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ANALYSIS OF CALENDAR EFFECTS IN MARKETS OF PRECIOUS METALS

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Abstract: Calendar effects are anomalies in the behavior of asset prices that may disprove the efficient market hypothesis. The well recognized are: day-of-the-week effect, month-of-the-year effect, holidays effect and turn-of-the-month effect. These anomalies are observed in many financial markets, most often on stock exchanges, thus studies on calendar effects usually focus on stock markets. However, the aim of the paper is searching for the anomalies in precious metals markets (the empirical data covers London daily spot prices from 2008 through 2013). This is the continuation of authors' prior research aimed at testing weak market efficiency hypothesis for precious metals markets.

Keywords: precious metals, calendar effects, linear regression, GARCH models

INTRODUCTION

Numerous financial analyses are based on the efficient market hypothesis, which may be also applied to commodity markets. According to the classical Fama's definition: a market in which prices always fully reflect available information is called efficient [Fama 1970]. Park and Irwin [2007] present a more detailed definition proposed by Jensen [1978]: a market is efficient with respect to information set θ_t if it is impossible to make economic profits by trading on the basis of information set θ_t. Jensen also subdivides the efficient market hypothesis into three types based on definitions of the information set θ_t: weak-form efficiency, where the information set θ_t is limited to the information contained in the past price history of the market as of time *t*; semistrong-form efficiency, where the information set θ_t is all information that is publicly available at time *t*; strong-form efficiency, where the information set θ_t is all public and private information available at time *t* [Jensen 1978]. One should note that the weak form is a restricted version of the semistrong form, and weak and semistrong forms are restricted versions of the strong form. The weak-form market efficiency hypothesis is tested the most often. To do this, technical analysis tools and statistical tests veryfing random changes in prices are applied. These are for example: unit root tests, autocorrelation tests, variance ratio test, runs test, as well as analysis of long-run relationships and correlations, and calendar effects analysis [Witkowska at al. 2008].

Calendar effects are anomalies in the behavior of asset prices that make the market inefficient. The best known are the following: the day-of-the-week effect, the month-of-the-year effect, holidays effect, and the turn-of-the-month effect. These and other anomalies[1] are observed in many financial markets, most often on stock exchanges, thus studies on calendar effects usually focus on stock markets. The aim of the paper is searching for the anomalies in precious metals markets. We focus on the day-of-the-week and the month-of-the-year effects. The paper is the continuation of authors' prior research aimed at testing weak market efficiency hypothesis for precious metals markets by the use of runs test, variance ratio test and autocorrelation test. The results obtained then were not homogeneous [Górska, Krawiec 2013].

EMPIRICAL DATA AND METHODOLOGY

Data

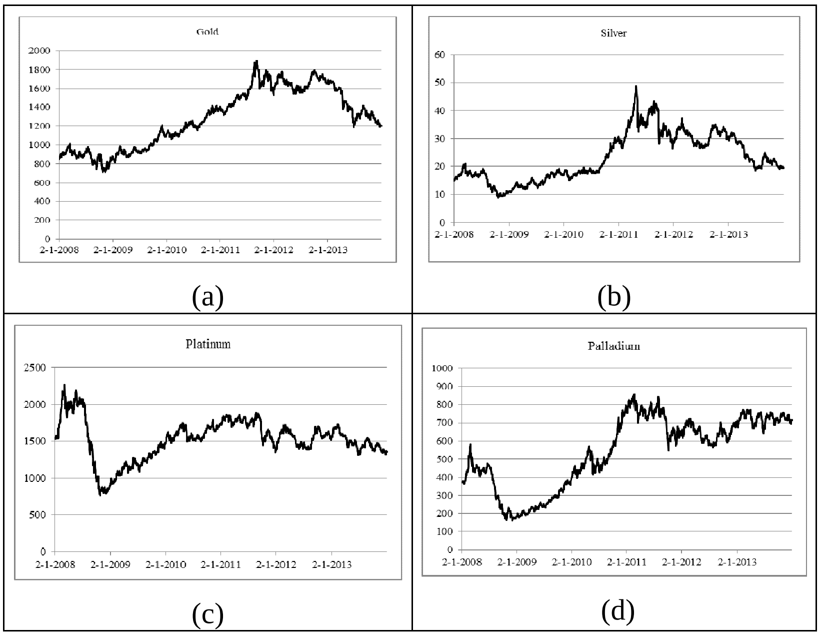
The empirical data used for the purpose of the analysis covers London daily closing prices of four precious metals (gold, silver, platinum and palladium) from 2008 through 2013. The quotations in USD per ounce are available at www.kitco.com. The prices of precious metals in the period under consideration are displayed in figure 1. First of all, there were calculated the returns:

$$R_t = \frac{P_t - P_{t-1}}{P_{t-1}}, \tag{1}$$

[1] There are also more advanced studies on lunar (new moon and full moon) effects in stock markets. Findings of Yuan at al. [2006], based on stock market returns of 48 countries, indicate that stock returns are lower on the days around a full moon than on the on the days around a new moon and the lunar effect is independent of other calendar-related anomalies such as the January effect, the day-of-the-week effect, the month effect, and the holiday effect. Keef and Khaled [2011] provide further evidence on international lunar effects.

where P_t is the price at time t and P_{t-1} is the price in the previous period. These rates of return became the base to evaluate some descriptive statistics for considered metals. The results are given in tables 1 and 2.

Figure 1. Prices of precious metals from 2008 through 2013: gold (a), silver (b), platinum (c), palladium (d)



Source: own elaboration

On the base of data given in tables 1 and 2, one can notice that expected rates of return (means) calculated for all days were positive. The highest of them was the one produced by palladium, the lowest – by platinum. However, analyzing weekday returns separately, we can notice negative returns in the case of gold: Tuesdays and Thursdays, in the case of silver: Fridays (this is the highest negative return of all weekdays), in the case of platinum: Tuesdays and Fridays, and in the case of palladium: Fridays. The highest positive expected rate of return is Monday silver return. When considering separate months, the highest positive expected rate of return is January platinum return, while the highest negative expected rate of return is September palladium return. There are also other negative monthly expected rates of return (in the case of gold: March, April, June, October, December, in the case of silver: May, June, October December, in the case of platinum: April, May, June, July, September, October, December, in the case of palladium: March, May, June, August).

Table 1. Descriptive statistics for daily returns on separate weekdays (2008-2013)

	Measure	All days	Mondays	Tuesdays	Wednesdays	Thursdays	Fridays
Gold	Mean	0,00033	0,00150	-0,00010	0,00036	-0,00042	0,00039
	std. dev.	0,01383	0,01519	0,01232	0,01373	0,01481	0,01298
	minimum	-0,09150	-0,09150	-0,04901	-0,05650	-0,05846	-0,03938
	maximum	0,07081	0,06198	0,03817	0,04586	0,07081	0,04946
	skewness	-0,25893	-1,01961	-0,25902	-0,19897	0,17142	0,10798
	kurtosis	4,25636	8,98234	1,24253	2,49095	3,92464	1,32139
Silver	Mean	0,00053	0,00316	0,00010	0,00167	0,00104	-0,00317
	std. dev.	0,02668	0,02802	0,02396	0,02444	0,02951	0,02691
	minimum	-0,17050	-0,14407	-0,10452	-0,07613	-0,17050	-0,13728
	maximum	0,20056	0,11111	0,18963	0,07232	0,20056	0,11385
	skewness	-0,03458	-0,69031	1,32845	-0,11617	0,24043	-0,64854
	kurtosis	7,47039	5,66200	13,41601	0,57967	11,21311	4,63205
Platinum	Mean	0,00006	0,00033	-0,00004	0,00061	0,00020	-0,00081
	std. dev.	0,01679	0,01722	0,01840	0,01511	0,01671	0,01643
	minimum	-0,08143	-0,07534	-0,08143	-0,05405	-0,07277	-0,07407
	maximum	0,07186	0,06853	0,07186	0,05200	0,05499	0,05657
	skewness	-0,50923	-0,36834	-0,60776	-0,48588	-0,34239	-0,70027
	kurtosis	3,44222	3,05964	5,08753	1,73355	2,40617	3,33568
Palladium	Mean	0,00069	0,00185	0,00015	0,00146	0,00077	-0,00070
	std. dev.	0,02289	0,02306	0,02189	0,02258	0,02601	0,02057
	minimum	-0,16355	-0,08498	-0,11355	-0,08591	-0,16355	-0,08353
	maximum	0,11538	0,07399	0,07084	0,11538	0,09958	0,05799
	skewness	-0,44769	-0,14178	-0,60218	0,05349	-0,90905	-0,43579
	kurtosis	4,08381	1,68553	3,42433	3,28852	6,94054	1,25974

Source: own calculations

The highest value of standard deviation calculated for all daily observations was observed for silver, while the lowest – for gold. When considering separate weekdays, the highest standard deviation is that for Thursday silver returns, the lowest for Tuesday gold returns. In the case of separate months, the highest standard deviation is that for September silver returns, and the lowest for July gold returns. For the whole period (all days) we can observe negative skewness, however for Tuesday silver returns, Wednesday palladium returns, Thursday gold and silver returns, and for Friday gold returns, skewness is positive. In the case of monthly returns, we have positive skewness for January (gold, silver, platinum, palladium), February (silver, platinum, palladium), March (gold), May (gold), June (platinum and palladium), July (gold, silver), September (gold and silver), October (palladium), November (gold and silver), December (gold, silver, platinum, palladium). Almost all values of kurtosis are positive (the only exception is negative kurtosis for May gold returns). This indicates more acute distributions in comparison to a normal distribution.

Table 2. Descriptive statistics for daily returns in separate months (2008-2013)

	Month	Measure					
		Mean	Std. dev.	Min	Max	Skewness	Kurtosis
Gold	January	0,0014	0,0121	-0,0255	0,0467	0,5803	1,5574
	February	0,0012	0,0115	-0,0429	0,0311	-0,3482	1,7237
	March	-0,0008	0,0131	-0,0479	0,0708	0,6516	7,6488
	April	-0,0005	0,0147	-0,0915	0,0232	-2,6992	12,5589
	May	0,0003	0,0127	-0,0266	0,0351	0,0267	-0,1347
	June	-0,0008	0,0125	-0,0585	0,0308	-0,7499	3,5530
	July	0,0010	0,0110	-0,0364	0,0426	0,1117	2,0572
	August	0,0014	0,0137	-0,0565	0,0342	-0,6431	2,9281
	September	0,0006	0,0163	-0,0539	0,0615	0,0893	3,0237
	October	-0,0005	0,0169	-0,0766	0,0574	-0,5644	3,9535
	November	0,0018	0,0145	-0,0315	0,0620	1,0086	2,6309
	December	-0,0012	0,0156	-0,0448	0,0520	0,1699	1,6472
Silver	January	0,0032	0,0228	-0,0514	0,0688	0,1333	0,4391
	February	0,0034	0,0190	-0,0595	0,0668	0,0537	1,1501
	March	0,0000	0,0258	-0,1182	0,0678	-0,6434	3,2383
	April	0,0002	0,0250	-0,1409	0,0751	-1,4655	8,2851
	May	-0,0010	0,0347	-0,1705	0,1138	-0,7502	6,1163
	June	-0,0026	0,0227	-0,0638	0,0723	-0,0670	0,8031
	July	0,0012	0,0201	-0,0543	0,0721	0,3171	0,9050
	August	0,0018	0,0266	-0,1373	0,0553	-1,3073	5,5573
	September	0,0004	0,0391	-0,1441	0,2006	1,2385	10,3227
	October	-0,0009	0,0288	-0,0963	0,1084	-0,3423	2,4793
	November	0,0016	0,0236	-0,0419	0,0949	1,0035	2,3791
	December	-0,0009	0,0255	-0,0869	0,0772	0,1034	1,1604
Platinum	January	0,0043	0,0155	-0,0447	0,0566	0,4300	1,5047
	February	0,0029	0,0153	-0,0478	0,0516	0,0842	1,5712
	March	0,0002	0,0194	-0,0664	0,0719	-0,3657	3,2863
	April	-0,0006	0,0147	-0,0598	0,0249	-1,3360	3,4248
	May	-0,0011	0,0172	-0,0602	0,0548	-0,0041	1,9272
	June	-0,0009	0,0138	-0,0384	0,0385	0,2945	0,5847
	July	-0,0001	0,0128	-0,0504	0,0304	-0,5586	1,5249
	August	0,0001	0,0170	-0,0741	0,0393	-0,9195	3,4445
	September	-0,0032	0,0207	-0,0814	0,0550	-1,2299	3,4482
	October	-0,0008	0,0193	-0,0728	0,0629	-0,7780	3,0803
	November	0,0007	0,0153	-0,0670	0,0520	-0,1054	3,6059
	December	-0,0007	0,0178	-0,0753	0,0685	0,0223	4,4839

(continued)

Table 2. (continued)

	Month	Measure					
		Mean	Std. dev.	Min.	Max.	Skewness	Kurtosis
Palladium	January	0,0027	0,0206	-0,0649	0,0708	0,1557	1,1193
	February	0,0038	0,0237	-0,0835	0,0996	0,1548	2,9462
	March	-0,0007	0,0255	-0,0859	0,0725	-0,9164	1,8687
	April	0,0006	0,0185	-0,0575	0,0521	-0,4259	0,8257
	May	-0,0005	0,0250	-0,1102	0,0740	-0,6173	3,5662
	June	-0,0009	0,0204	-0,0550	0,0584	0,1028	0,5325
	July	0,0013	0,0175	-0,0719	0,0544	-0,2398	1,9966
	August	-0,0007	0,0191	-0,0619	0,0469	-0,4550	0,8013
	September	-0,0033	0,0259	-0,1136	0,0730	-0,8787	3,5731
	October	0,0020	0,0257	-0,0863	0,1154	0,2556	3,5867
	November	0,0019	0,0278	-0,1636	0,0787	-1,2060	9,2073
	December	0,0022	0,0219	-0,0695	0,0674	0,0153	2,3167

Source: own calculations

Methodology

In order to study calendar effects we use econometric models. The study focuses on the-day-of-the-week and the month-of-the-year effects. The day-of-the-week effect is one of the most frequently investigated seasonal anomalies in capital markets [Cross 1973, French 1980, Gibbons and Hess 1981, Keim and Stambaugh 1984, Lakonishok and Smidt 1988, Lakonishok and Maberly 1990]. Researchers revealed that Monday and Friday returns differ from returns on other weekdays: Monday returns are statistically significantly negative, while Friday returns – positive. Another well documented anomaly is January effect. It is proved that returns on stock markets often are much higher in January than in other months [Rozeff and Kinney 1976, Keim 1983, Haugen and Lakonishok 1988, Bouman and Jacobsen 2002, Fountas and Segredakis 2002, Lucey and Zhao 2008]. Another monthly effects are: May effect (low returns) and September effect (high returns). There were also several studies in Poland investigating calendar effects for Warsaw Stock Exchange. Different results were presented by Szyszka [1999], Papla [2000], Osińska [2006], Landmesser [2006], Rozkrut [2006], Witkowska and Kompa [2007], Kluth [2007] etc.

One of possible methods for examining calendar effects is estimating the following equation:

$$R_t = \beta_1 D_{1t} + \beta_2 D_{2t} + \beta_3 D_{3t} + \beta_4 D_{4t} + \beta_5 D_{5t} + \varepsilon_t \,, \qquad (2)$$

where:

R_t - is the daily return of the asset,

D_{it} - are dummy variables which take on the value of 1 if the corresponding return for day *t* is Monday, Tuesday, Wednesday, Thursday or Friday respectively, and 0 otherwise.

β_i capture the mean daily return for each of the days of the week, but Borges [2009] points out that the *t*-test for those coefficients only inform us if they are significantly different from zero. According to her, if the time period under study is sufficiently long, it is to be expected that mean daily return is positive, however a very small number. Therefore, the significance of the *t*-tests is biased in favor of accepting positive excess returns, and against accepting negative excess returns. She suggests to estimate five equations separately, each aiming at detecting a specific day of the week effect:

$$R_t = \alpha + \beta_{i1} D_{it} + \varepsilon_t . \quad (3)$$

Here, if we include only the dummy variable for Mondays, α captures the mean daily return of non-Mondays and β_1 is the excess return of Mondays, relative to non-Mondays. The *t*-test of β_1 tells us if this effect is significant. The same is for β_2, β_3, β_4 and β_5, for detecting other weekdays effects.

The above discussion can be transferred to month effect analysis as well. The only difference is that we need twelve different dummies: M_i (i=1,…,12). Each takes the value of 1 if the corresponding return for day *t* is of January, February etc., and 0 otherwise.

In order to investigate calendar effects GARCH models may be applied as well. GARCH (p, q), developed by Bollerslev in 1986, is of the following form:

$$\sigma_t^2 = \alpha_0 + \sum_{i=1}^{q} \alpha_i \varepsilon_{t-i}^2 + \sum_{i=1}^{p} \lambda_i \sigma_{t-i}^2 . \quad (4)$$

In the paper here, following Borges [2009], after performing a test of ARCH effects on our data, we evaluate the most simple form - GARCH (1,1), including only one lag both in the ARCH term (last period's volatility) and in the GARCH term (last period's variance). Dummies indicate days and months of observation.

RESULTS

In order to detect calendar effects in daily returns generated by four precious metals, following procedures described in the previous section, we start with estimating individual regressions for the day-of-the-week and month effects. The results for the β_i coefficients are given in table 3. They reveal significant the day-of-the-week effect – Friday effect in the case of silver only. Here, Friday silver returns are statistically significantly negative (not positive as one could have expected). Significant monthly effects are: January effect (platinum) and September effect (platinum and palladium). September returns are statistically significantly negative.

Table 3. Calendar effects for precious metals (2008-2013) – linear simple regressions

Effect	Metal			
	Gold	Silver	Platinum	Palladium
Monday (D_1)	0,0014	0,0032	0,0003	0,0014
Tuesday (D_2)	-0,0005	-0,0005	-0,0001	-0,0007
Wednesday (D_3)	0,0000	0,0014	0,0007	0,0010
Thursday (D_4)	-0,0009	0,0006	0,0002	0,0001
Friday (D_5)	0,0001	-0,0046*	-0,0011	-0,0017
January (M_1)	0,0012	0,0029	0,0046*	0,0022
February (M_2)	0,0010	0,0031	0,0030	0,0034
March (M_3)	-0,0012	-0,0005	0,0001	-0,0016
April (M_4)	-0,0009	-0,0003	-0,0007	0,0000
May (M_5)	0,0000	-0,0016	-0,0012	-0,0013
June (M_6)	-0,0013	-0,0035	-0,0010	-0,0017
July (M_7)	0,0007	0,0007	-0,0002	0,0006
August (M_8)	0,0012	0,0014	0,0001	-0,0015
September (M_9)	0,0003	-0,0002	-0,0035*	-0,0043*
October (M_{10})	-0,0010	-0,0016	-0,0010	0,0015
November (M_{11})	0,0016	0,0011	0,0008	0,0013
December (M_{12})	-0,0017	-0,0015	-0,0008	0,0016

Source: own calculations Note: *significance at the 0,05 level

In the second step of research, after confirming the presence of ARCH effects in our data, we estimate GARCH (1, 1) models. The adequate results are presented in table 4. They confirm the January effect in the case of platinum and detect another month effect – September effect in the case of gold and silver. However, the GARCH (1,1) approach gives no evidence of any day-of-the-week effect.

CONCLUDING REMARKS

The aim of the paper was to study calendar effects in markets of precious metals. Usually researchs on calendar effects focus on stock markets rather than on commodity markets and if they cover commodities the most often are limited to oil or gold and sometimes silver. Our study extends the investigation to the four most important precious metals: gold, silver platinum and palladium and is based on London daily closing prices from 2008 through 2013.

First of all, we find almost no evidence of calendar effects on London gold market (the only exception is September effect under GARCH methodology), that implies its efficiency. Our results confirm prior findings of Smith [2002], who stated that London gold closing prices follow a random walk. In his opinion the closing price is more efficient than morning and afternoon fixings, because it is determined by additional information during the day and involves many more market participants. Moreover, researchers broadly agree that the U.S. gold market is also efficient (see Tschoegl [1980], Solt, Swanson [1981], Aggarwal, Soenen [1988]). Charlie at al. [2007] generalize and conclude that the gold market itself is relatively efficient. However, Qi and Wang [2013] provide evidence of monthly effects in Chinese gold market.

Table 4. Calendar effects for precious metals (2008-2013) – GARCH (1,1) approach

Effect	Metal			
	Gold	Silver	Platinum	Palladium
Monday (D_1)	0,000916	0,001787	0,000339	0,001255
Tuesday (D_2)	0,000711	0,001525	0,000713	0,001196
Wednesday (D_3)	0,000373	0,002177	0,000951	0,000930
Thursday (D_4)	-0,000017	0,001126	-0,000384	0,000429
Friday (D_5)	0,000561	-0,002125	-0,000319	0,000785
α_0	0,000003	0,000031	0,000004	0,000008
α_1	0,052945	0,088835	0,062163	0,065413
λ_1	0,930780	0,868468	0,921607	0,919585
January (M_1)	0,000529	0,003189	0,004316*	0,001855
February (M_2)	0,000776	0,002076	0,001068	0,002425
March (M_3)	-0,000418	0,000218	-0,000059	-0,000865
April (M_4)	0,001225	-0,002897	-0,000492	-0,000088
May (M_5)	0,000579	-0,000495	-0,001731	-0,000040
June (M_6)	-0,000634	-0,002145	-0,001506	-0,001113
July (M_7)	0,000721	0,000757	0,000899	0,001919
August (M_8)	0,001530	0,003474	0,001047	0,000907
September (M_9)	0,001948*	0,006581*	0,000489	-0,000049
October (M_{10})	0,000355	-0,000668	0,000200	0,001622
November (M_{11})	0,001173	0,001380	0,000041	0,001959
December (M_{12})	-0,001733	-0,001806	-0,000778	0,001679
α_0	0,000003	0,000031	0,000004	0,000008
α_1	0,0558847	0,096919	0,057289	0,062837
λ_1	0,928998	0,859957	0,928591	0,922777

Source: own calculations Note: *significance at the 0,05 level

According to Christian [2007] silver shares some characteristics with gold, so one could expect its efficiency as well, but our study for silver detects both the-day-of-the-week (Friday) effect and the-month-of-the-year (September) effect. In the case of platinum and palladium the only observable calendar anomalies are monthly effects: January and September for platinum and September for palladium. However, considering only the effects that are significant under both applied methodologies, we should recognize the January effect for platinum solely.

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