Short-term and long-term relationships between gold prices and precious metal (palladium, silver and platinum) and energy (crude oil and gasoline) prices

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ABSTRACT

Throughout history, investors have attempted to determine the future states and prices of instruments that they consider to invest in. Thus, various econometric models have been developed in order to determine the variables influencing the prices of investment instruments, as well as the relationships between such variables. The main aim of the present study was to examine the variables that may be related to gold prices. These variables were divided into two groups: precious metals and energy. According to the results of unit root (or stationary) tests and cointegration tests, a vector autoregression model (VAR) was constructed to reveal the short-term interaction between gold prices and precious metals, and a vector error correction model (VECM) was employed to reveal relationship between gold prices and energy prices. The results of the VAR analysis indicated that gold prices have a short-term correlation with silver prices; platinum prices have a short-term correlation with gold and silver prices; and there is a short-term correlation between silver prices and palladium prices. According to the results of the VECM analysis, gasoline and crude oil prices have no long-term correlations with gold prices, but gold and crude oil prices have a long-term correlation with gasoline prices.

1. Introduction

Recently, national and international financial markets have become severely complex as a result of the introduction of new financial market instruments. This complexity raises questions in the minds of investors. To overcome this complexity, most investors (especially non-professionals) traditionally invest in gold, which has been considered to be a simple and safe haven for many investors.

The main motives underlying the demand for gold can be divided into three groups: jewellery, industrial dentistry and investment (Baur & McDermott, 2010). Jewellery and industrial dentistry motives depend on the purchasing power of consumers. On the other hand,

investors may demand gold for speculation and value-keeping purposes. Hence, the gold market, which has provided important gains recently, basically depends on two motives: gold demand for aesthetic purposes and gold demand for precautionary purposes (Ziaei, 2012). Among these, one of the most important characteristics of gold is that it is an instrument of investment in every period.

Gold has provided more distinct advantages for its investors in comparison to other commodities (Zhang & Wei, 2010). The gold market is regarded as an active market as it has provided good profit-making opportunities and various measures for risk control recently, thereby standing as an investment instrument that attracts investors (Ziaei, 2012).

The gold and oil markets have been the primary representatives of the commodity market (Zhang & Wei, 2010). Gold has been the most important precious metal in almost every century. Hence, it has usually played an important role politically and economically. Accordingly, gold prices accompanied by oil prices stand as two very important indicators in international markets (Beckmann & Czudaj, 2013).

Investors can use gold as a hedge against inflation and foreign exchange rate fluctuations. According to Kearney and Lombra (2009), precious metals such as gold and platinum are considered to be attractive assets in periods of high inflation and economic and political instability. Increases in oil prices create inflationist pressure. When oil prices increase, companies are perturbed due to fluctuating costs and irregular profits. Such increases in commodity prices change consumer expenditures directly or indirectly. Increases in oil prices reduce the disposable earnings of individuals, and thus lead to inflation, which causes a rise in gold prices. This is because investors invest in gold as they believe that it will keep its value (Wang & Chueh, 2013). In addition, gold production, foreign exchange rates and reserves, oil prices and other commodities or some financial market instruments affect gold prices as well (Anand & Madhogaria, 2012). Therefore, fluctuations in oil prices can be predictors of movements in gold prices (Le & Chang, 2012).

The purpose of this study is to examine the relationship between gold prices, energy prices and some commodity prices. For this purpose, crude oil prices and gasoline prices were regarded as representing the energy sector. On the other hand, with regards to precious metal, we used silver, palladium and platinum prices. The study was conducted using weekly data for the period 1990–2014. The study differs from similar studies due to its use of different exogenous variables and the time period under assessment. As exogenous and endogenous variables differ, the relationship between the variables differs as well. In addition, using different time periods and time series (daily, weekly, monthly or annually) may affect the results of these analysis. It may not be possible to generalise the results for a single time period to the whole period. Accordingly, replicating the studies for different time periods may contribute to the generalisation of the findings.

This study is organised as follows: in the following section, the literature on the relationship between gold prices, other precious metals prices and energy prices is examined. Afterwards, the data and the methodology are presented, which is followed by a section on the details of the analysis and findings. The findings of the study are discussed in the last section.

2. Literature

In their research, Baur and McDermott (2010) explained the role of gold in global financial markets. In this regard, they tested whether gold is a safe haven against stocks in national

stock markets for the period between 1979 and 2009. According to the results, although gold stood as a hedge and a safe haven in most European stock markets and the U.S.A., this is not valid for many other markets, such as Australia, Canada, Japan and BRIC countries (the countries of Brazil, Russia, India and China).

Narayan, Narayan, and Zheng (2010) investigated long-term correlations between gold, crude oil and future contracts. They concluded that: (1) investors use gold market as a hedge against inflation; and (2) oil prices can be used for estimating gold prices or vice versa, at least in the analysis period (2 January 1995–3 June 2009).

Blose (2010) investigated how the changes in the expected inflation rate affected gold prices and revealed that the surprises experienced in the U.S. consumer price index did not influence spot gold prices. In addition, the changes in the inflation expectations of investors might affect the speculative strategies in bond markets rather than gold prices. Additionally, investors could not set their market inflation expectations through analysing gold prices.

Chang, Della Chang, and Huang (2013) analysed gold prices and the correlations among five global gold markets (London, New York, Japan, Hong Kong and Taiwan). They employed the augmenting-level vector autoregression model (VAR) in order to investigate the investment strategy connections between Taiwan and other gold markets. As a result, they detected a two-way causality relationship between London and New York gold markets and a one-way causality relationship between New York and other markets. In addition, the New York gold market played a leading role and was influential in global gold markets.

Ziaei (2012) used the generalised method of moments in order to analyse the effects of gold prices in the Association of Southeast Asian Nations (ASEAN)+3 countries (Indonesia, Malaysia, The Philippines, Singapore, Thailand, China, Japan and South Korea) on equity, bonds and domestic borrowing. It was found out that gold prices had a significant effect on borrowing and equity, but did not have any effect on domestic credits.

Wang and Chueh (2013) dealt with the short-term and long-term dynamic interactions among interest rates, oil prices, gold prices and the U.S. dollar. The study employed the threshold cointegration model and the threshold error correction model for analysis covering the period between 2 January 1989 and 20 December 2007. It was seen that gold prices and crude oil prices were related positively in the short term. Moreover, the researchers determined that while interest rates had a negative effect on gold futures prices, crude oil had a positive effect on futures. Furthermore, there was a price transmission from interest rates to gold prices.

Kearney and Lombra (2009) showed that there was a positive correlation between gold and platinum prices for the period from 1985 to 2006. The correlation, which was positive in the short term in the earlier years (1996–2001), turned out to be negative in subsequent years.

Le and Chang (2012) investigated the effect of fluctuations in oil prices on returns on gold, based on monthly data for the period between May 1994 and April 2011 via the structural vector autoregressive model. They determined that the shocks in oil prices had a statistically significant positive correlation with real returns on gold. It was found that the effect was symmetric, but not linear.

Apergis (2014) analysed, based on daily and quarterly data, whether there was any correlation between gold prices and nominal Australian dollar/U.S. dollar and real foreign exchange rates for the period between 2000 and 2012 through the vector error correction model (VECM). It was concluded that gold prices could be used for estimating Australian dollar/U.S. dollar foreign exchange rates.

Soytas, Sari, Hammoudeh, and Hacihasanoglu (2009) revealed that the Turkish precious metal spot market, the U.S. dollar/Turkish Lira (TL) exchange rate and the bond market did not have roles in estimating world oil prices in the long term. Similarly, Sari, Hammoudeh, and Soytas (2010) analysed information permeability and acting together of precious metals (gold, silver, platinum and palladium) spot prices, oil prices and the U.S. dollar/Turkish Lira (TL) exchange rate for the period between 4 January 1999 and 19 October 2007 using VAR analysis, and the results indicated a weak long-term balance and short-term strong returns.

Beckmann and Czudaj (2013) analysed short-term and long-term relationships between the nominal effective foreign exchange rate, oil, gold and the U.S. consumer price index. The results of a cointegrated VAR showed that oil and gold were two important commodities and they had significantly different economic effects, and that gold and oil distributions were positively correlated with U.S. consumer prices.

Lili and Chengmei (2013) analysed the factors influencing gold prices via factor-augmented VAR. To this end, variables were reduced to three factors (gold reserve and energy products price – F1; financial market index – F2; and global macroeconomic indicator – F3) through the factor analysis on the macroeconomic variables affecting gold prices. The results revealed that there is a positive correlation between spot gold prices and F1, but a negative correlation between gold prices and F2 and F3.

Souček (2013) conducted a study to reveal the acting together of capital movements, crude oil and gold futures markets represented by short positions. The researcher showed that there is a positive correlation between demand for crude oil futures for hedging and stocks, whereas there is a negative reaction to sudden shocks in interest rates in other markets.

Anand and Madhogaria (2012) investigated the correlation and causality between stock returns and gold prices across six countries (the U.S.A., the U.K., Germany, Japan, India and China). They employed the Granger causality test and a VECM for the analysis covering the period between January 2002 and December 2011. It was concluded that there was feedback causality between the variables.

Batchelor and Gulley (1995) analysed the correlation between demand for jewellery, gold prices, real expenditures of consumers and control variables. They conducted a seemingly unrelated regression analysis by use of jewellery sales data-sets in six developed countries (the U.S.A., Japan, Germany, France, Italy and England). They determined that a direct price elasticity of between –0.5 and –1.0 and expected price changes were speculative purchase proofs.

Topçu and Aksoy (2012) examined the short-term and long-term correlations between gold, stocks, government debt securities, the consumer price index and the producer price index for the period between January 2003 and December 2011 through causality, cointegration and regression analyses. The results of the regression analysis indicated that return on investment in gold had a negative correlation with stock returns, but had a positive correlation with the producer price index. In addition, the researchers showed that there was a causality relationship between gold returns and producer and consumer price indices. In a similar study (Poyraz & Didin, 2008), a regression analysis was conducted in order to reveal the effects of foreign exchange rates, foreign exchange reserves and oil prices on gold prices. The results indicated that foreign exchange rates, oil prices and oil reserves influence gold prices. Tokat (2013) examined the volatility of gold price per gram, the U.S. dollar and the Borsa Istanbul-100 index via the Generalized AutoRegressive Conditional

Heteroskedasticity (GARCH) model and showed that all of the examined variables had heteroskedastic volatility.

3. Data and methodology

3.1. Data

In this study, the correlations of world gold prices with silver, platinum, palladium, crude oil and gasoline prices were investigated. The data were gathered from www.quandl.com, and analyses were made on the monthly data for the period between July 1990 and February 2014.

Underestimating the assumption of normal distribution may lead to type 1 and type 2 errors. In order to increase the normality of the variables, to change measurement levels and to stabilise the variance data, transformation can be conducted. Data can be transformed via taking the inverse, logarithm or square root. Among these, taking the logarithm or log transformation are the most widely used transformations (Feng et al., 2014). However, findings should be carefully interpreted when using log transformation, especially for regression-type analysis. Findings should be interpreted after taking anti-logs of the coefficients.

The logarithmic first differences of each variable that will be used in the analysis are shown in Figure 1. The biggest change in the logarithmic first differences appears to be in gasoline prices. The change is also observed to be large in palladium and crude oil prices in terms of the fluctuations in the first differences.

3.2. Methodology and analysis

The present study made an attempt to reveal the correlations between gold princes and the prices of some precious metals (silver, platinum and palladium) and energy (crude oil prices and gasoline) prices. Since the data used for this purpose were time-series data, such data were subjected to stationarity analysis and causality analysis initially. The natural logarithms of all variables were calculated for data transformation.

The augmented Dickey–Fuller (ADF) (Dickey & Fuller, 1981) unit root test was used for the stationary analysis. The ADF unit root test results concerning the variables used are given in Table 1, and the test results regarding first differences are also presented in Table 1. According to these results, the variables were not stationary on that level, but their first differences were stationary. Thus, the variable is integrated of order one, denoted by I(1).

In the present study, the short-term and the long-term relationships between gold prices and precious metals (silver, platinum and palladium) and energy sector (Brent crude oil and gasoline) prices were investigated. To this end, after the ADF stationary test was carried out, optimum lag selection was made for these two models established by using the criteria of Akaike information criterion (AIC), Hannan-Quinn information criterion (HQIC) and Schwarz' Bayesian Information Criterion (SBI). According to the results of AIC and HQIC, the optimum lag was 2 for the Lngold (G), Lnsilver (S) Lnpall (Pl) Lnplat (Pt) model, and similarly, the optimum lag for the Lngold (G), Lnoil (O) and Lngas (Gs) model was 1 based on HQIC and SBI, and it was 4 based on AIC. Accordingly, the optimum log length was 4.

Considering the determined lag values, the Johansen cointegration test was conducted to see whether or not there was cointegration among the variables. A cointegration analysis is
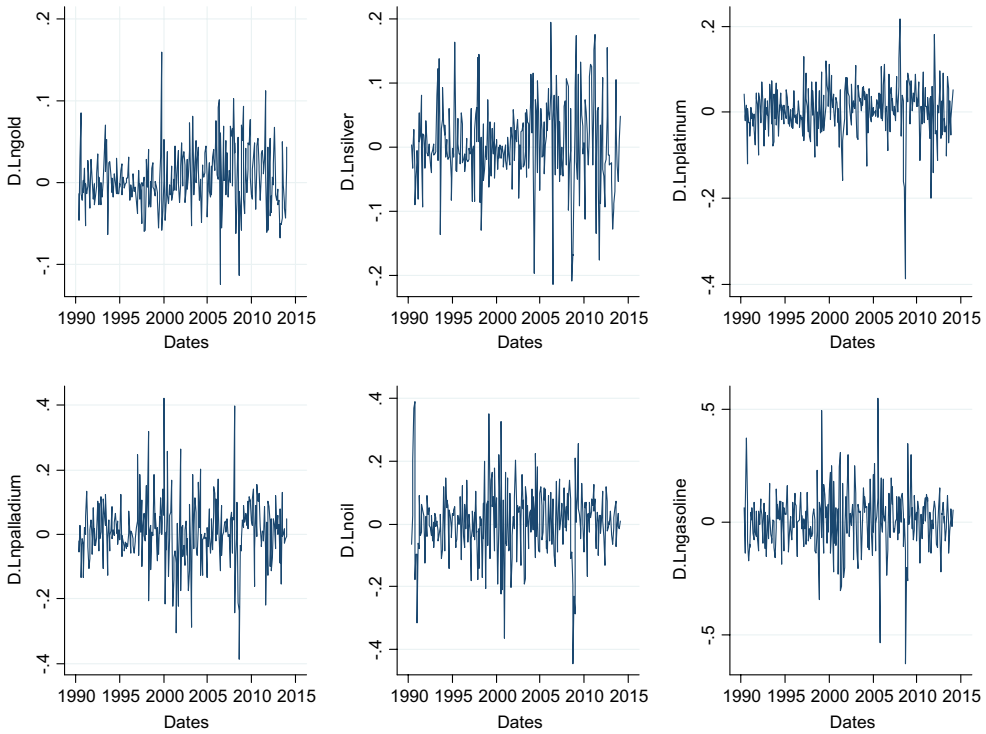
Figure 1. The logarithmic first differences of the variables used in the analysis. Source: Own calculation.

Table 1. The results of the augmented Dickey–Fuller stationary analysis.

	Level values		First differences	
	Non-trend model	Trend model	Non-trend model	Trend model
Variables	t-statistic	t-statistic	t-statistic	t-statistic
LnGold (G)	2.122	−1.337	−8.969*	−9.368*
LnSilver (S)	1.024	−2.150	−9.103*	−9.197*
LnPlatinum (Pt)	0.858	−3.309	−8.331*	−8.375*
LnPalladium (Pl)	0.861	−2.201	−8.697*	−8.734*
LnOil (O)	0.756	−3.065	−9.105*	−9.137*
LnGasoline (Gs)	−1.098	−3.202	−11.523*	−11.543*

Notes: For the non-trend model, t-values were taken as −3.750, −3.000 and −2.630 for the significance levels of 1%, 5% and 10%, respectively. For the trend model, t-values were taken as 4.380, −3.600 and −3.240 for the significance levels of 1%, 5% and 10%, respectively.*Significance level of 1%.
Source: Own calculation and results.

made to reveal whether or not there is a long-term relationship between the variables. Lack of cointegration means the lack of a long-term relationship between the related variables. Cointegration analysis tests the null hypothesis suggesting that there is no cointegration against the existence of cointegration. Cointegration analyses employ eigenvalue and trace statistic values as test statistics. The cointegration test determines the type of the regression model to be applied (VAR or VECM) (Pradhan & Bagchi, 2013).

The test results concerning the cointegration of gold prices with silver, platinum and palladium are given in Table 2, and the test results concerning the cointegration of gold prices with crude oil and gasoline prices are provided in Table 3.

Since the trace statistic value ($r = 0$; $\lambda_{\text{trace}} = 40.3089$) is lower than the 5% critical value (47.21), and the max statistics value ($r = 0$, $\lambda_{\text{max}} = 20.8466$) is lower than the 5% critical value (27.07), the null hypothesis cannot be rejected. This result shows that there was no cointegration between gold prices and silver, platinum and palladium prices. Therefore, the VAR was used for revealing the relationship between the variables. The four general equations (eq. 1–4) used for the VAR are indicated as follows:

$$G_t = \alpha_0 + \sum_{i=1}^{p=2} \alpha_{1i} G_{t-i} + \sum_{j=1}^{p=2} \alpha_{2j} S_{t-j} + \sum_{k=1}^{p=2} \alpha_{3k} Pl_{t-k} + \sum_{l=1}^{p=2} \alpha_{4l} Pt_{t-l} + \varepsilon_{1t} \tag{1}$$

$$S_t = \beta_0 + \sum_{i=1}^{p=2} \beta_{1i} G_{t-i} + \sum_{j=1}^{p=2} \beta_{2j} S_{t-j} + \sum_{k=1}^{p=2} \beta_{3k} Pl_{t-k} + \sum_{l=1}^{p=2} \beta_{4l} Pt_{t-l} + \varepsilon_{2t} \tag{2}$$

$$Pl_t = \gamma_0 + \sum_{i=1}^{p=2} \gamma_{1i} G_{t-i} + \sum_{j=1}^{p=2} \gamma_{2j} S_{t-j} + \sum_{k=1}^{p=2} \gamma_{3k} Pl_{t-k} + \sum_{l=1}^{p=2} \gamma_{4l} Pt_{t-l} + \varepsilon_{3t} \tag{3}$$

$$Pt_t = \delta_0 + \sum_{i=1}^{p=2} \delta_{1i} G_{t-i} + \sum_{j=1}^{p=2} \delta_{2j} S_{t-j} + \sum_{k=1}^{p=2} \delta_{3k} Pl_{t-k} + \sum_{l=1}^{p=2} \delta_{4l} Pt_{t-l} + \varepsilon_{4t} \tag{4}$$

In the equations given above, G refers to the logarithmic values of gold prices; S refers to the logarithmic values of silver prices; Pl refers to the logarithmic values of palladium prices; and Pt refers to the logarithmic values of platinum prices. Since no cointegration was detected between the variables, it was necessary to investigate short-term causality, but not long-term causality between the variables in the established model. Thus, based on the VAR results (Table 4), when gold prices were taken as the independent variable,

Table 2. Johansen cointegration test results for gold prices with silver, platinium and palladium.

Cointegration rank	The log likeli-hood (LL)	Eigenvalue	λ_{trace}	5% critical value	λ_{max}	5% critical value
0	1778.7346		40.3089*	47.21	20.8466*	27.07
1	1789.1579	0.07053	19.4623	29.68	13.89	20.97
2	1796.1029	0.04757	5.5723	15.41	5.3985	14.07
3	1798.8021	0.01876	0.1738	3.76	0.1738	3.76
4	1798.889	0.00061				

Varibles: LnGold (G), LnSilver (S), LnPalladium (Pl) and LnPlatinum (Pt).
*Significant at 1%.
Source: Own calculation and results.

Table 3. Johansen cointegration test results for gold prices with crude oil and gasoline prices.

Cointegration rank	The log likelihood (LL)	Eigenvalue	Trace statistic	5% critical value
0	1073.2334		100.9381	29.68
1	1118.5280	0.27229	10.3489*	15.41
2	1123.6726	0.03546	0.0596	3.76
3	1123.7024	0.00021		

Variables: LnGold (G), LnOil (O) and LnGasoline (Gs).
*Significant at 1%.
Source: Own calculation and results.

the one-period lag effect of the gold prices ($\alpha_{11} = 0.95, z = 12.29$) and the one-period and two-period lag effects of platinum prices ($\alpha_{41} = 0.199, z = 4.6$ and $\alpha_{41} = -0.173, z = -3.93$) on gold prices were determined to be statistically significant at the significance level of 1%. Silver prices were taken as the independent variable in the second model. It was found that the second lag of gold ($\beta_{12} = 0.374, z = 2.82$), the first and second lags of silver ($\beta_{21} = 1.127, z = 14.76$ and $\beta_{22} = -0.206, z = -2.67$) and the first and second lag of platinum ($\beta_{41} = 0.271, z = 3.6$ and $\beta_{42} = -0.232, z = -3.04$) had statistically significant effects on silver prices at the significance level of 1%. In addition to these, the first lag of gold ($\beta_{11} = -0.318, z = -2.36$) and the first and second lags of palladium ($\beta_{31} = 0.104, z = 2.35$ and $\beta_{32} = -0.101, z = -2.31$) had statistically significant effects on silver prices at the significance level of 5%. In the third model, platinum prices were taken as the independent variable. It was seen that platinum prices were significantly affected by only the one-period lag of platinum prices ($\delta_{41} = 0.079, z = -13.17$) at the significance level of 1%. Finally, palladium prices were taken as the independent variable, and it was determined that palladium was significantly affected by the one-period lag of palladium prices ($\gamma_{21} = 0.260, z = 2.04$) at the significance level of 5% and by the one-period lag of silver prices ($\gamma_{21} = 0.923, z = 12.5$) at the significance level of 1%.

The Granger causality analysis results indicated that there was a statistically significant mutual causality between silver prices and palladium prices ($S \leftrightarrow Pl$) at the significance level of 10% in the short term. Moreover, a statistically significant short-term causality was detected from gold prices to silver prices ($G \to S$) and from platinum prices to gold prices ($Pt \to G$) and to silver prices ($Pt \to S$) at the significance level of 5%. The causality relationships between these variables are demonstrated in Figure 2 and Table 5.

Some Granger causality was detected within the studied timespan of this study, and it cannot be claimed that the nature of this causality remains outside this time period. Therefore, similar studies could be conducted for different time periods. This is a point for future research.

To reveal the long-term and the short-term relationships between gold prices and energy prices (gasoline and crude oil prices), whether or not such variables were cointegrated was tested (Table 3). The results indicated that there is one cointegrating vector ($r \le 1$).

If the series are cointegrated, the series move together in the long run. A VAR of the first differences does not capture the long-run relationship. Therefore, it is appropriate to use VECM rather than VAR in order to reveal the long-term and the short-term tendencies between the series. The VECM is fit to the first differences, and a lagged error

Table 4. VAR coefficients.

Exploratory variables	LnGold (G) coefficient (z-statistic)	LnSilver (S) coefficient (z-statistic)	LnPalladium (Pl) coefficient (z-statistic)	LnPlatinum (Pt) coefficient (z-statistic)
G(−1)	0.9532* (12.29)	−0.3180** (−2.36)	−0.266 (−1.18)	0.1404 (−0.13)
G(−2)	0.0244 (0.32)	0.3741* (2.82)	0.2328 (1.05)	0.1387 (0.26)
S(−1)	−0.006 (−0.14)	1.1265* (14.76)	0.2595** (2.04)	0.0797 (0.8)
S(−2)	0.0129 (0.29)	−0.206* (−2.67)	−0.184 (−1.43)	0.0805 (−1.04)
Pl(−1)	−0.0011 (−0.04)	0.1039** (2.35)	0.9226* (12.5)	0.0461 (1.21)
Pl(−2)	−0.008 (−0.32)	−0.101** (−2.31)	0.0542 (0.74)	0.0457 (−1.11)
Pt(−1)	0.1995* (4.6)	0.2709* (3.6)	0.1514 (1.2)	0.0785* (13.17)
Pt(−2)	−0.173* (−3.93)	−0.232* (−3.04)	−0.190 (−1.49)	0.0798 (−0.46)
const	0.0087 (0.09)	−0.450** (−2.54)	0.4398 (1.49)	0.1850 (−0.42)

*Significant at 1%.
**Significant at 5%.
Anti-logs of coefficients were taken.
Source: Own calculation and results.
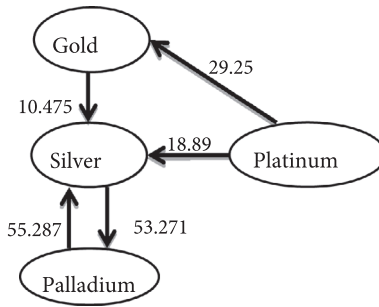
Figure 2. The causality relationships between gold, silver, platinum and palladium prices. Note: The numbers on/near the arrows are χ^2 values. Source: Own calculation.

Table 5. Granger causality Wald tests.

Explanatory variables	LnGold (G) χ^2 (probability)	LnSilver (S) χ^2 (probability)	LnPalladium (Pl) χ^2 (probability)	LnPlatinum (Pt) χ^2 (probability)
G		10.475* (0.005)	15.927 (0.451)	0.32478 (0.850)
S	0.17863 (0.915)		53.271*** (0.070)	12.123 (0.545)
Pl	2.823 (0.244)	55.287*** (0.063)		15.667 (0.457)
Pt	29.249* (0.000)	18.89* (0.000)	38.374 (0.147)	
All	38.995* (0.000)	50.836* (0.000)	10.231 (0.115)	27.908 (0.835)

Note: 'All' means the Granger causality test set for all independent variables. Wald tests are based on χ^2 statistics.
*Significant at 1%.
***Significant at 10%.
Source: Own calculation and results.

correction (EC) term is added. The VECM equations that were established are indicated in the Equations 5–7.

$$\Delta G_t = \alpha_1 + \sum_{i=1}^{p=4} \alpha_{2,i}\Delta G_{t-i} + \sum_{k=1}^{p=4} \alpha_{3,k}\Delta O_{t-k} + \sum_{l=1}^{p=4} \alpha_{4,l}\Delta Gs_{t-l} + \delta_1 EC_{t-1} + \varepsilon_{1t} \qquad (5)$$

$$\Delta O_t = \beta_1 + \sum_{i=1}^{p=4} \beta_{2,i}\Delta G_{t-i} + \sum_{k=1}^{p=4} \beta_{3,k}\Delta O_{t-k} + \sum_{l=1}^{p=4} \beta_{4,l}\Delta Gs_{t-l} + \delta_2 EC_{t-1} + \varepsilon_{2t} \qquad (6)$$

$$\Delta Gs_t = \gamma_3 + \sum_{i=1}^{p=4} \gamma_{3,i}\Delta G_{t-i} + \sum_{k=1}^{p=4} \gamma_{3,k}\Delta O_{t-k} + \sum_{l=1}^{p=4} \gamma_{4,l}\Delta Gs_{t-l} + \delta_3 EC_{t-1} + \varepsilon_{3t} \qquad (7)$$

In the formulations above, ΔG refers to the logarithmic first differences of gold returns, ΔO refers to those of crude oil returns, ΔGs refers to those of gasoline returns and EC is the error correction term, which is the estimated residual from the cointegration regression. The results of the VECM are summarised in Table 6, and they indicates that the models fit well. In the gold (ΔG) equation, the lagged EC term ($\delta_1 = 0.0347$, $t = 0.25$) is positive, but the coefficient is not significantly different from zero. The coefficient of the lagged EC term for crude oil (ΔO) is significantly positive ($\delta_2 = 0.0009$, $t = 3.41$), and the coefficient of the lagged EC term for gasoline (ΔGs) is significantly negative ($\delta_3 = -0.0307$, $t = -2.51$).

Table 6. Estimated VECM Results.

Exploratory variables	Gold (ΔG) coefficient (z-statistic)	Crude Oil (ΔO) coefficient (z-statistic)	Gasoline (ΔGs) coefficient (z-statistic)
ΔG(−1)	0.1243** (2.06)	0.3715** (2.1)	0.1816 (0.85)
ΔG(−2)	−0.0871 (−1.45)	−0.0685 (−0.39)	−0.0070 (−0.03)
ΔG(−3)	0.0761 (1.29)	0.2710 (1.57)	0.2583 (1.24)
ΔO(−1)	0.0611*** (1.75)	0.1663 (1.62)	0.0576 (0.47)
ΔO(−2)	−0.0008 (−0.02)	0.2775* (2.88)	0.2385** (2.06)
ΔO(−3)	0.0132 (0.44)	0.1671*** (1.88)	−0.0833 (−0.78)
ΔGs(−1)	0.0089 (0.26)	−0.1064 (−1.08)	0.0621 (0.52)
ΔGs(−2)	−0.0319 (−1.1)	−0.3482* (−4.11)	−0.3127* (−3.06)
ΔGs(−3)	−0.0391 (−1.44)	−0.1418*** (−1.78)	−0.0073 (−0.08)
EC	0.0009 (0.25)	0.0347* (3.41)	−0.0307** (−2.51)
cons	0.0038*** (1.79)	0.0025 (0.40)	0.0029 (0.39)
R^2	0.0349	0.1023	0.1232
χ^2	33.2806	34.0418	42.8425

*Significant at 1%.
**Significant at 5%.
***Significant at 10%.
z-statistics in parentheses. Anti-logs of coefficients were taken.
Source: Own calculation and results.

The short-run dynamics are captured through the individual coefficients of the difference terms. The examination of the short-term relationship between the variables demonstrated that the gold return is affected by only the first lag of gold ($\alpha_{2,1} = 0.124$, $z = 2.06$) and the one-period lag of oil ($\alpha_{3,1} = 0.0611$, $z = 1.75$). The other short-run coefficients in this equation are not significantly different from zero. In the crude oil regression, the effects of the one-lag of gold ($\beta_{2,1} = 0.372$, $z = 2.1$), the two-lag of oil ($\beta_{3,2} = 0.278$, $z = 2.88$) and the three-lag of oil ($\beta_{3,3} = 0.167$, $z = 1.88$) are significant positive, but the effects of the two- and three-lags of gasoline ($\beta_{4,2} = -0.348$, $z = -4.11$; $\beta_{4,3} = -0.142$, $z = -1.78$) are significantly negative. For the gasoline equation, the short-run coefficient of the second-lag of oil ($\gamma_{3,2} = 0.239$, $z = 2.06$) is significantly positive and the second-lag of gasoline ($\gamma_{4,2} = -0.313$, $z = -3.06$) has a significantly negative effect on gasoline, but the other short-run coefficients in this equation are not significantly different from zero.

4. Conclusion

The price of gold, which has kept its importance for some investors and has mostly been considered as a safe haven over the years, may depend on many factors, such as crude oil price (Beckmann & Czudaj, 2013; Le & Chang, 2012; Narayan et al., 2010; Souček, 2013; Soytas et al., 2009; Wang & Chueh, 2013), inflation rates (Blose, 2010), real exchange rates (Apergis, 2014; Beckmann & Czudaj, 2013; Wang & Chueh, 2013), interest rates (Wang & Chueh, 2013), platinum prices (Kearney & Lombra, 2009; Sari et al., 2010), the consumer price index (Beckmann & Czudaj, 2013), gold reserves (Lili & Chengmei, 2013), stock indices (Anand & Madhogaria, 2012; Lili & Chengmei, 2013; Topçu & Aksoy, 2012) and future contracts (Narayan et al., 2010).

Although it is thought at the first glance that gold prices depend on national and international macroeconomic variables, capital markets and the prices/returns of other commodity market investment instruments, it is necessary to examine the behaviours of gold investors and to conduct a thorough analysis of the factors that are influential on such behaviours

in order to understand the changes and movements in gold prices. Gold investors differ from investors in capital markets, derivative markets and other commodity market instruments. Gold has a distinctive investor profile because it stands both as a store of value and as a reserve. Thus, its pricing involves many different factors. Therefore, the present study investigated the long-term and short-term correlations between gold prices and the prices of some precious metals, oil and gasoline, whose investors were thought to have similar behaviours to those of gold.

Future studies in this area could be conducted according to two approaches. One approach is replicating the present study with the use of different time periods and time series in order to obtain a better understanding of whether volatility is permanent or whether there is a breakdown of volatility over time. Also, time periods covering the financial crisis can provide support for the validity of previous findings. The second approach would involve analysing macro-variables in terms of the local currencies of the Organisation for Economic Co-operation and Development or other country groups.

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