e) Labys and Granger (1970) – on the markets of: wheat, soybeans, corn, sugar, cotton, cocoa.
f) Wang and Ke (2005) - on the marketof wheat,
g) Lokare (2007) – on the markets of: sugar and cotton,
h) Kristoufek and Vosvrda (2013) – on the market of sugar.

The conclusions presented in this paper are inconsistent with those proven by:

a) Fortenberry and Zapta (1993) – on the markets: of corn and soybeans,
b) Aulton *et al.* (1997) – on the market of wheat,
c) Sabuhoro and Laure (1997) – on the markets of: coffee and cocoa,
d) Zunino *et al.* (2011) – on the markets of: cotton, wheat and coffee,
e) Kristoufek and Vosvrda (2013) – on the market of cocoa,
f) McKenzie and Holt (2002) – on the markets of: corn and soybeans,
g) Lee *et al.* (2013) – on the markets of: corn, soybeans and wheat.

Further research on the occurrence of calendar anomalies in the agricultural market should include the following assets: oat, frozen orange juice, rye, soybean oil and rubber.

References

Abraham, A. and Ikenberry, D., 1994. Individual investors and the Weekend Effect, *Journal of Financial and Quantitative Analysis*, No 2, pp.263-277. http://dx.doi.org/10.2307/2331225

Agrawal, A. and Tandon, K., 1994. Anomalies or illusions?:Evidence from stock markets in eighteen countries, *Journal of International Money and Finance*, No. 13, pp.83-106. http://dx.doi.org/10.1016/0261-5606(94)90026-4

Ali, J. and Gupta, K., 2011. Efficiency in agricultural commodity futures markets in India: evidence from cointegration and causality tests, *Agricultural Finance Review*, No. 71, pp.162-178. http://dx.doi.org/10.1108/00021461111152555

Ariel, R., 1987. A monthly effect in stock returns, *Journal of Financial Economics*, No. 17, pp. 161-174. http://dx.doi.org/10.1016/0304-405X(87)90066-3

Ariel, R., 1990. High stock returns before holidays: existence and evidence on possible causes, J*ournal Finance*, No. 45, pp.1611-1626. http://dx.doi.org/10.1111/j.1540-6261.1990.tb03731.x

Aulton, A., Ennew, C. and Rayner, A., 1997. Efficiency tests of futures markets for UK agricultural commodities, *Journal of Agricultural Economics*, No. 48, pp.408-423. http://dx.doi.org/10.1111/j.1477-9552.1997.tb01162.x

Barone, E., 1990. The Italian stock market: Efficiency and calendar anomalies, *Journal of Banking and Finance*, No. 14, pp.493-510. http://dx.doi.org/10.1016/0378-4266(90)90061-6

Bernstein, J., 1991. *Cycles of profit*. New York: Harper Colins.

Bigman, D. and Goldfarb, D., 1985. Efficiency and efficient trading rules for food and feed grains in the world commodity markets: the Israeli experience, *Journal of Futures Markets*, No. 5, pp.1-10. http://dx.doi.org/10.1002/fut.3990050102

Bigman, D., Goldfarb, D. and Schechtman, E., 1983. Futures market efficiency and the time content of the information sets, *Journal of Futures Markets*, No. 3, pp.321-334. http://dx.doi.org/10.1002/fut.3990030307

Board, J. and Sutcliffe, C., 1988. The weekend effect in UK stock market returns, *Journal of Business, Finance & Accounting*, No. 15, pp.199-213.

Brinegar, C., 1970. A statistical analysis of speculative price behavior, *Food Research Institute Studies*, No. 9, pp.1-57.

Buczek, S., 2005. Efektywność informacyjna rynków akcji. Teoria a rzeczywistość, Szkoła Główna Handlowa w Warszawie, Warszawa.

Cadsby, C.and Ratner, M., 1992. Turn-of-month and pre-holiday effects on stock returns: Some international evidence. *Journal of Banking and Finance*, No. 16, pp.497-509. http://dx.doi.org/10.1016/0378-4266(92)90041-W

Canarella, G. and Pollard, S., 1985. Efficiency of commodity futures: a vector autoregression analysis. *Journal of Futures Markets*, No. 5, pp.57-76. http://dx.doi.org/10.1002/fut.3990050107

Cargill, T. and Rausser, G., 1972. Time and frequency representations of future prices as a stochastic process. *Journal of American Statistical Association*, No. 67, pp.23-30. http://dx.doi.org/10.1080/01621459.1972.10481201

Cargill, T. and Rausser, G., 1975. Temporal price behavior in commodity futures markets. Journal of Finance, No. 30, pp.1043-1053.

Condoyanni, L., O'Hanlon, J. and Ward, C., 1987. Day of the week effects on stock returns: international evidence. *Journal of Business Finance and Accounting,* No. 14, pp.159-174. http://dx.doi.org/10.1111/j.1468-5957.1987.tb00536.x

Connolly, R., 1991. A posterior odds analysis of the weekend effect. *Journal of Econometrics*, No. 49, pp.51-104. http://dx.doi.org/10.1016/0304-4076(91)90010-B

Corhay, A., Hawawini, G. and Michel, P.,1988. *Stock market anomalies*. Cambridge: Cambridge University Press.

Coutts, J. and Hayes, P., 1999. The weekend effect, the stock exchange account and the financial times industrial ordinary shares index 1987-1994. *Applied Financial Economics*, No. 9, pp.67-71. http://dx.doi.org/10.1080/096031099332537

Cross, F., 1973. The behavior of stock prices and Fridays and Mondays. *Financial Analyst Journal*, No.. 29, pp.67-69. http://dx.doi.org/10.2469/faj.v29.n6.67

Dubois, M. and Louvet, P., 1996. The day-of-the-week effect: The international evidence. *Journal of Banking and Finance*, No. 20, pp.1463-1484. http://dx.doi.org/10.1016/0378-4266(95)00054-2

Fabozzi, F., Fuss, R. and Kaiser D., 2008. A handbook of commodity investing. Wiley & Sons, Hoboken. http://dx.doi.org/10.1002/9781118267004

Fama, E., 1970. Efficient capital markets: a review of theory and empirical work. *Journal of Finance*, No. 25, pp. 383-417. http://dx.doi.org/10.2307/2325486

French, K., 1980. Stock returns and weekend effect. *Journal of Financial Economics*, No. 8, pp. 55-69. http://dx.doi.org/10.1016/0304-405X(80)90021-5

Fields, M., 1934. Security prices and stock exchange holidays in relation to short selling. *Journal of Business*, No. 7, pp.328-338. http://dx.doi.org/10.1086/232387

Fortenberry, R. and Zapata, H., 1993. An examination of cointegration relation between futures and local grain markets. *Journal of Futures Markets*, No. 13, pp.921-932. http://dx.doi.org/10.1002/fut.3990130809

Froot, K. and Thaler, R., 1990. Anomalies: foreign exchange. *Journal of Economic Perspectives*, No. 4, pp.179-192. http://dx.doi.org/10.1257/jep.4.3.179

Garcia, P., Hudson, M. and Waller, M., 1988. The pricing efficiency of agricultural futures markets: an analysis of previous research result. *Southern Journal of Agricultural Economics*, No. 20, pp.119-130.

Gibbons, M. and Hess, P., 1981. Day of the week effects and asset returns. *Journal of Business*, No. 54, pp.579-596. http://dx.doi.org/10.1086/296147

Gordon, J., 1985. The distribution of daily changes in commodity futures prices. *Technical Bulletin,* ERS USDA, No. 1702.

Gorska, A. and Krawiec, M., 2013. Badania efektywności informacyjnej w formie słabiej na rynku metali szlachetnych. *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, No. 768, pp.143-156.

Gu, A., 2003. The declining January effect: evidence from U.S. equity markets. *Quarterly Review of Economics and Finance*, No. 43, pp.395-404. http://dx.doi.org/10.1016/S1062-9769(02)00160-6

Helms, B., Kaen, F. and Roseman, R., 1984. Memory in commodity futures contracts. *Journal of Futures Markets*, No. 4, pp.559-568. http://dx.doi.org/10.1002/fut.3990040408

Hunt, B., 1974. Short run price cycles in the Sydney wool futures market. *Australian Journal of Agricultural Economics*, No. 18, pp.133-143.

Jaffe, J. and Westerfield, R., 1985. The week-end effect in common stock returns: The international evidence. *Journal of Finance*, Nol. 40, pp.410-428.

Jaffe, J., Westerfield, R. and Ma, C., 1989. A twist on Monday effect in stock prices: Evidence from the US and foreign stock markets. *Journal of Banking and Finance*, No. 15, pp.641-650. http://dx.doi.org/10.1016/0378-4266(89)90035-6

Johnson, R. and Soenen, L., 1997. Gold as an investment asset – perspectives from different countries. *Journal of Investing*, No. 6, pp.94-99. http://dx.doi.org/10.3905/joi.1997.408427

Just, R. and Rausser, G., 1975. Commodity price forecasting with large-scale econometric models and the futures markets: A survey. *American Journal of Agricultural Economics*, No. 55, pp.584-593.

Kato, K., Schwarz, S. and Ziemba, W.,1990. Day of the weekend effects in Japanese stocks. *Japanese Capital Markets*, Ballinger, New York.

Keim, D., 1983. Size-related anomalies and stock return seasonality: further empirical evidence. *Journal of Financial Economics*, No. 12, pp.13-32. http://dx.doi.org/10.1016/0304-405X(83)90025-9

Keim, D. and Stambaugh, F., 1984. A further investigation of weekend effects in stock returns. *Journal of Finance*, No. 39, pp.819-840. http://dx.doi.org/10.1111/j.1540-6261.1984.tb03675.x

Kellard, N., Newbold, P., Rayner, T. and Ennew, C., 1999. The relative efficiency of commodity futures markets. *Journal of Futures Markets*, No. 19, pp.413–432. http://dx.doi.org/10.1002/(SICI)1096-9934(199906)19:4<413::AID-FUT2>3.0.CO;2-F

Kim, C. and Park, J., 1994. Holiday effects and stock returns: further evidence. *Journal of Financial and Quantitative Analysis*, No. 29, pp.145-157. http://dx.doi.org/10.2307/2331196

Kim, H., Oh, G. and Kim, S., 2011a. Multifractal analysis of Korean agricultural market. *Physica A*, No. 390, pp.4286-4292. http://dx.doi.org/10.1016/j.physa.2011.06.046

Kim, M., Kim, J., Jo, Y. and Kim, S., 2011b. Dependence structure of the commodity and stock markets, and relevant multi-spread strategy, *Physica A*, No. 390, pp.3842-3854. http://dx.doi.org/10.1016/j.physa.2011.06.037

Kofi, T., 1972. A framework for comparing the efficiency of the futures markets. *American Journal of Agricultural Economics*, No. 55, pp.584-593.

Kramer, W., 1996. Stochastic properties of German stock returns. *Empirical Economics*, No. 21, pp.281-306. http://dx.doi.org/10.1007/BF01175974

Kristoufek, L. and Vosvrda, M., 2013. Commodity futures and market efficiency. *Energy Economics*, No. 42, pp.50-57.

Labys, W. and Granger, C., 1970. *Speculation, hedging and commodity price forecasting*. Lexington MA: Health Lexington Books.

Lakonishok, J. and Maberly, E.,1990. The weekend effect: trading patterns of individual and institutional investors. *Journal of Finance*, No. 45, pp.231-243. http://dx.doi.org/10.1111/j.1540-6261.1990.tb05089.x

Lakonishok, J. and Levi, M.,1982. Weekend Effect on stock returns: A note. *Journal of Finance*, No. 37, pp.883-889. http://dx.doi.org/10.1111/j.1540-6261.1982.tb02231.x

Lakonishok, J. and Smidt, S., 1988. Are seasonal anomalies real. A ninety-year perspective. *Review of Financial Studies*, No. 1, pp.403-425. http://dx.doi.org/10.1093/rfs/1.4.403

Larson, A., 1960. Measurement of a random process in future prices. *Food Research Institute Studies*, No. 1, pp. 313-324.

Latif, M., Arshad, S., Fatima, M. and Rarooq, S., 2011. Market efficiency, market anomalies, causes, evidences and some behavioral aspects of market anomalies. *Research Journal of Finance and Accounting*, No. 2, pp. 1-14.

Leath, M. and Garcia, P., 1983. The efficiency of the corn futures markets in establishing forward prices. *North Central Journal of Agricultural Economics*, No. 5, pp.91-101. http://dx.doi.org/10.2307/1349144

Lee, K., Hsu, C. and Ke, M., 2013. Testing the monthly effect of agricultural futures markets with stochastic dominance. *International Review of Accounting, Banking and Finance*, No. 5, pp. 35-60.

Lokare, S., 2007. Commodity derivatives and price risk management: an empirical anecdote from India. *Reserve Bank of India Occasional Papers*, No. 28.

Martell, T. and Helms, B., 1978. A re-examination of price changes in the commodity futures markets. *International Futures Trading Seminar*, No. 5 Chicago Board of Trade.

Martell, T. and Philipatos, G., 1974. Adoption information and dependence in commodity markets. *Journal of Finance*, No. 29, pp.493-498. http://dx.doi.org/10.2307/2978818

Mckenzie, A. and Holt, M., 1998. Market efficiency in agricultural futures markets. 1998 American Agricultural Economics Association Annual Meeting in Salt Lake City.

Mckenzie, A. and Holt, M., 2002. Market efficiency in agricultural futures markets. *Applied Economics*, No. 34, pp. 1519–1532. http://dx.doi.org/10.1080/00036840110102761

Mills, T. and Coutts, J., 1995. Calendar effects in the London Stock Exchange FTSE indices. *European Journal of Finance*, No. 1, pp.79-93. http://dx.doi.org/10.1080/13518479500000010

Otto, S., 2011. A speculative efficiency analysis of the London Metal Exchange in a multi-contract framework. *International Journal of Economics and Finance*, No. 3, pp.3-16.

Osinska, M., 2006, *Ekonometria finansowa*. Warszawa: PWE.

Peiro E., 1994. Daily seasonality in stock returns: Further international evidence. *Economics Letters*, No. 45, pp.227-232. http://dx.doi.org/10.1016/0165-1765(94)90140-6

Rozeff, M. and Kinney, W.,1976. Capital market seasonality: the case of stock returns. *Journal of Financial Economics*, No. 3, pp.379-402. http://dx.doi.org/10.1016/0304-405X(76)90028-3

Rausser, G. and Carter, C., 1983. Futures market efficiency in the soybean complex. *Review of Economics and Statistics*, No. 65, pp.469-478. http://dx.doi.org/10.2307/1924192

Sabuhoro, J. and Larue, B., 1997. The market efficiency hypothesis: the case of coffee and cocoa futures, *Agricultural Economics*, No. 16, pp.171-184. http://dx.doi.org/10.1016/S0169-5150(97)00003-0

Sahoo, P. and Kumar, R., 2009. Efficiency and futures trading – price nexus in Indian commodity futures markets. *Global Business Review*, No. 10, pp.187-201. http://dx.doi.org/10.1177/097215090901000204

Schwert, W.,2002.Anomalies and market efficiency. *Simon School of Business Working Paper no*. FR 02-13.

Sehgal, S., Rajput, N. and Dua, R., 2012. Price discovery in Indian agricultural commodity markets. *International Journal of Accounting and Financial Reporting*, No. 2, pp.34-54.

Simson, E., 1988. *Stock market anomalies*. Cambridge: Cambridge University Press.

Smidt, S., 1965. A test of the serial independence of price changes in soybean futures. *Food Research Institute Studies*, No. 5, pp.117-136.

Solnik, B. and Bosquet, L., 1990. Day-of-the-week effect on the Paris Bourse, *Journal of Banking and Finance*, No. 14, pp.461-468. http://dx.doi.org/10.1016/0378-4266(90)90059-B

Spriggs, J., 1981. Forecasting of Indiana monthly farm prices using Univariate Box-Jenkins analysis and corn futures prices*, North Central Journal of Agricultural Economy*, No. 3, pp.81-87. http://dx.doi.org/10.2307/1349412

Sutheebanjard, P. and Premchaiswadi, W.,2010. Analysis of calendar effects: day-of-the-week effect on the Stock Exchange of Thailand (SET). *International Journal of Trade, Economics and Finance*, No.1,pp. 2010-2023.

Stevenson, R. and Bear, R., 1970. Commodity futures trends or random walk. *Journal of Finances*, No. 25, pp.65-81.

Szyszka, A., 2007.,Wycena papierów wartościowych na rynku kapitałowym w świetle finansów behawioralnych. Wydawnictwo Akademii Ekonomicznej w Poznaniu, Poznań.

Theobald, M. and Price, V., 1984. Seasonality estimation in thin markets. *Journal of Finance*, No., pp.377-392.

Tomek, W. and Gray, R., 1970. Temporal relationship among prices on commodity futures markets: their allocative and stabilizing role. *American Journal of Agricultural Economics*, No. 52, pp.372-380. http://dx.doi.org/10.2307/1237388

Wang, H. and Ke, B., 2005.Efficiency tests of agricultural commodity futures markets in China. *Australian Journal of Agricultural and Resource Economics*, No. 49, pp.125–141. http://dx.doi.org/10.1111/j.1467-8489.2005.00283.x

Zunino, L., Tabak, M., Serinaldi, F., Zanin, M., Perez, G. and Rosso, O., 2011. Commodity predictability analysis with a permutation information theory approach. *Physica A*, No. 390, pp.876-890. http://dx.doi.org/10.1016/j.physa.2010.11.020

Appendix

Table 6. Average monthly rates of return for all analyzed metals

	Corn	Wheat	Coffee	Sugar	Cocoa	Cotton	Soybeans
January	0.52%	-1.65%	2.81%	-0.04%	3.11%	2.14%	-0.02%
February	2.50%	-1.20%	3.05%	-1.50%	1.41%	1.79%	2.73%
March	1.48%	-0.41%	-0.95%	-4.43%	-1.03%	-0.35%	1.24%
April	-0.34%	-0.10%	1.59%	-3.96%	0.87%	-1.24%	2.23%
May	0.52%	0.58%	0.71%	-0.72%	-1.79%	-1.92%	0.06%
June	-3.96%	-3.29%	-3.30%	5.31%	2.77%	-0.66%	0.91%
July	-4.16%	0.49%	0.23%	3.70%	0.65%	-3.89%	-4.29%
August	0.60%	1.28%	0.31%	-1.82%	0.69%	0.99%	-0.84%
September	-2.09%	1.92%	-2.43%	0.36%	1.30%	-1.51%	-4.96%
October	2.44%	-0.98%	-0.88%	1.36%	-4.16%	0.42%	1.95%
November	-1.23%	-0.96%	1.40%	0.86%	0.55%	-0.21%	1.97%
December	5.20%	1.92%	1.88%	2.40%	1.96%	4.01%	0.90%

Source: own calculations

Table 7. Rates of return for each day of the week and rates of return for Monday open and Friday close prices

	Monday	Tuesday	Wednesday	Thursday	Friday	Monday open/ Friday close (weekend effect)
Corn	0.1034%	-0.0362%	0.2447%	0.0013%	-0.0052%	-0.0392%
Wheat	-0.0868%	-0.3927%	-0.0393%	-0.3036%	0.0143%	0.2568%
Coffee	-0.3266%	-0.0347%	-0.0204%	-0.4133%	-0.8282%	0.4672%
Sugar	-0.3525%	-0.1142%	0.2106%	-0.1857%	0.0405%	0.1622%
Cocoa	-0.4298%	0.1643%	-0.0376%	0.0229%	-0.2826%	-0.0533%
Cotton	-0.3958%	-0.3904%	-0.0929%	-0.3841%	-0.2598%	0.2522%
Soybeans	0.2017%	0.1848%	0.1622%	0.0781%	0.1132%	-0.3034%

Source: own calculations