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Analysis of Selected Seasonality Effects in the Following Metal Markets: Gold, Silver, Platinum, Palladium and Copper

ABSTRACT

The commodity market has been becoming one of the most popular segments of the financial markets among individual and institutional investors in recent years. Similarly to the equity market, the problem of anomalies in the commodities market is becoming an interesting phenomenon, especially in the segment of the precious metals. This paper tests the hypothesis of monthly, the day-of-the week and weekend effects of the precious metal markets quoted on the London Metal Exchange for gold, silver, platinum and copper in the period of 1.01.1995–31.12.2015 considering also palladium in the period 1.01.1998–31.12.2015. Calculations presented in this paper indicate the absence of the monthly effect on gold, silver, platinum, copper markets but proved occurrence of monthly anomaly in the month of September on palladium market. In the analyzed period day-of-the week effect for any of the studied metal markets was not observed but the weekend effect was registered on the gold and copper markets.

Keywords: Market Efficiency, Metal Markets, Calendar Anomalies

1. Introduction

Efficient market hypothesis (EMH), the center of the influential paper of Fama¹, has been a cornerstone of financial economics for many decades. Although actual definitions differ from that formulated by Fama, the efficiency of markets prevents systematic beating of the market, usually in a form of above-average risk-adjusted returns. The problem of the financial markets efficiency, especially of equity markets, has been discussed in a number of scientific works, which has led to a sizable set of publications examining this subject. In many empirical works dedicated to the time series analysis of rates of return and stock prices, there were found statistically significant effects of both types, 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 Simson² or Latif et al.³.

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

A) **Day-of-the-week effect** – daily average rates of return registered on the stock market differ for various days of the week. One of the first works dedicated to this type of effect, was developed by Kelly⁴, who proved that the average rate of return of the US stock markets on Monday is lower than average rates of return for other days of the week. Empirical work of Hirsch⁵ confirmed the existence of the day-of-the-week effect. In his study, he examined behavior of the S&P500 index in the period from June 1952 to June 1985, proving that the index close on Monday was lower in 57% of cases than the index close on the preceding Friday. For other days of the week, the following trend was observed

¹ E. Fama, *Efficient Capital Markets; A Review of Theory and Empirical Work*, “Journal of Finance” 1970, vol. 25, pp. 383–417.

² E. Simson, *Stock Market Anomalies*, Cambridge University Press, Cambridge 1988.

³ M. Latif, S. Arshad, M. Fatima, S. Rarooq, *Market Efficiency, Market Anomalies, Causes, Evidences and Some Behavioral Aspects of Market Anomalies*, “Research Journal of Finance and Accounting” 2011, vol. 2, no. 9/10, pp. 1–14.

⁴ F. Kelly, *Why You Win or Lose: The Psychology of Speculation*, Houghton Mifflin, Boston 1930.

⁵ Y. Hirsch, *Don't Sell Stock on Monday*, Penguin Books, New York 1987.

– the index close on one session was higher than the index close on the previous session (Tuesday/Monday in 43% of observations, Wednesday/Tuesday in 55.6%, Thursday/Wednesday in 52.6%, Friday/Thursday in 58%). The day-of-the-week effect in the US market was also presented, among others, in the works of: Jaffe et al.⁶, French⁷, Lakonishok and Maberly⁸. The evidence for the UK market was examined by: Theobald and Price⁹, Jaffe and Westerfield¹⁰, Board and Sutcliffe¹¹, Agrawal and Tandon¹², Peiro¹³, Mills and Coutts¹⁴, Dubois and Louvet¹⁵, Coutts and Hayes¹⁶. Peiro¹⁷, Agrawal and Tandon¹⁸, Dubois and Louvet¹⁹ and Kramer²⁰ provided evidence of negative Monday and Tuesday returns for Frankfurt exchange. In works of Solnik and Bousquet²¹, Agarwal and Tandon²², there was found an evidence of negative Tuesday rates of return in Paris market, while Condoyanni et al.²³ and Peiro²⁴ demonstrated negative Monday and Tuesday rates or return

⁶ J. Jaffe, R. Westerfield, C. Ma, *A Twist on Monday Effect in Stock Prices: Evidence from the US and Foreign Stock Markets*, "Journal of Banking and Finance" 1989, vol. 15, pp. 641–650.

⁷ K. French, *Stock Returns and Weekend Effect*, "Journal of Financial Economics" 1980, vol. 8, pp. 55–69.

⁸ J. Lakonishok, E. Maberly, *The Weekend Effect: Trading Patterns of Individual and Institutional Investors*, "Journal of Finance" 1990, vol. 45, pp. 231–243.

⁹ M. Theobald, V. Price, *Seasonality Estimation in Thin Markets*, "Journal of Finance" 1984, vol. 39, pp. 377–392.

¹⁰ J. Jaffe, R. Westerfield, *The Week-end Effect in Common Stock Returns: The International Evidence*, "Journal of Finance" 1985, vol. 40, pp. 410–428.

¹¹ J. Board, C. Sutcliffe, *The Weekend Effect in UK Stock Market Returns*, "Journal of Business, Finance & Accounting" 1988, vol. 15, no. 2, pp. 199–213.

¹² A. Agrawal, K. Tandon, *Anomalies or Illusions?: Evidence from Stock Markets in Eighteen Countries*, "Journal of International Money and Finance" 1994, vol. 13, pp. 83–106.

¹³ E. Peiro, *Daily Seasonality in Stock Returns: Further International Evidence*, "Economics Letters" 1994, vol. 45, pp. 227–232.

¹⁴ T. Mills, J. Coutts, *Calendar Effects in the London Stock Exchange FTSE Indices*, "European Journal of Finance" 1995, vol. 1, pp. 79–93.

¹⁵ M. Dubois, P. Louvet, *The Day-of-the-week Effect: The International Evidence*, "Journal of Banking and Finance" 1996, vol. 20, pp. 1463–1484.

¹⁶ J. Coutts, P. Hayes, *The Weekend Effect, the Stock Exchange Account and the Financial Times Industrial Ordinary Shares Index 1987–1994*, "Applied Financial Economics" 1999, vol. 9, pp. 67–71.

¹⁷ E. Peiro, *Daily...*, op. cit., pp. 227–232.

¹⁸ A. Agrawal, K. Tandon, *Anomalies...*, op. cit., pp. 83–106.

¹⁹ M. Dubois, P. Louvet, *The Day-of-the-week...*, op. cit., pp. 1463–1484.

²⁰ W. Kramer, *Stochastic Properties of German Stock Returns*, "Empirical Economics" 1996, vol. 21, pp. 281–306.

²¹ B. Solnik, L. Bosquet, *Day-of-the-Week Effect on the Paris Bourse*, "Journal of Banking and Finance" 1990, vol. 14, pp. 461–468.

²² A. Agrawal, K. Tandon, *Anomalies...*, op. cit., pp. 83–106.

²³ L. Condoyanni, J. O'Hanlon, C. Ward, *Day of the Week Effects on Stock Returns: International Evidence*, "Journal of Business Finance and Accounting" 1987, vol. 14, pp. 159–174.

²⁴ E. Peiro, *Daily...*, op. cit., pp. 227–232.

on the same market and Barone²⁵ in Milan. Research regarding rates of return on other market was performed in works of Kato et al.²⁶, and also by Sutheebanjard and Premchaiswadi²⁷. On the Polish market, findings regarding the day-of-the-week effect were conducted among others by: Buczek²⁸ and Szyszka²⁹.

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 Keim³⁰, 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 the UK, the period from December to April consisted of months, which on average produced positive returns³¹. Bernstein³², taking into consideration the behavior of the US equity market in the period from 1940 to 1989, found the interdependence between rates of returns in each month. Modern researches, e.g. by Gu³³ and Schwert³⁴ 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.

²⁵ E. Barone, *The Italian Stock Market: Efficiency and Calendar Anomalies*, “Journal of Banking and Finance” 1990, vol. 14, pp. 493–510.

²⁶ K. Kato, S. Schwarz, W. Ziemba, *Day of the Weekend Effects in Japanese Stocks*, “Japanese Capital Markets”, Ballinger, New York 1990.

²⁷ P. Sutheebanjard, W. Premchaiswadi, *Analysis of Calendar Effects: Day-of-the-Week Effect on the Stock Exchange of Thailand (SET)*, “International Journal of Trade, Economics and Finance” 2010, vol. 1, pp. 2010–2023.

²⁸ S. Buczek, *Efektywność informacyjna rynków akcji. Teoria a rzeczywistość*, Warsaw School of Economics Publishing House, Warsaw 2005, pp. 51–55.

²⁹ A. Szyszka, *Wycena papierów wartościowych na rynku kapitałowym w świetle finansów behawioralnych*, Wydawnictwo Akademii Ekonomicznej w Poznaniu, Poznan 2007, pp. 141–146.

³⁰ D. Keim, *Size-related Anomalies and Stock Return Seasonality: Further Empirical Evidence*, “Journal of Financial Economics” 1983, vol. 12, pp. 13–32.

³¹ M. Rozeff, W. Kinney, *Capital Market Seasonality: The Case of Stock Returns*, “Journal of Financial Economics” 1976, vol. 3, pp. 379–402; A. Corhay, G. Hawawini, P. Michel, *Stock Market Anomalies*, Cambridge University Press, Cambridge 1988.

³² J. Bernstein, *Cycles of Profit*, Harpercolins, New York 1991.

³³ A. Gu, *The Declining January Effect: Evidence from U.S. Equity Markets*, “Quarterly Review of Economics and Finance” 2003, vol. 43, pp. 395–404.

³⁴ W. Schwert, *Anomalies and Market Efficiency*, Simon School of Business Working Paper no. FR 02–13, 2002.

C) Other seasonal effects – the following calendar effects can be found in the financial literature:

1. The weekend effect – Cross³⁵ found that markets tend to raise on Fridays and fall on Mondays. His findings generated a flood of research³⁶. In the literature two ways of computing weekend rates of return are implemented. In the first, Friday close and Monday open prices are used, while in the second Friday close and Monday close prices are employed.
2. The holiday effect – markets before holidays or other trading breaks tend to rise. In the US there is a number of studies looking at this, e.g. Fields³⁷, Ariel³⁸, Lakonishok and Smith³⁹ and Cadsby and Ratner⁴⁰.
3. Within-the-month effect – positive rates of returns only occur in the first half of the month⁴¹.
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 Smidt⁴² found that the four days at the turn-of-the-month averaged a cumulative rate of increase of 0.473% versus 0.0612% for any average four days periods. 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 markets⁴³. It is often seen as a separate asset class, which in turn leads to low correlation of commodity

³⁵ F. Cross, *The Behavior of Stock Prices and Fridays and Mondays*, "Financial Analyst Journal" 1973, vol. 29, pp. 67–69.

³⁶ J. Lakonishok, M. Levi, *Weekend Effect on Stock Returns: A Note*, "Journal of Finance" 1982, no. 37, pp. 883–889; J. Jaffe, R. Westerfield, *The Week-end Effect...*, op. cit., pp. 410–428; L. Condoynani, J. O'Hanlon, C. Ward, *Day of the Week Effects...*, op. cit., pp. 159–174; R. Connolly, *A Posterior Odds Analysis of the Weekend Effect*, "Journal of Econometrics" 1991, vol. 49, pp. 51–104.

³⁷ M. Fields, *Security Prices and Stock Exchange Holidays in Relation to Short Selling*, "Journal of Business" 1934, vol. 7, pp. 328–338.

³⁸ R. Ariel, *A Monthly Effect in Stock Returns*, "Journal of Financial Economics" 1987, vol. 17, pp. 161–174; R. Ariel, *High Stock Returns Before Holidays: Existence and Evidence on Possible Causes*, "Journal Finance" 1990, vol. 45, pp. 1611–1626.

³⁹ J. Lakonishok, S. Shmidt, *Are Seasonal Anomalies Real. A Ninety-Year Perspective*, "Review of Financial Studies" 1988, vol. 1, pp. 403–425.

⁴⁰ C. Cadsby, M. Ratner, *Turn-of-Month and Pre-holiday Effects on Stock Returns: Some International Evidence*, "Journal of Banking and Finance" 1992, vol. 16, pp. 497–509.

⁴¹ R. Ariel, *A Monthly...*, op. cit., pp. 161–174; C. Kim, J. Park, *Holiday Effects and Stock Returns: Further Evidence*, "Journal of Financial and Quantitative Analysis" 1994, vol. 29, pp. 145–157.

⁴² J. Lakonishok, S. Shmidt, *Are Seasonal...*, op.cit., pp. 403–425.

⁴³ R. Johnson, L. Soenen, *Gold as an Investment Asset – Perspectives from Different Countries*, "Journal of Investing" 1997, vol. 6, pp. 94–99.

market rates of return with returns on the stock or bonds markets. The consequence of this fact is the possibility of constructing more diversified investment portfolio compared to a portfolio consisting solely of shares or bonds. 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 investor's preferences in building an investment portfolio is clearly visible in the period of increased inflation⁴⁴. 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.

The aim of this article is to examine the prevalence of selected seasonality effects on the markets of the following metals: gold, silver, platinum, copper and palladium. Analysis of the seasonality effects will apply to monthly returns, returns over various days of the week and 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 metals quoted on the London Metal Exchange in the period from 1.01.1995 to 31.12.2015 for gold, silver, platinum and copper, as well as in the period from 1.01.1998 to 31.12.2015 for palladium. Prices of metals are taken from the Reuters.

2. Literature Review

In the scientific literature a statement can be found that the stock market is somehow predestined to record number of anomalies, whereas the foreign exchange is the most effective of all the markets⁴⁵. It is worth noting that the number of scientific researches dedicated to commodity market efficiency is lower than those of stock market.

Commodity market efficiency, in particular of the gold market, was presented in studies of Ball et al.⁴⁶ and Ma⁴⁷, who proved the existence of the weekend effect. The latter author divided the rates of return of Monday fixing gold price into two periods: before 1981 and after 1981. The first period was characterized by the presence of negative returns on Tuesdays and positive on Wednesdays, while in the period

⁴⁴ A. Górka, M. Krawiec, *Badania efektywności informacyjnej w formie słabiej na rynku metali szlachetnych*, "Zeszyty Naukowe Uniwersytetu Szczecińskiego" 2013, vol. 768, pp. 143–156.

⁴⁵ K. Froot, R. Thaler, *Anomalies: Foreign Exchange*, "Journal of Economic Perspectives" 1990, vol. 4, pp. 179–192.

⁴⁶ C. Ball, W. Torous, A. Tschoegl, *Gold and the Weekend Effect*, "Journal of Futures Markets" 1983, vol. 2, pp. 175–182.

⁴⁷ C. Ma, *A Further Investigation of the Day-of-the-Week Effect in the Gold Market*, "Journal of Futures Markets" 1986, vol. 6, pp. 409–419.

after 1981, negative returns were dominant during Monday sessions and no longer took place on Tuesdays. Similar conclusions were reached by Chang and Kim⁴⁸, Chamberlain et al.⁴⁹ and also by Johnston and Kracaw⁵⁰. The study conducted by Coutts and Sheikh⁵¹ denied the existence of the January effect on the gold market. The work of Tully and Lucey⁵² proved the existence of significant negative returns on Mondays only on the gold market, but not on the gold futures contracts market. The authors showed weakening of Monday effect in years, in which their analysis was carried out. Lucey⁵³ proved existence of some seasonal effects in the metal market. According to his research on the LME in the period of 1989–2002 for aluminum, copper, zinc, lead and nickel prices, the lowest and negative average rate of return was observed on Mondays, while the Tuesday average rate of return was the highest, with the Friday being the second highest. The main conclusion of this work was the statement that the metal market showed the stereotypical pattern of daily seasonality that was commonly described in the literature concentrating on equity markets. MacDonald and Taylor⁵⁴ tested for cointegration for four metals in the LME for the period of 1976–1987. They conclude that the copper and lead futures markets can be considered efficient but reject the EMH for tin and zinc. Based on the analysis of gold prices in the US market Tschoegle⁵⁵, Solton and Swanson⁵⁶ and Aggarwal and Soenen⁵⁷ concluded that the gold market is efficient. A similar deduction was reached by Mayo⁵⁸ and Smith⁵⁹, who tested the random walk hypothesis for the morning and

⁴⁸ E. Chang, C. Kim, *Day of the Week Effects and Commodity Price Changes*, "Journal of Futures Markets" 1988, vol. 4, pp. 229–241.

⁴⁹ T. Chamberlain, S. Cheun, C. Kwan, *Day of the Week Patterns in Futures Prices: Some Further Results*, "Quarterly Journal of Business and Economics" 1988, vol. 29, pp. 68–89.

⁵⁰ E. Johnston, W. Kracaw, *Day of the Week Effects in Financial Futures: An Analysis of GNMA, T-bond, T-note and T-bill Contracts*, "Journal of Financial and Quantitative Analysis" 1991, vol. 26, pp. 23–44.

⁵¹ J. Coutts, M. Sheikh, *The January Effect and Monthly Seasonality in the All Gold Index on the Johannesburg Stock Exchange 1987–1997*, "Applied Economics Letters" 2000, vol. 7, pp. 489–492.

⁵² E. Tully, B. Lucey, *Seasonality, Risk and Return in Daily COMEX Gold and Silver Data 1982–2002*, IIS Discussion Paper no. 57, Institute for International Integration Studies, Dublin 2003.

⁵³ B. Lucey, *Daily Seasonality in LME Base Metal Returns 1989–2002: A Robust Analysis*, 2003, Available at SSRN: <http://dx.doi.org/10.2139/ssrn.368301>

⁵⁴ R. MacDonald, M. Taylor, *Metal Prices, Efficiency and Cointegrations: Some Evidence from the LME*, "Bulletin of Economic Research" 1988, vol. 40, pp. 535–239.

⁵⁵ A. Tschoegl, *Efficiency in the Gold Market – A Note*, "Journal of Banking and Finance" 1980, vol. 4, pp. 371–379.

⁵⁶ M. Solton, P. Swanson, *On the Efficiency of the Markets of Gold and Silver*, "Journal of Business" 1981, vol. 54, pp. 453–478.

⁵⁷ R. Aggarwal, L. Soenen, *The Nature and Efficiency of the Gold Market*, "Journal of Portfolio Management" 1988, vol. 14, pp. 18–21.

⁵⁸ H. Mayo, *Wstęp do inwestowania*, Wydawnictwo K.E. Liber, Warsaw 1997.

⁵⁹ G. Smith, *Tests of the Random Walk Hypothesis for London Gold Process*, "Applied Econometrics Letters" 2002, vol. 9, pp. 671–674.

afternoon fixing, as well as the close price of gold in London. Weak form of market efficiency of gold, silver, platinum and palladium was also demonstrated in the work of the Gorska and Krawiec⁶⁰.

In summary, there has not been consensus about the efficiency of metal markets. One reason of the heterogeneous results are the different test setups and the second – analyzing market efficiency of metals quoted on the London Metal Exchange from a single-market perspective⁶¹.

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 to n_1 and n_2 respectively, the hypotheses H_0 and H_1 should be tested with the use of statistics z ⁶²:

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

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:

$$H_0 : E(r_1) = E(r_2)$$

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

⁶⁰ A. Górska, M. Krawiec, *Badania...*, op. cit., pp. 143–156.

⁶¹ S. Otto, *A Speculative Efficiency Analysis of the London Metal Exchange in a Multi-Contract Framework*, "International Journal of Economics and Finance" 2011, vol. 3, pp. 3–16.

⁶² M. Osińska, *Ekonometria finansowa*, PWE, Warsaw 2006, pp. 43–44.

In particular:

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 metal market.

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 metal market.

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 close and Friday open/Thursday close) on the metal market.

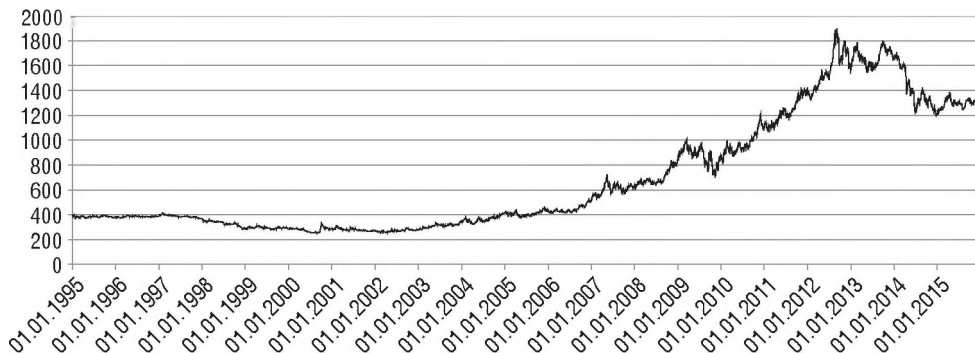
In all analyzed cases, z statistic and the p -value are calculated. If the p -value is less than or equal to 0.05; then the hypothesis H_0 is rejected in favor of the hypothesis H_1 . Otherwise, there is no reason to reject hypothesis H_0 .

4. Analysis of Results

4.1. The Analysis of the Monthly Effect

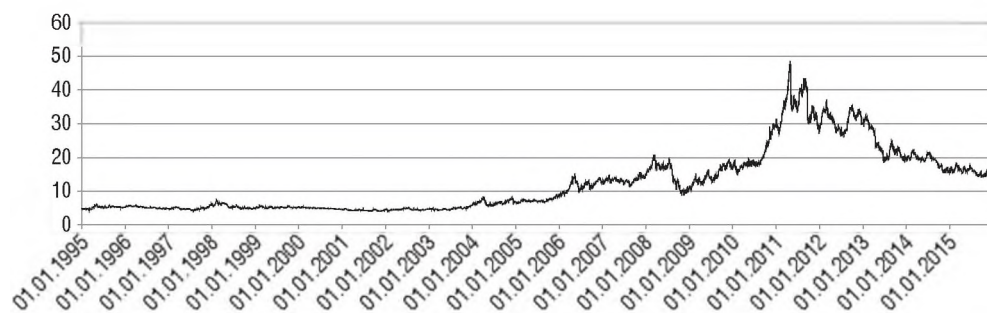
The prices of gold, silver, platinum and copper in the period from 1.01.1995 to 31.12.2015 are presented in Figures from 1 to 4, and of palladium in the period from 1.01.1998 to 31.12.2015 in Figure 5.

Figure 1. The Daily Gold Prices in USD/Ounce in the Period from 1.01.1995 to 31.12.2015



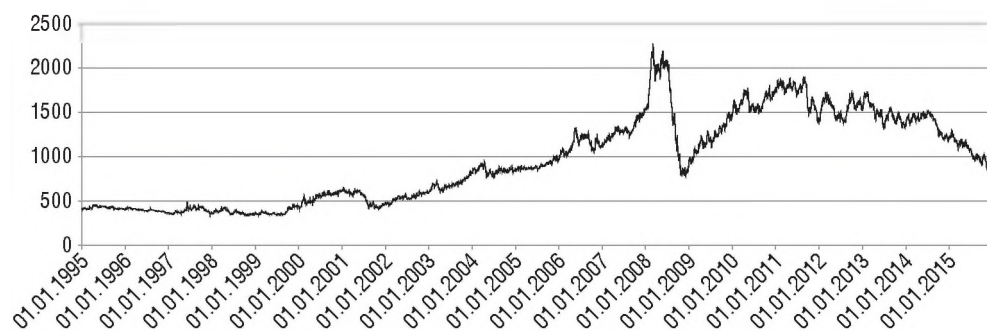
Source: own calculations based on Reuters.

Figure 2. The Daily Silver Prices in USD/Ounce in the Period from 1.01.1995 to 31.12.2015



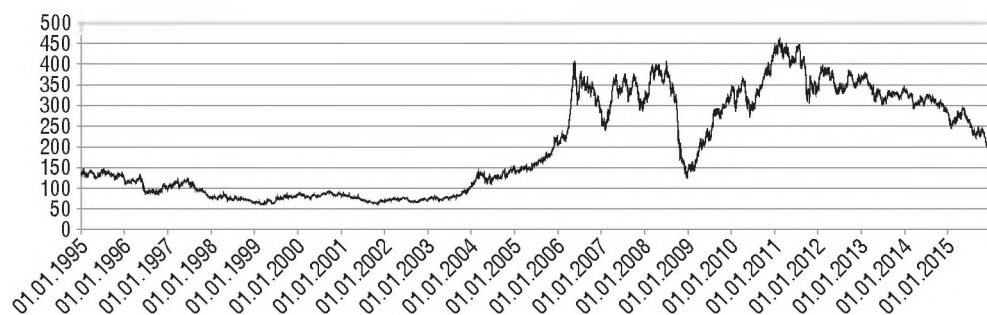
Source: own calculations based on Reuters.

Figure 3. The Daily Platinum Prices in USD/Ounce in the Period from 1.01.1995 to 31.12.2015



Source: own calculations based on Reuters.

Figure 4. The Daily Copper Prices in USD/Tone in the Period from 1.01.1995 to 31.12.2015



Source: own calculations based on Reuters.

Figure 5. The Daily Palladium Prices in USD/Ounce in the Period from 1.01.1998 to 31.12.2015



Source: own calculations based on Reuters.

The monthly average rates of return for each metal and for each month are presented in Appendix – Table 6. The number and percentage of positive and negative monthly returns on the metal market for each month are presented in Table 1.

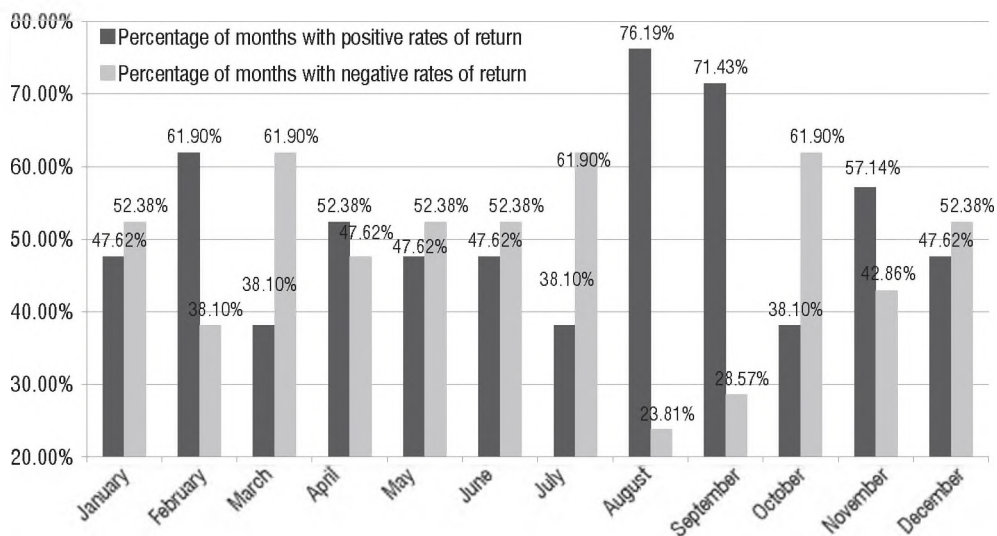
Table 1. The Number and Percentage of Positive and Negative Monthly Returns on the Markets of: Gold, Silver, Platinum, Copper and Palladium

	Metal	January	February	March	April	May	June	July	August	September	October	November	December
Number of positive rates of return	Gold	10	13	8	11	10	10	8	16	15	8	12	10
	Silver	14	14	14	14	14	14	14	14	14	14	14	14
	Platinum	15	15	15	15	15	15	15	15	15	15	15	15
	Copper	13	13	13	13	13	13	13	13	13	13	13	13
	Palladium	16	10	11	8	7	6	11	8	11	12	10	11
Number of negative rates of return	Gold	11	8	13	10	11	11	13	5	6	13	9	11
	Silver	7	7	7	7	7	7	7	7	7	7	7	7
	Platinum	6	6	6	6	6	6	6	6	6	6	6	6
	Copper	8	8	8	8	8	8	8	8	8	8	8	8
	Palladium	2	8	7	10	11	12	7	10	7	6	8	7
Percentage of months with positive rates of return	Gold	47.62	61.90	38.10	52.38	47.62	47.62	38.10	76.19	71.43	38.10	57.14	47.62
	Silver	66.67	66.67	66.67	66.67	66.67	66.67	66.67	66.67	66.67	66.67	66.67	66.67
	Platinum	71.43	71.43	71.43	71.43	71.43	71.43	71.43	71.43	71.43	71.43	71.43	71.43
	Copper	61.90	61.90	61.90	61.90	61.90	61.90	61.90	61.90	61.90	61.90	61.90	61.90
	Palladium	88.89	55.56	61.11	44.44	38.89	33.33	61.11	44.44	61.11	66.69	55.56	61.11

	Metal	January	February	March	April	May	June	July	August	September	October	November	December
Percentage of months with negative rates of return	Gold	52.38	38.10	61.90	47.62	52.38	52.38	61.90	23.81	28.57	61.90	42.86	52.38
	Silver	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33	33.33
	Platinum	28.57	28.57	28.57	28.57	28.57	28.57	28.57	28.57	28.57	28.57	28.57	28.57
	Copper	38.10	38.10	38.10	38.10	38.10	38.10	38.10	38.10	38.10	38.10	38.10	38.10
	Palladium	11.11	44.44	38.89	55.56	61.11	66.69	38.89	55.56	38.89	33.33	44.44	38.89

Source: own calculations.

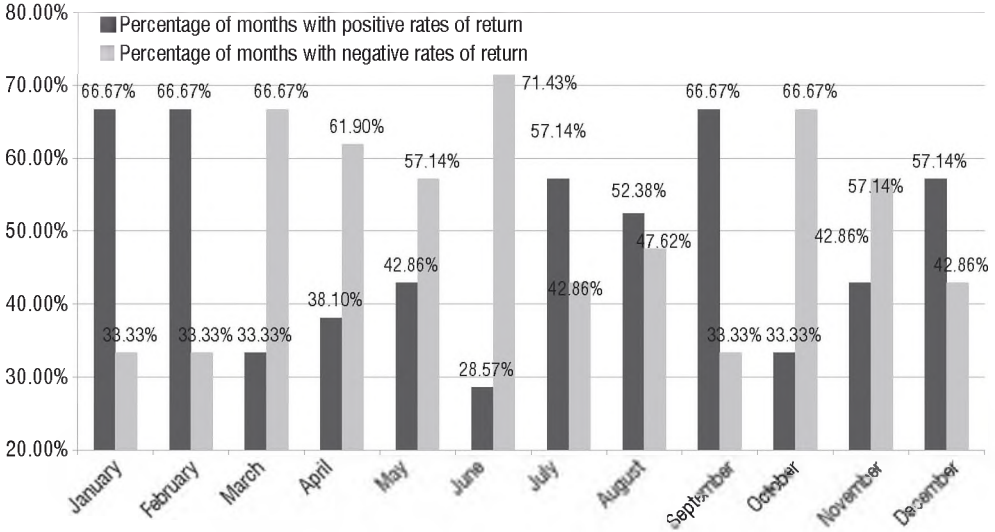
Figure 6. The Percentage of Monthly Positive and Negative Returns in Each Month for Gold



Source: own calculations.

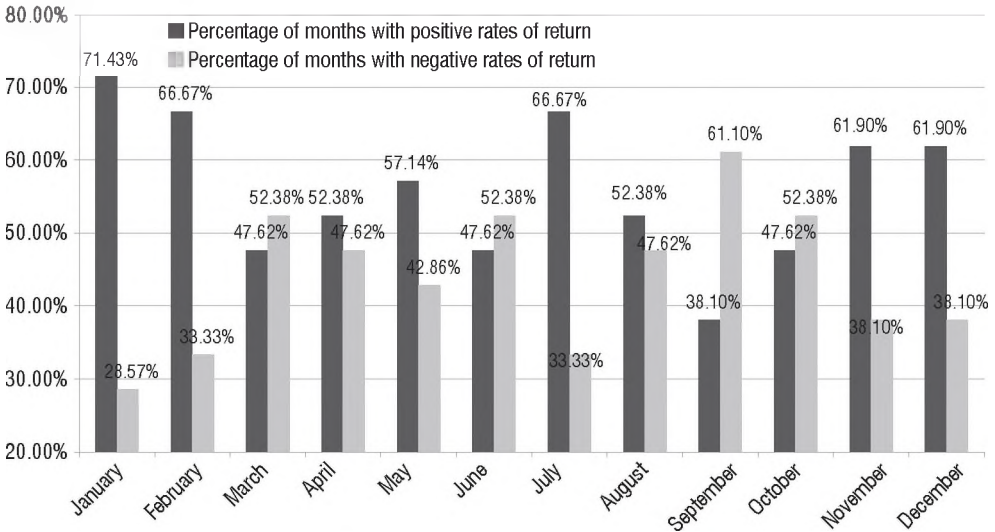
In the analyzed period, on the gold market the positive monthly returns were the most frequently observed in August – in 76.19% of all observations – see Figure 6. The second, third and fourth months in which the positive returns were most frequent were: September (71.43%), February (61.90%) and April (52.38%). In turn, the months with the highest percentage of negative monthly returns were March, July and October – negative returns were observed in 61.90% cases. In the months of: January, May, June and December negative returns occurred in 52.38% of situations.

Figure 7. The Percentage of Monthly Positive and Negative Returns in Each Month for Silver



Source: own calculations.

Figure 8. The Percentage of Monthly Positive and Negative Returns in Each Month for Platinum

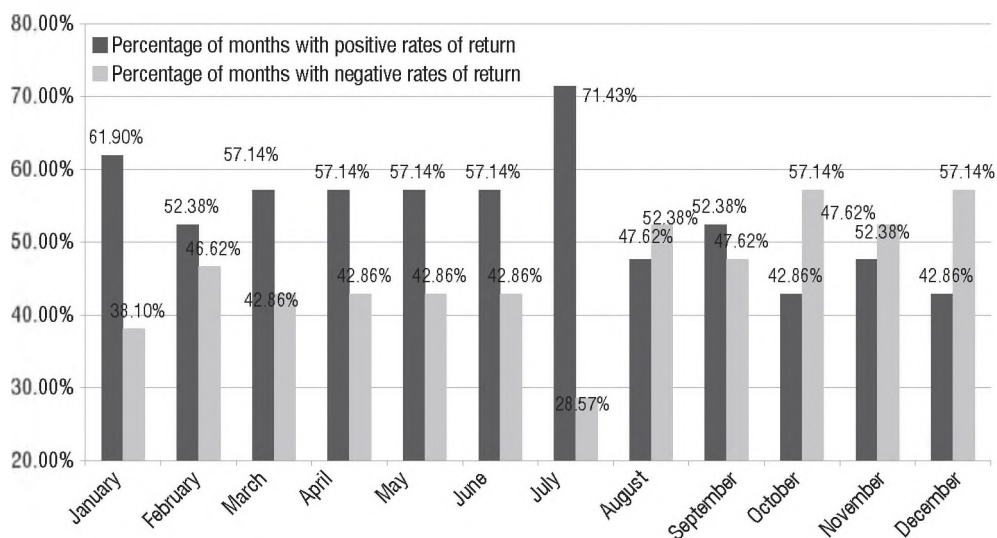


Source: own calculations.

In the analyzed period on the silver market the positive monthly returns occurred more frequently in January and September – in 66.67% of observations – see Figure 7. These two months were followed by months of July and December, in which the positive monthly rates were noted in 57.14% of cases. On the other hand, negative monthly rates of return occurred most frequently in the month of June (71.43%) and also in March and October (66.67%).

January was the month, in which the highest percentage of positive monthly returns was recorded on the platinum market (71.43%) – see Figure 8. The second highest percentage of positive returns took place in February and July – in both months it was recorded at 66.67% level. On the other hand, the most negative rate of return occurred in the month of September (61.10%) and in the months of March, June and October – 52.38% of all observations.

Figure 9. The Percentage of Monthly Positive and Negative Returns in Each Month for Copper



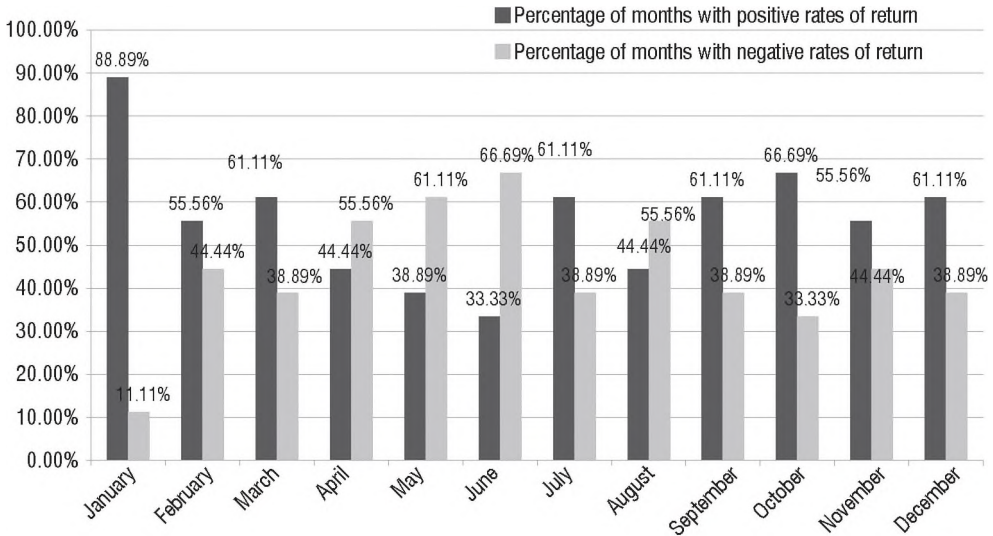
Source: own calculations.

Regarding the copper market, the highest percentage of monthly positive returns was recorded in July (71.43%), followed by January (61.90%) – see Figure 9. The negative rates of returns were most common in the months of October and December – 57.14% of all observations.

On palladium market monthly positive returns took place most frequently in January (88.89%), which was followed by October (66.69%) – see Figure 10. In the

months of March, September and December they occurred in 61.11% of all observations. The negative monthly rates of return were achieved on palladium market in June (66.69%) and May (61.11%).

Figure 10. The Percentage of Monthly Positive and Negative Returns in Each Month in Palladium Market



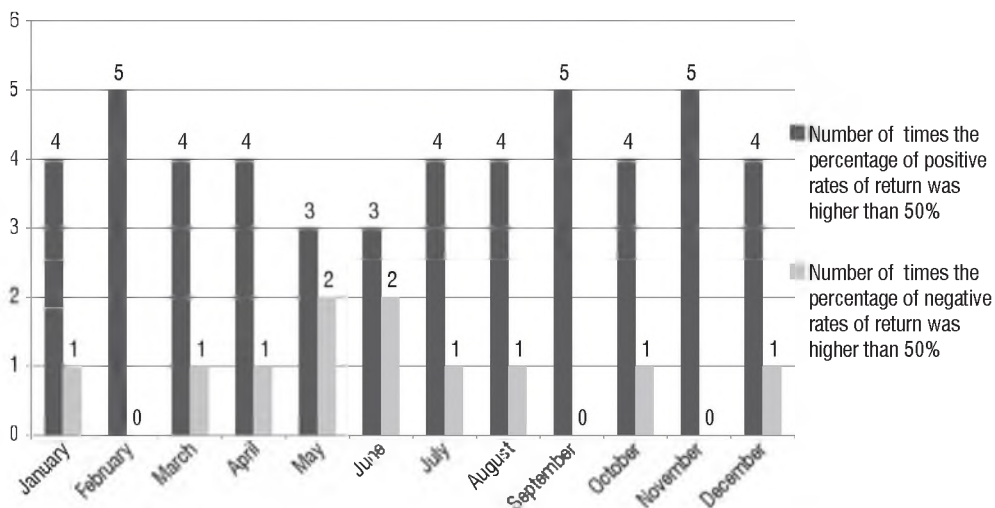
Source: own calculations.

The percentage share of positive returns on the market of all analyzed metals, amounting to over 50%, was the highest in the following months: February, September and November. On the other hand, in January, March, April, July, August, October and December the percentage of positive returns was greater than 50% on the market of 4 out of 5 metals, but in May and June only on the market of 3 out of 5 metals. The percentage of negative monthly rates of return was greater than 50% on the markets of 2 out of 5 metals in the months of May and June – see Figure 11.

The January effect should have been considered only in the case of palladium – the monthly average rate of return for that month amounted to 4.55% and was the highest in comparison with the other monthly average rates of return. The highest monthly rates of return in February were reported for silver (3.54%) and platinum (3.63%). The highest monthly rate of return for gold and copper occurred in the following months: September (2.23%) and July (2.50%) respectively. The lowest monthly rate of return for silver and palladium were recorded in June: -2.27% and -2.22% respectively, and for gold and copper in October: -1.04% and -1.56% respectively.

On the platinum market the lowest monthly rate of return occurred in the month of September and was equal to -1.19% .

Figure 11. Number of Times When the Percentage of Positive and Negative Rates of Return Was Higher Than 50% for All Analyzed Metal Markets



Source: own calculations.

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

The results allow drawing the following conclusions:

1. In the case of gold, there was no reason to reject the null hypothesis for each of the analyzed months. This indicates that the effect of month of the year did not occur in the analyzed period.
2. In the case of silver, there was no reason to reject the null hypothesis for each of the analyzed months. This indicates that the effect of month of the year did not occur in the analyzed period.
3. In the case of platinum, 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 palladium, the null hypothesis was rejected in favor of the alternative hypothesis for the month of September. This fact indicates the occurrence of the effect of the month on the analyzed metal market. 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. It is worth mentioning that p-value calculated

for monthly rates of return in January and December was equal respectively to 0.08 and 0.07, and was close to the significance level (0.05).

5. In the case of copper, there was no reason to reject the null hypothesis for each of the analyzed months. This constitutes evidence that the effect of month of the year did not occur in the market of this metal.

Table 2. The Results of Testing the Null Hypothesis for the Monthly Returns on the Metal Market

	Gold	Silver	Platinum	Palladium	Copper
January	0.494205 0.621162	0.779292 0.435808	0.886696 0.375242	1.775192 0.075866	0.51489 0.60663
February	0.541893 0.587892	0.839251 0.401329	0.890276 0.373318	1.468573 0.141949	0.441668 0.65873
March	-0.85102 0.394757	0.09163 0.926992	-0.46249 0.643728	-0.35475 0.722775	0.644814 0.519048
April	-0.26674 0.78967	-0.5544 0.579304	-0.38057 0.703525	-0.25645 0.7976	0.627882 0.530081
May	-0.63547 0.525125	-0.93273 0.35096	0.060356 0.951872	-0.78998 0.429539	-0.24551 0.806061
June	-0.84137 0.40014	-1.01465 0.310272	-0.80818 0.418985	-1.17435 0.240255	-0.541 0.58851
July	-0.71058 0.477342	0.550839 0.581744	-0.55678 0.577678	0.523895 0.600352	0.740656 0.458902
August	0.637257 0.523957	0.017958 0.985672	-0.40048 0.688806	-1.17967 0.23813	-0.80542 0.420575
September	0.771795 0.440236	0.23922 0.810935	-0.98694 0.323671	-1.94724 0.049506	-0.72933 0.465799
October	-0.98988 0.322233	-0.82685 0.408322	-0.85637 0.323671	0.733754 0.463099	-0.81912 0.412718
November	0.641101 0.521457	0.526124 0.598802	0.550054 0.582282	-0.01646 0.986864	0.513793 0.607397
December	-0.36309 0.716537	0.153459 0.878036	0.192085 0.8476757	1.827811 0.067578	-0.88457 0.376388

The first value in the cell represents test statistic for z, and the second is the p-value.

Source: own calculations.

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 for the weekend effect are shown in the Appendix in Table 7. Information regarding number and frequency

of positive and negative rates of return, computed for each day of the week, divided into markets of analyzed metals, are included in Table 3.

Table 3. The Number and Percentage of Positive and Negative Rates of Returns on the Markets of: Gold, Silver, Platinum, Copper and Palladium for Each Day of the Week in the Analyzed Period

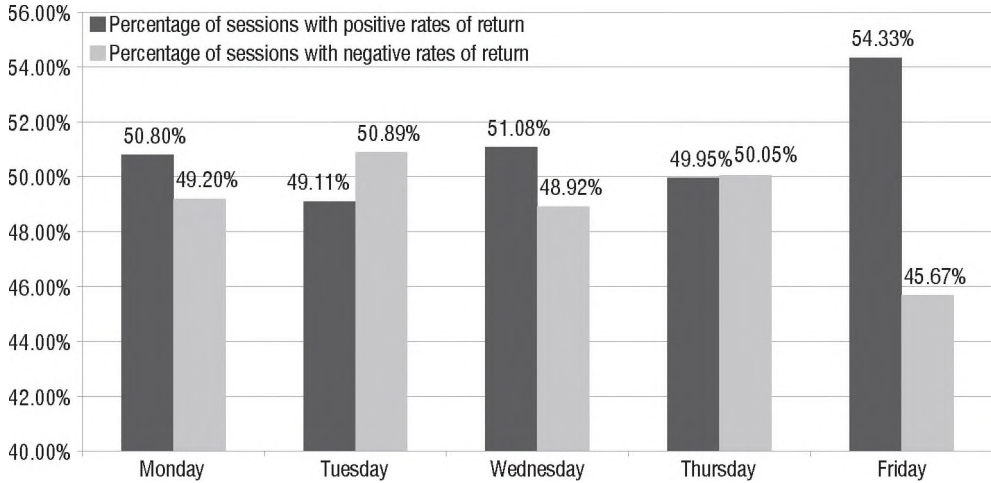
	Metal	Monday	Tuesday	Wednesday	Thursday	Friday
Number of positive rates of return	Gold	541	526	542	532	577
	Silver	541	553	559	566	559
	Platinum	518	518	518	518	518
	Copper	521	521	521	521	521
	Palladium	467	467	467	467	467
Number of negative rates of return	Gold	524	545	519	533	485
	Silver	507	503	498	488	491
	Platinum	526	526	526	526	526
	Copper	562	562	562	562	562
	Palladium	408	408	408	408	408
Percentage of days with positive rates of return (in %)	Gold	50.80	49.11	51.08	49.95	54.33
	Silver	51.62	52.37	52.89	53.70	53.24
	Platinum	49.62	49.62	49.62	49.62	49.62
	Copper	48.11	48.11	48.11	48.11	48.11
	Palladium	53.37	53.37	53.37	53.37	53.37
Percentage of days with negative rates of return (in %)	Gold	49.20	50.89	48.92	50.05	45.67
	Silver	48.38	47.63	47.11	46.30	46.76
	Platinum	50.38	50.38	50.38	50.38	50.38
	Copper	51.89	51.89	51.89	51.89	51.89
	Palladium	46.63	46.63	46.63	46.63	46.63

Source: own calculations.

The highest average daily rate of return for all metals except palladium was observed on Fridays. On the palladium market, the highest average daily rate of return was recorded for Monday sessions. Regarding all analyzed metals, the maximum average daily rate of return turned out to be positive. The lowest average daily rates of return were registered on Tuesday session on the markets of gold, platinum and palladium, while on the markets of silver and copper on Mondays and Thursdays respectively. In all cases, except for copper, the daily average returns were negative.

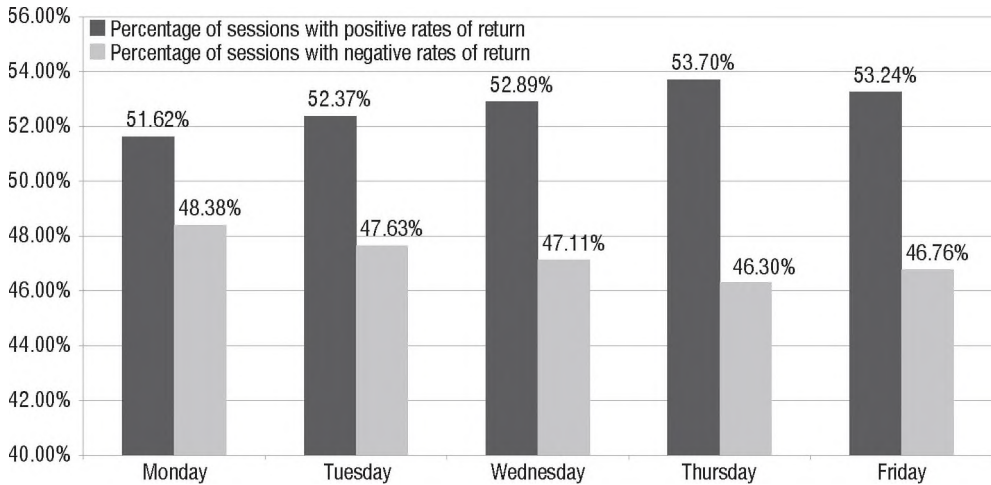
The gold market experienced positive returns mostly on Fridays (54.33%), followed by 51.08% on Wednesdays and 50.80% on Mondays. The negative rates of return were reported more often on Tuesdays (50.89%) and Thursdays (50.05%) – see Figure 12.

Figure 12. The Frequency of Positive and Negative Returns over Various Days of the Week for Gold



Source: own calculations.

Figure 13. The Frequency of Positive and Negative Returns over Various Days of the Week for Silver

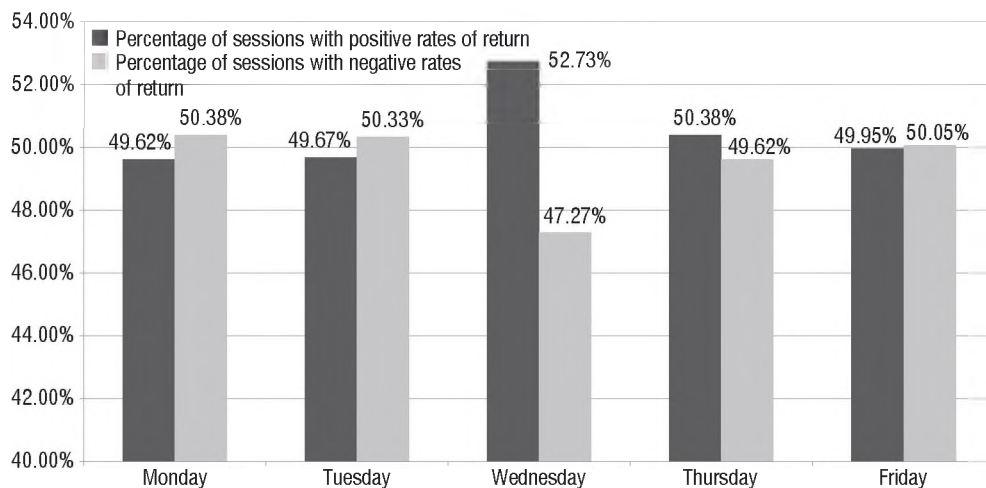


Source: own calculations.

On the silver market frequency of positive returns was higher than 50% for all days of the week, and the highest was found to be on Thursdays (53.70%). Negative rate of return was recorded mostly on Mondays (48.38%) – see Figure 13.

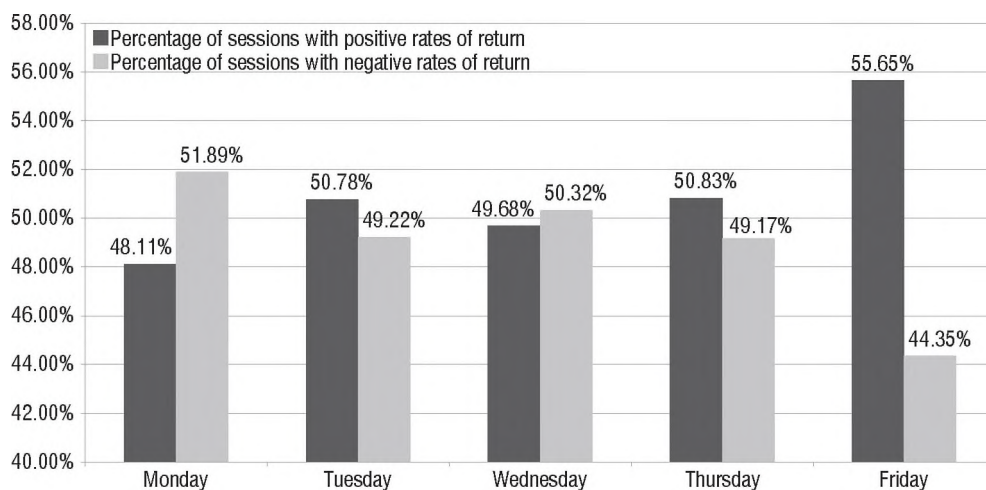
On the platinum market frequency of positive and negative rates of return for individual days was similar except for Wednesday sessions, when positive rates of return were recorded in 52.73% of all observations. The highest negative rate of return was registered on Mondays (50.38%) – see Figure 14.

Figure 14. The Frequency of Positive and Negative Returns over Various Days of the Week for Palladium



Source: own calculations.

Figure 15. The Frequency of Positive and Negative Returns over Various Days of the Week for Copper

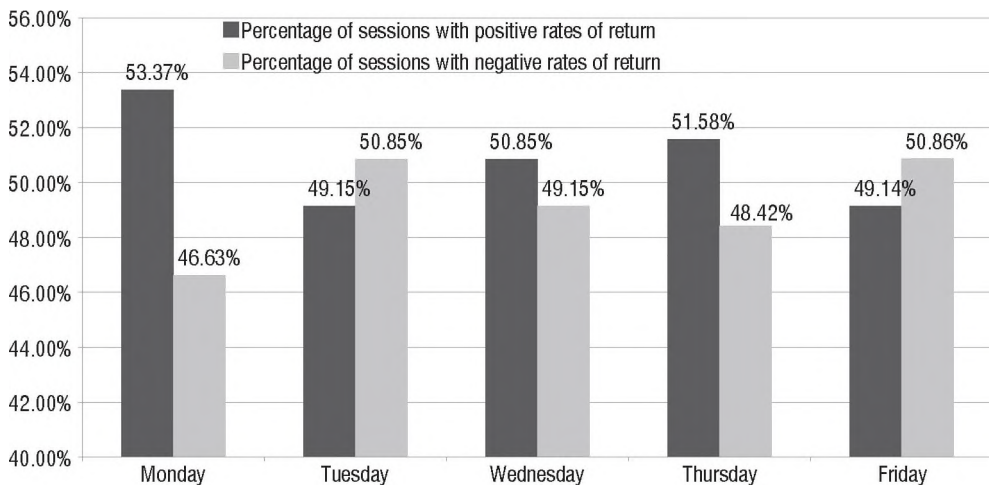


Source: own calculations.

On the copper market frequency of positive returns proved to be the highest on Fridays (55.65%) – see Figure 15. In addition, on Tuesdays and Thursdays positive rates of return were reported in 50.78% and 50.83% of all observations respectively. Negative rates of return dominated sessions on Mondays in 51.89% and on Wednesdays in 50.32% cases.

On the palladium market, positive returns were recorded mostly on Mondays (53.37%) and Thursdays (51.58%) – see Figure 16. On the other hand, negative rates of return were most common during Friday and Tuesday sessions – in 50.86% and 50.85% of all observations respectively.

Figure 16. The Frequency of Positive and Negative Returns over Various Days of the Week for Palladium



Source: own calculations.

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

The results of testing H_0 hypothesis permit to draw following conclusions:

1. In the case of gold, there was no reason to reject the null hypothesis for each analyzed day of the week. The p-value for Monday and Friday session is equal to 0.09 and slightly differs from the assumed level of significance (0.05).
2. In the case of silver, there was no reason to reject the null hypothesis for each analyzed day of the week. The lowest p-value of 0.14 was recorded for rates of return calculated for Monday sessions.

3. In the case of platinum, there was no reason to reject the null hypothesis for each analyzed day of the week. The lowest p-value of 0.07 was recorded for rates of return on Tuesday session and it is close to the significance level (0.05).
4. In the case of copper there was no reason to reject the null hypothesis for each analyzed day of the week. The lowest p-value of 0.10 was obtained for the rate of return on Monday sessions.
5. In the case of copper there was no reason to reject the null hypothesis for each analyzed day of the week.

Table 4. The Results of Testing the Null Hypothesis for the Day-of-the Week Rates of Return on the Metal Market

	Gold	Silver	Platinum	Palladium	Copper
Monday	-1.69129 0.090781	-1.47168 0.141107	-0.71334 0.475634	0.98747 0.323412	-1.65489 0.097947
Tuesday	-1.52704 0.12675	-0.25967 0.795116	-1.77766 0.075459	-0.30842 0.757761	-1.45448 0.145813
Wednesday	-1.35549 0.175262	-0.22291 0.823603	0.310531 0.756157	-0.37488 0.707751	-1.15745 0.247087
Thursday	-0.6971 0.485737	0.261722 0.793536	0.422078 0.672968	-0.063 0.949764	-0.1779 0.855375
Friday	1.671577 0.094608	0.541978 0.587834	0.613398 0.539613	-0.05756 0.954097	1.501258 0.133289

The first value in the cell represents test statistic for z, and the second is the p-value.
Source: own calculations.

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 metal and the result of statistical testing of null hypothesis leads to the data presented in Table 5.

Table 5. The Results of Testing the Null Hypothesis for the Weekend Rates of Return on the Metal Market

Gold	Silver	Platinum	Palladium	Copper
3.253784088 0.001138788	0.987954473 0.323175	1.714192 0.086493	-1.104867 0.269217	2.128574 0.033289

The first value in the cell represents statistic test for z, and the second is the p-value.
Source: own calculations.

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

1. In the case of silver, platinum and palladium there were no reasons to reject the null hypothesis. The p-value for platinum is equal to 0.09, and slightly differs from the assumed level of significance (0.05).
2. In the case of gold and copper, the null hypothesis was rejected in favor of the alternative hypothesis. Thus, the effect of the weekend took place in the covered period on the market of these two precious metals.

5. Conclusion

In recent years, there has been observed an increased interest in the commodity market, including precious metals, from the part of 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 the specific features are assigned to the precious metal 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 correlation⁶³.

In the world literature, in contrast to the stock market, relatively little space was dedicated to the occurrence of the seasonality effects on the metal market. This fact was one of the reasons encouraging us to take specific empirical studies.

The aim of this study was to determine the prevalence of selected effects of seasonality on the following metal markets: gold, silver, platinum, copper and palladium. Analysis of the effects of seasonality included an examination of monthly returns, returns over various days of the week and so-called weekend effect. Calculations presented in this paper indicate the absence of the monthly effect in the following analyzed segments of precious metal markets of gold, silver, platinum, copper. The existence of seasonality effect occurred only in case of palladium market during the month of September. The occurrence of seasonality effect for palladium was not observed for the rates of returns calculated for all remaining months.

In the analyzed period there was no occurrence of day-of-the-week effect for any of the studied metal markets. The weekend effect was registered only on the gold and copper markets.

⁶³ *The Handbook of Commodity Investing*, eds. F. Fabozzi, R. Füss, D. Keiser, John Wiley & Sons, Hoboken, New Jersey 2008.

Results obtained in the article regarding the weekend effect on the gold market are consistent with those of Ball et al.⁶⁴, Ma⁶⁵, Chang and Kim⁶⁶, Chamberlain et al.⁶⁷, Johnson and Kracaw⁶⁸. The analysis confirmed the absence of the monthly effect of on the gold market in the month of January, which is consistent with the results obtained in the work of Coutts and Sheikh⁶⁹. The highest daily rate of return on the copper market was registered for Friday sessions. According to Lucey⁷⁰ Friday rate of return was the second, after Tuesday's most-higher daily rate of return. The lowest daily rate of return was recorded on Thursdays, and not, as proved Lucey⁷¹ on Mondays.

Further research on the occurrence of calendar anomalies in the metal market should include the following assets: zinc, tin, lead, aluminum and nickel.

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⁶⁴ C. Ball, W. Torous, A. Tschoegl, *Gold...*, op. cit., pp. 175–182.

⁶⁵ C. Ma, *A Further...*, op. cit., pp. 409–419.

⁶⁶ E. Chang, C. Kim, *Day...*, op. cit., pp. 229–241.

⁶⁷ T. Chamberlain, S. Cheun, C. Kwan, *Day...*, op. cit., pp. 68–89.

⁶⁸ E. Johnston, W. Kracaw, *Day...*, op. cit., pp. 23–44.

⁶⁹ J. Coutts, M. Sheikh, *The January...*, op. cit., pp. 489–492.

⁷⁰ B. Lucey, *Daily...*, op. cit.

⁷¹ Ibidem.

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Appendix

Table 6. Average Monthly Rates of Return for All Analyzed Metals (in %)

	Gold	Silver	Platinum	Palladium	Copper
January	0.1098	2.7586	3.3128	4.5539	1.7021
February	1.2694	3.5372	3.6332	4.3995	1.4384
March	-0.5669	0.5974	-0.1647	0.6126	1.9409
April	0.1437	-0.6913	-0.0803	0.2018	2.0117
May	-0.2178	-2.0356	0.5046	-1.1416	0.1381
June	-0.6025	-2.7721	-0.8321	-2.2194	-0.5794
July	-0.2387	1.5776	-0.2201	1.8832	2.5021
August	1.4245	0.4613	-0.1062	-1.6058	-0.9084
September	2.2339	0.9512	-1.1943	1.3262	-0.9077
October	-1.0398	-1.4234	-1.0387	2.3266	-1.5552
November	1.5066	1.6312	1.5589	0.8358	1.6966
December	0.0043	0.7112	0.6973	1.4778	-1.3469

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 (in %)

	Monday	Tuesday	Wednesday	Thursday	Friday	Monday open/Friday close (weekend effect)
Gold	-0.0178	-0.0195	-0.0056	0.0301	0.1757	0.0294
Silver	-0.0884	0.0353	0.0384	0.0925	0.1201	0.0223
Platinum	-0.0675	-0.1556	0.0115	0.0211	0.0356	0.1146
Palladium	0.0757	-0.0979	-0.0109	-0.0634	-0.0656	0.0312
Copper	0.0249	0.0313	0.0554	0.0151	0.3035	-0.0415

Source: own calculations.