Analysis of the Relationship between Oil and Gold Prices

Article *in* The Journal of Finance · January 2011

1 author:

Jana Simakova
Silesian University in Opava

Analysis of the Relationship between Oil and Gold Prices

Jana Šimáková
Silesian University in Opava
School of Business Administration in Karvina, Department of Finance
Univerzitní nám. 1934/3
Karviná 733 40
Czech Republic
E-mail: simakova@opf.slu.cz

Abstract
This article focuses on the relationship between oil and gold prices. The aim of this article is to analyze and determine the character of the co-movement between price levels. This article also presents the basic characteristic and determinants of current price trends. This work uses methods of analysis and synthesis of theoretical knowledge from literature, published articles and other publications. There is also included a quantitative analysis of the variables, such as Granger causality test, Johansen cointegration test and Vector Error Correction model. This paper reveals the existence of a long-term relationship between analyzed variables.

Key words: oil, gold, Granger causality, cointegration test, Vector Error Correction Model
JEL code: C32, E37

1. Introduction

Trend of market interconnectivity in the world economy is noticeable also in the commodity field, with its most important representatives – gold and oil. Gold, the most traded precious metal and oil, the most traded raw material, play an important role in shaping economy. The first connection between gold and oil have begun in history, when producers of the Middle East recquired gold in exchange for crude oil. Important milestone was in 1933. In 1933, the original oil concession in Saudi Arabia could be traded in gold only. As a result of many historical events, gold and oil markets went through huge development and significant relationship between these two commodities was no longer determined at the level of payment only.

Today, gold, oil and also other commodities are predominantly quoted in U.S. Dollars. In relation to oil, major player is OPEC (The Organization of the Petroleum Exporting Countries), which formally agreed to sale its oil production exclusively in U.S. Dollars. In the case of gold it is important to mention that from 1944 to 1971, U.S. dollars were convertible into gold, in order to prevent any trade imbalances between countries. Then and there, price of gold was fixed at $35 per troy ounce. Even the price of oil was relatively stable at around $3 per barrel. After 1971, when the dollar convertibility into gold was cancelled, price stability of both researched commodities has disappeared, but despite the significant volatility in their price levels, kind of common trend can still be seen in their price development.

The aim of the theoretical and quantitative data review is analysis of the relationship between gold and oil prices in the content of the global economy. This paper contains the basic characteristics, determinants of developments in gold and oil prices and focuses on specification of markets, where these commodities are traded. Furthermore, there is quantitative analysis of the variables. For this purpose, various statistical and econometric tools are used. Most of the previous studies in regards to gold and oil in long-term relationship used traditional time series models, which assumed linear and symmetrical processes. Enders and Siklos (2001) have demonstrated the low relevance of using the symmetric cointegration tests in situations that involve asymmetric processes. Therefore this study uses Johansen cointegration test and Vector Error Correction model to investigate asymmetric cointegration relation, confirming the long-term equilibrium between oil and gold price levels.

2. Literature Review

Some existing studies look into co-movement, cointegration and lead lag relationship between crude oil and gold, but almost every study does it different way. Some of the researchers choose to investigate potential long run relationship between spot price and some financial instruments with the same underlying asset – gold or crude oil. Other researchers look for relationship between this commodities and macroeconomic factors. Most of analysis use traditional time series models, but few more recent studies use new methods of examining asymmetrical processes.

Cashin et al. (1999) test the correlations between seven commodities with the time period from April 1960 to November 1985. Empirical results from this study demonstrate that there exist significant correlation between oil and gold. Systematic co-movement in oil and gold price levels confirm Pindyck and Rotemberg (1990). Ewing et al. (2006) and Fattouh (2010) examine the asymmetry in the spread adjustment process for oil and metal commodities.

Relationship examined through the common factor is less common. Most of these studies explained link between gold and oil prices through the inflation channel. There are several studies (Hunt, 2006; Hooker, 2002) that have established this link empirically. When oil prices rise, almost every price rises (Furlong et al.,1996). It follows that when inflation rises, the price of gold (as a good) goes up as well. Different channel was researched by Melvin and Sultan (1990). Their main thesis is the impact on gold prices through the export revenue channel. Gold is basic part of the international reserve portfolio of most countries, including the oil producing countries. When oil price rises, oil exporters revenues from oil rise, and this may have implications for the gold price level, provided that gold consists of a significant share of the asset portfolio of oil exporters and oil exporters purchase gold in proportion to their property. In that case, an oil price rise leads to a rise in gold price.

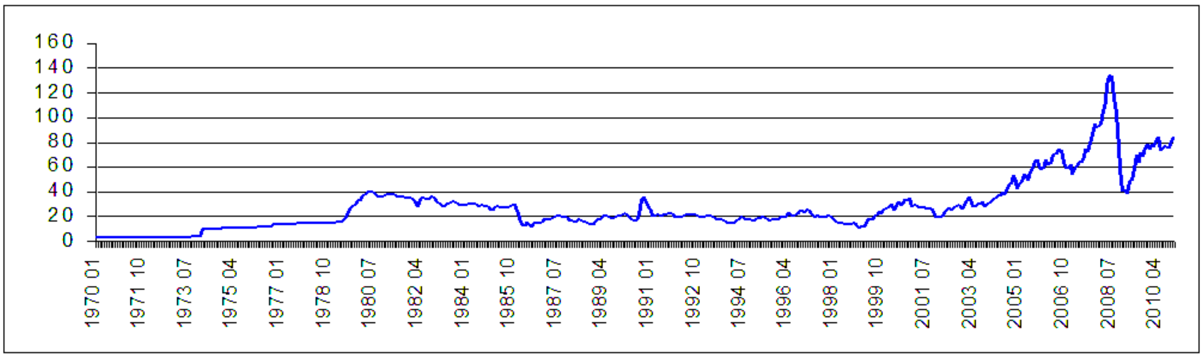
Compared with others, this analysis is implemented using a longer time period, from January 1970 to December 2010 and is divided to several time frames. In this paper are partly replicated the previous researches, but with newer data including recession years and except inflation, other common determinants are examined.

3. Oil Price

Oil was initially traded for its fundamental purposes, but over time gained a permanent place in the investment portfolio. Oil and its derivates are specific with high liquidity, volatility and relatively high profit opportunities for investors. Price formation is an important factor influencing the oil market. Determining the price of this commodity is derived from the market mechanism (the relationship of the global and regional supply and demand). According to Baláž (2002), the oil market is differentiated from other commodity market by certain specifics. Oil market shows considerable deviation from the perfect market, where the price range is just above marginal costs. There are many reasons, but mainly it is caused by an attempt of the dominant producers to control the sale prices. Quoting price of oil affects the pricing of all major oil producers and they regulate the supply of oil in order to achieve price targets. This market is also largely determined by political factors and internal situations in major producing and consuming countries, as well as international conflicts and tensions.

Historical development of the oil market formed a few main production and consumption centers, with their own quoting price. These are mainly spot markets in different parts of the world arranged according to mining areas (North Sea crude oil market, Russian oil market, etc.) and commodity exchange centers (IPE, NYMEX, etc.). Prices in these markets have a very high correlation and reaction to each other. Price differences are due to different quality and amount of transport costs. Given the possibility of arbitrage, there are not significant differences between long-term sustainable prices. Price development in the years 1970 to 2010 can be seen in Figure 1.

Figure 1: Oil prices in 1970 – 2010



Source: Federal Reserve Economic Data

3.1 Oil demand

The most important consumers of oil are developed market economies. Significant changes in global demand are in most cases caused by demand in these countries. Physical oil demand is also in the medium and long term, influenced by various macroeconomic indicators. GDP growth is inevitable with certain delay accompanied by a growth in demand for this raw material and vice versa. Other important factors are exchange rates, with most important currency which is U.S. Dollar. Because most oil trading is conducted through the USD, there is an indirect correlation between dollar and oil prices. Consumption also depends on the season, interest in the oil increases particularly during the summer months because of motoring and in winter during the heating season. Factors affecting oil demand, according to Baláž (2002) are divided into the following categories:

- changes in world population, world GDP, structural changes in the economy;
- changes in energy balance;
- climatic conditions and changes;
- importers exchange rates against the U.S. Dollar;
- commercial policy actions in importing countries;
- speculations and other factors.

3.2 Oil supply

Total supply of this raw material is determined by the limited world oil reserves. In long term condition, supply of crude oil is determined especially by the level of investments into oil processing industry, which are influenced by two main indicators, profitability and risk. In countries with the nationalization of industry these criteria are often absent (because of political activities focused on state interest and budgets) and this deforms oil market. As oil demand is mainly determined by the developed market economies, production of oil is indicated mainly by OPEC countries. They stimulate reducing or increasing oil production. In short term, there is a marked fluctuation during the period of hurricanes, earthquakes, when the production capacities are limited. According to Baláž (2002), total oil supply depends on several factors:

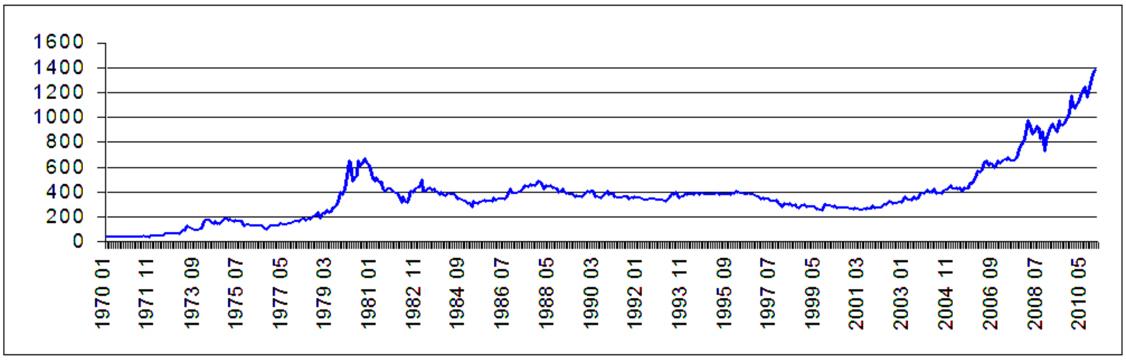
- amount of proven global oil reserves and new deposits;
- technical and technological advances in oil extraction and processing;
- monetary system in producing countries;
- political factors, the activities of OPEC and NOPEC (Non-Oil Power Exporting Countries);
- short-term factors: natural disasters, accidents, political and military conflicts.

4. Gold Price

A significant component of gold demand is resulting from the composition and characteristics of this rare commodity. However, the reality shows that gold is used as essential component of investment portfolio. Supply and demand are main factors that determine the price of gold. Dynamics of supply and demand in bullion market are supported by functionality and features of this precious metal, as well as investment characteristics. The World Gold Council, organisation of the gold industry representing approximately 60% of global corporate gold production, says that the price of gold is in many terms influenced by governments and central banks. Monetary policy performed by governments, changes in interest rates, inflationary policy, this all affects the price of gold, which is often used as an official reserve asset.

The final price of the major amount of sold gold is based on the prices on the world markets and gold prices set by the London Fix, which is determined twice a day by members of The London Gold Market Fixing Ltd. The value of the London Fix is used as a benchmark for the prices of most investment items and derivates of gold traded worldwide. Price development in the years 1970 to 2010 can be seen in Figure 2.

Figure 2: Gold prices in 1970 - 2010



Source: Kitco

4.1 Gold demand

Demand for this rare and limited natural raw material occurs in many geographic areas and sectors. On the forefront of consumption are China and India, with its rising economic strength. Part of demand in East Asia, India and the Middle East is also connected with a strong cultural and religious significance, which is not directly associated with global economic trends. Demand for gold is powered by a combination of affordability and desirability, another relevant factor is growth in living standards of population and the fact, that gold represents safe haven investment. Technically, gold offers high thermal and electrical conductivity, and excellent resistance to corrosion. This explains why more than half of the industrial demand is resulting from its use in electrical components and demand of gold in technology sector continues to grow. According to biocompatibility and resistance to corrosion and bacteria, gold is also applied in medicine.

In terms of gold market, the exchange rates (especially dollar exchange rate in which gold is quoted) are very important. There is a negative correlation. If the dollar falls / depreciates, the price of gold usually goes up; strong dollar keeps the price of gold controlled and low. On the other hand, low dollar moves price of gold up. Demand also increases during the periods of price stability or moderate growth rates and then decreases in period of volatility. In short, the demand factors are possibly incorporated into the following categories:

- world population, world GDP;
- growth of living standards of population;
- policy of central banks;
- exchange rates against the USD;
- technological development;
- speculative and other effects.

4.2 Gold supply

The gold supply is influenced by the gold mining companies on all continents. This wide geographical expansion means that the circumstances in any region, political or any other have a significant impact on the overall supply of gold. Currently, the global level of mining production is relatively stable. Stability of production is based on the fact that new discovered mines replaced terminated production and do not extend level of supply. From economic view, gold is inelastic in short period; it means amount of mined gold is not able to respond to price changes. While production of gold mines is relatively inelastic, recycled gold ensures that, if necessary, there exists at least one potential source to be traded. Currently about one third of all deliveries represents a recycled gold and to the increasing gold supply central banks with selling their reserves are biggest contributors. This conditions help to satisfy increased demand and keep gold prices relatively stable.

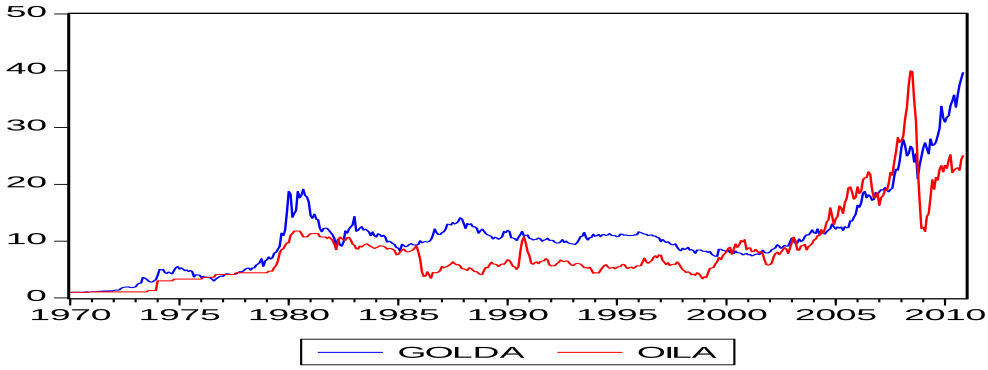
Central banks and international organizations (such as The International Monetary Fund) keep almost one fifth of the world's reserves of extracted gold in the form of reserve assets. Governments hold in average 10% of its reserves in gold. The sale of national gold is largely influenced by the CBGA (Central Bank Gold Agreement – includes euro area countries, Switzerland and Sweden), which should stabilize the gold market. The World Gold Council summarizes the main factors that affect the total amount of this commodity to these categories:

- verified global gold reserves, recycled gold and new deposits;
- technical and technological progress in gold mining;
- monetary system in each country;
- political factors;
- short-term factors: natural disasters, political and military conflicts.

5. Quantitative analysis

For the quantitative testing of the relationship between gold (GOLD) and oil (OIL) price levels are presented in monthly frequency for period 1970 to 2010, prices are indicated as monthly averages. WTI (West Texas Intermediate) market is chosen as a representative of the oil. Oil price quoted in dollars per barrel. Data originates in The Federal Reserve Economic Data portal. The price of gold is listed in dollars per troy ounce. The data relating to gold originates from Kitco website. There are 491 available observations in total. The analysis is affected by means of econometric tools in the program EViews5. Co-movement in oil and gold prices is already visible in Figure 3, which captures adjusted time series GOLDA and OILA. Peak can be seen in this figure too and was followed by bottom in oil time series in 2008 for few months.

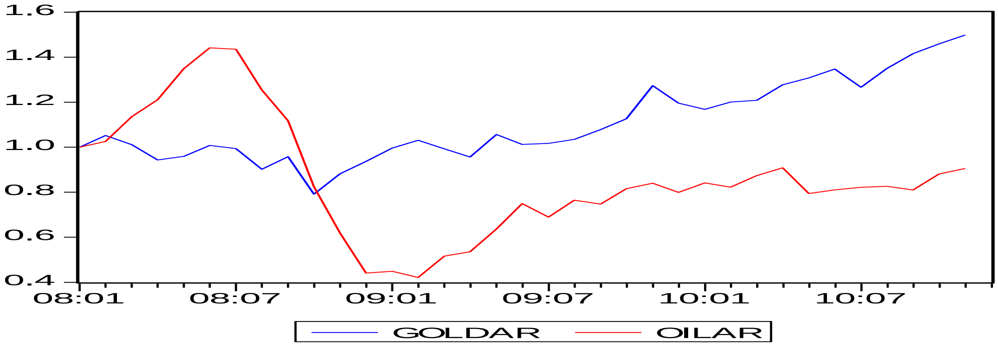
Figure 3: Adjusted time series of gold and oil from 1970 to 2010



Source: author's calculations

This oil price fluctuation during previous recession years is illustrated in Figure 4. During the unconventional unexpected behavior of market, this is represented by sinusoid followed by return to co-movement of investigated time series.

Figure 4: Adjusted time series of gold and oil from 2008 to 2010

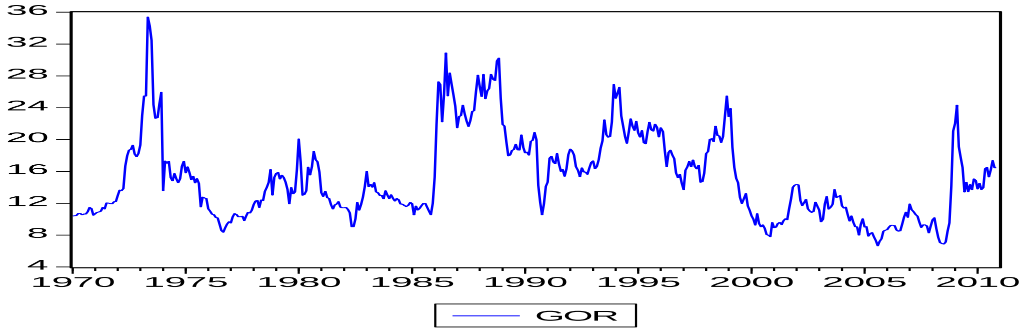


Source: author's calculations

5.1 GOLD/OIL RATIO

The easiest way how to quantify a relationship between two variables is ratio. The ratio between gold and oil is calculated as a proportion of the gold price to the price of oil related to time. The development of the GOR variable can be seen in Figure 5.

Figure 5: GOR from 1970 to 2010



Source: author's calculations

When the ratio is high, it means that gold is overvalued compared to oil; gold is too expensive or oil is too cheap. Alternatively, their growing or declining trends are in disproportion. From descriptive statistics, listed in Table 1, result in average value of the ratio between these two commodities – 15, 18. The Figure 5 shows significant fluctuations from this average, standard deviation has a value of 5,32. When the last period (2008 – 2010) was examined, approximately same values can be observed.

Table 1: Descriptive statistics GOR

	GOR 1970 -2010	GOR 2008 -2010
Mean	15,18	13,94
Median	14,01	14,34
Maximum	35,39	24,31
Minimum	6,67	6,88
Standard deviation	5,32	4,39
Skewness	0,88	0,90
Kurtosis	3,39	2,68

Source: author's calculations

5.2 Correlation of gold and oil prices

Correlation is a statistical technique which shows whether and how strongly two variables or processes are related (Aldrich, 1995). As visible from Table 2, the degree of correlation between gold and oil is strongly positive. For the whole period, the value of correlation coefficient is 0, 85. The result is that between most traded commodity of the precious metals and most traded raw material is a linear relationship. As seen in Figure 4, price moving in recent years (esp. in 2008) was different; in some part of the year even reverse. This was confirmed with correlation analysis as well. The correlation coefficient in this period was almost 0 and in some months reached negative values even.

Table 2: Correlation between gold and oil

	GOLD	OIL
GOLD	1	**0,85**
OIL	**0,85**	1

Source: author's calculations

5.3 Transformation of gold and oil time series

Beforeconducting other tests, time series are modified by logarithmic transformation (LNGOLD and LNOIL). This helps to reduce skewness and heteroscedasticity and to stabilize variability. The stability of regressors is needed in initial testing. As can be seen in Table 4, the null hypothesis confirmed the presence of unit root in both logarithmed price levels, it means nonstationarity. To obtain the stationary time series, rates of growth for both commodities (TRGOLD and TROIL) are calculated. For the stationarity testing, Augmented Dickey-Fuller testing at a 5% level of significance (α=0,05) was used. The results are stated in the Table 3.

Table 3: ADF test

DATA	TEST STATISTICS	CRITICAL VALUE;α=0,05	RESULT
LNOIL	-1,88	-2,87	nonstationary TS
TROIL	**-17,51**	**-2,87**	**stationary TS**
LNGOLD	-2,12	-2,87	nonstationary TS
TRGOLD	**-21,7**	**-2,87**	**stationary TS**

Source: author's calculations

Basic characteristics of the position, variability and form of growth rates are listed in following Table 4.

Table 4: Descriptive statistics

	TRGOLD	TROIL
Mean	0,75	0,66
Median	0,36	0,00
Maximum	32,87	85,26
Minimum	-25,32	-39,60
Standard deviation	5,96	8,33
Skewness	0,47	1,82
Kurtosis	7,76	26,73

Source: author's calculations

The descriptive statistics show that the price level of gold is rising, on average, more than the price level of oil. The growth rate in oil prices is more volatile. Both time series are right-skewed and more pointed than in the normal distribution.

5.4 Analysis of the relationship between gold and oil through the common factor

As was already mentioned, based on theoretical support, the mutual development of price levels of gold and oil are determined by some common factors. The purpose of this section is to provide empirical support before testing the long-term relationship. Therefore following variables are included:

- Consumer Price Index (CPI);
- Rate of U.S. three-month Treasury bills (TB3MS);
- Index of industrial production and capacity utilization (IND);
- Gold mining index (GMI).

In this case, the sample is shortened and divided to periods from 2000 to 2010 (131 observations) and 2000 to 2007 (96 observations) to determine how the crisis influenced results. Data were mined from portals of Federal Reserve Economic Data (CPI, TB3MS, IND) and Yahoo Finance (GMI). Relations between time series are analyzed with Least Square method (OLS). The general model is defined as:

$$\textit{dependant variable} = a0 + a\textit{variable} + e; \qquad (1)$$

Residues in this model are marked as *e.* Models and include constants, no trend and optimal lags for serial correlation and are determined by using Schwartz information criterion. Time series need to be stationary, for that purpose from CPI, IND, and GMI are calculated growth rates (CPI to INF, IND to TRIND, GMI to TRGMI) and TR3MS is at first transformed to a monthly basis and stationarity is achieved through differentiation (TB3MS to DTB3). The results of augmented Dickey-Fuller tests can be seen in Table 5.

Table 5: ADF tests

DATA	TEST STATISTICS	CRITICAL VALUE;α=0,05	RESULT
CPI	-1,09	-2,88	nonstationary TS
INF	**-8,43**	**-2,87**	**stationary TS**
TB3MS	-1,77	-2,89	nonstationary TS
DTB3	**-5,65**	**-2,89**	**stationary TS**
IND	-0,83	-2,89	nonstationary TS
TRIND	**-10,06**	**-2,89**	**stationary TS**
GMI	0,58	-2,88	nonstationary TS
TRGMI	**-14,73**	**-2,88**	**stationary TS**

Source: author's calculations

CONSUMER PRICE INDEX

To investigate the relationship between gold, oil and inflation, three presumptions are defined:

1. rising oil prices affect inflation;
2. inflation leads to an increase in gold prices;
3. in case first and second presumption is accepted, the rise in oil prices leads to an increase in gold prices.

Table 6: Correlation table INF

	TRGOLD	TROIL	INF
TRGOLD	1	**0,26**	**0,07**
TROIL	**0,26**	1	**0,58**
INF	**0,07**	**0,58**	1

Source: author's calculations

The correlation, between those variables, shows a positive numbers. This is represented in Table 6. There is seen as well, that the growth rate of oil is strongly positive related to inflation. Regression models are configured for presumptions mentioned in previous text.In first (short) time frame, hypotheses were confirmed. In sample with recession months, second presumption can not be accepted. OLS test results for hypotheses in shortened and follows:

INF (96) = 0,20 + 0,02*TROIL	prob.=0,00
INF (131) = 0,17 + 0,03*TROIL	prob.=0,00
TRGOLD (96) = 2,04*INF	prob.= 0,04
TRGOLD (131) = 1,45*INF	prob.= 0,11

THREE-MONTH U.S. TREASURY BILLS

Another important factor, which affects oil and gold prices are interest rates. As a benchmark are chosen 3-month U.S. treasury bills denominated in U.S. dollars. For the purposes of this work are defined following presumptions:

1. increasing interest rates lead to increase in oil price;
2. increasing interest rates lead to decrease in gold prices;
3. if first and second presumptions are confirmed, changes in interest rates affects reverse development in gold and oil price levels.

Table 7: Correlation table DTB3

	DTB3	TROIL	TRGOLD
DTB3	1	**0,05**	**-0,09**
TROIL	**0,05**	1	**0,26**
TRGOLD	**-0,09**	**0,26**	1

Source: author’s calculations

Correlation analysis in Table 7 confirmed co-movement in oil price and interest rates and opposite movement in gold price and interest rates. Change in interest rates has different development as gold and oil prices.Based on the results of Least Square analysis, it is not possible to confirm a short-term links in any period. Results of OLS tests with interest rates are:

TROIL (96) = 1,37 + 2*DTB3	prob.=0,63
TROIL (131) = 0,85 -1,7*DTB3	prob.=0,69
TRGOLD (96) = 1,03 – 1,97*DTB3	prob.=0,37
TRGOLD (131) = 1,18 – 0,66*DTB3	prob.=0,77

INDEX OF INDUSTRIAL PRODUCTION AND CAPACITY UTILIZATION

Big part of oil and gold demand represents industry; because of this, Index of Industrial Production and Capacity Utilization is included. Presumptions are as follows:

1. growth in industry leads oil price increasing;
2. growth in industry leads gold price increasing;
3. growth in industry implicite co-movement in oil and gold prices

Table 8: Correlation table TRIND

	TRIND	TROIL	TRGOLD
TRIND	1	**0,14**	**0,06**
TROIL	**0,14**	1	**0,26**
TRGOLD	**0,06**	**0,26**	1

Source: author’s calculations

Correlation analysis listed in Table 8 confirmed low positive correlation in price movements of variables. Using the least square method, no short-term links were confirmed. Regression models including the index of industrial production looks as follows:

TROIL (96) = 1,35 + 0.26*TRIND	prob.=0,17
TROIL (131) = 0,88 – 0,22*TRIND	prob.=0,21
TRGOLD (96) = 1,11 + 0.06*TRIND	prob.=0,59
TRGOLD (131) = 0,04 + 0.09*TRIND	prob.=0,64

GOLD MINING INDEX

One of the factors that affect the final price of gold is cost of production, involving mainly energy costs. The presumptions are:

1. rise in oil prices affects drop in stock prices of mining companies;
2. drop in stock prices of mining companies leads to growth of gold prices;
3. in case first and second presumptions are correct, oil prices leads to an increase in gold prices.

Table 9: Correlation table TRGMI

	TRGMI	TROIL	TRGOLD
TRGMI	1	**-0,04**	**-0,18**
TROIL	**-0,04**	1	**0,26**
TRGOLD	**-0,18**	**0,26**	1

Source: author's calculations

Regarding to the correlation Table 9 between variables, there are inverse links. Based on the values of probabilities, these models are not relevant and therefore short-term relationship between gold, oil and gold mining companies in this model were not confirmed.

TRGMI (96) = 2,15 – 0,06*TROIL	prob. = 0,69
TRGMI (131) = 1,94 – 0,15*TROIL	prob. = 0,16
TRGOLD (96) = 1,24 – 0,07*TRGMI	prob. = 0,08
TRGOLD (131) = 1,29 – 0,05*TRGMI	prob. = 0,15

5.5 Granger Causality

Although the gold/oil ratio, correlation analysis and Least Square method help to illustrate the relationship between oil and gold prices, they do not imply causation. Granger causality is used to provide information about causal relations. The Granger causality (1969) indicates that one time series is useful in forecasting another, in other words that current value of one variable is caused by past value of other variables.Let $Y_t(h|\Omega_t)$ be the prediction of one-dimensional process $\{Y_t\}$ constructed in time t, based on all possible information available in time t, Ω_t,, which has the minimum mean square error $MSE[Y_t(h|\Omega_t)]$. Let $\{Z_{t-s}, s\geq 0\}$ be a part of Ω_t. One-dimensional process $\{Z_t\}$ Granger-causes the process $\{Y_t\}$, if

$$MSE[Y_t(h|\Omega_t)] < MSE[Y_t(h|\Omega_t \backslash \{Z_{t-s}, s\geq 0)\}] \qquad (2)$$

for at least one of the horizons h= 1,2,…, while $\Omega_t \backslash \{Z_{t-s}, s\geq 0)\}$ means all information except information contained in past and present process $\{Z_t\}$. So if the process $\{Y_t\}$ can be more precisely foreseen because of information from the process $\{Z_t\}$, then $\{Z_t\}$ it has impact on $\{Y_t\}$.

After Granger causality test, it can be concluded that the change in oil prices precedes the gold price development in one month. After lag changes, the Granger causality has not been proven in any direction. After including "common factors" to the Granger causality test, it can be concluded, that inflation precedes the development of the gold price in one month and then in every half year interval. Interest rates do not contribute to the development of oil prices and do contribute to forecast gold prices with 3 and 6-month lags. Index of Industrial Production and Utilization significantly Granger-causes the growth rate of oil price level and Gold Mining Index precedes both examined variables. Results of relevant tests can be seen in Table 10.

Table 10: Granger causality

	Probability						
	lag 1	lag 2	lag 3	lag 4	lag 6	lag 10	lag 12
gold≠> oil	0,77	0,56	0,6	0,71	0,88	0,22	0,21
oil ≠> gold	**0,04**	0,11	0,18	0,31	0,45	0,92	0,7
inf≠> trgold	**0,02**	0,07	0,12	0,12	0,25	0,47	0,49
troil≠> inf	**0**	0,06	0,05	0,06	**0,02**	0,07	**0,04**
inf≠> troil	**0,02**	0,2	0,34	0,19	0,19	0,07	0,05
dtb3≠> trgold	0,25	0,44	**0,04**	0,06	**0,03**	0,06	0,07
trind ≠> troil	**0,01**	**0,04**	**0,02**	**0,01**	**0,04**	0,13	0,06
trgmi ≠> trgold	0,22	0,12	0,15	0,21	**0**	**0**	**0**
trgmi ≠> troil	0,43	0,51	**0,04**	0,3	0	**0,02**	0,8

Source: author's calculations

5.6 Long-term relationship between gold and oil markets

It was previously confirmed non-stationarity of oil and gold time series, but for economic and financial variables is relatively specific, that combination of two non-stationary one-dimensional processes can be stationary, which implicite a long-term economic equilibrium. This section is devoted to the cointegration test and construction of final Vector Error Correction (VEC) model that is used to confirm the evidence of long-term relationship between spot prices of gold and oil. Johansen cointegration test was used, which verifies a common stochastic drift between two or more time series (Johansen, 1997). The VEC model Cipra (2008) defines as:

$$\Delta y_t = \gamma \,.\, \Delta x_t + \alpha \,.\, (y_{t-1} - \beta \,.\, x_{t-1}) + \varepsilon_t\,, \qquad (3)$$

where $(y_{t-1} - \beta \,.\, x_{t-1})$ is error correction, parameter β represents long-term relationship, parameter γ represents short-term relationship and parameter α determine speeds of balancing to long-term equlibrium.

Augmented Dickey-Fuller tests for the original time series confirmed the presence of unit roots, but for all variables was found the first-difference stationarity. Non-stationarity on the same level I (1) is the basic precondition of cointegration between variables (Blake, Fomby, 1997). Optimal two-month lag in Johansen cointegration test was determined by lag structure in EViews5. Cointegration test confirmed the existence of one cointegration equation. The equation is following:

LNGOLD = 0,64*LNOIL + 3,73C,

which means that percentage increase in oil price affect 0,64 % increase in gold price. The value 0,64 is parameter β, consequently a long-term relationship.

Cointegration test revealed long-term relationship, but for the examination of short-term fluctuation in cointegrated time series error correction model is used CPI and GMI indexes are incorporated, which makes model more relevant, indicator adjusted R-squared is 0,5303, which indicates that model explains 53,03 % of reality. The applicability of model was tested using several tests of residues. The final models are following:

D(LNGOLD) = - 0,03*(LNGOLD(-1) – 0,64*LNOIL(-1) – 3,73) – 0,08*D(LNGOLD(-1)) – 0,05*D(LNOIL(-1)) – 0,23 + 0,012*LNGMI + 0.03*LNCPI;

D(LNOIL) = 0,15*(LNGOLD(-1) – 0,64*LNOIL(-1) – 3,73) – 0,06*D(LNGOLD(-1)) + 0,01*D(LNOIL(-1)) – 2,64 – 0,07*LNGMI + 0,75*LNCPI – 0,1*LNIND.

6. Conclusion

The aim of this article was to analyze the relationship between gold and oil price levels. The main research was performed for the period of 1970 – 2010 and then adapted separately to each quantitative analysis. Relationship between selected variables was expressed verbally, graphically and algebraically. Strong positive correlation in the whole sample between gold and oil was found out, but in recent years, there was some unconventional development noticed. On the other hand, proportional analysis confirmed that gold/oil ratio is during this time moving on its long-term values.

Gold as well as oil is influenced by specific factors, but according to second and third chapter some channels were indetified through which co-movement can be illustrated. Correlation analysis confirmed it in case of inflation, industry, interest rates and stock prices of gold mining companies. Least squares method verified just inflation regression model. Regarding Granger causality test, causal links between gold and oil price levels were identified. Johansen cointegration test revealed long-term relationship between examined variables and Vector Error Correction model confirmed, that after market fluctuations, both time series return to long- term equilibrium.

References

ALDRICH, J. (1995). Correlations Genuine and Spurious in Pearson and Yule.*Statistical Science*, vol. 10 (4), pp. 364–376.

ARLT, J. (1999). *Moderní metody modelování ekonomických časových řad*. Praha: Grada.

BALÁŽ, P. (2000). *Ropa a svetové hospodárstvo v období globalizácie* . Bratislava : Sprint.

BALKE, N., FOMBY, T. (1997). Treshold cointegration. *International Economic Review*, vol. 38(3), pp. 627-45.

CASHIN, P. et al. (1999). Booms and slumps in world commodity prices, *Reserve Bank of New Zealand Discussion Paper* vol. 99 (8).

CIPRA, T. (2008). *Finanční ekonometr*ie. Praha: Ekopress.

EWING, B., et al. (2006). Examining asymmetric behavior in US petroleum futures and spot prices, *The Energy Journal*, vol. 27, pp. 9-23.

FATTOUH, B. (2010). The dynamics of crude oil price differential, *Energy Economics*, vol. 32, pp. 334-342.

FURLONG, P., et.al. (1996). Commodity Prices and Inflation. *FRBSF Economic Review*, vol. 96 (2), pp. 27-47.

GRANGER, C. W. J. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica,* vol.37 (3), pp. 424-38.

HAMILTON, J. D.(1994). *Time Series Analysis*. 2nd ed. Princeton, New Jersey: Princeton University Press.

HOOKER, M. A., (2002). Are oil shocks inflationary? Asymmetric and nonlinear specifications versus changes in regime. *Journal of Money, Credit and Banking*, vol. 34, pp.540-561.

HUNT, B., (2006). Oil price shocks and the U.S. stagflation of the 1970s: Some insights from GEM. *Energy Journal*, vol. 27, 61-80.

JOHANSEN, S. (1997). *Likelihood-Based Interference in Cointegrated Vector Autoregressive Models.* Oxford: Oxford University Press.

MELVIN, M., SULTAN, J. (1990). South African political unrest, oil prices, and the time varying risk premium in the fold futures market. *Journal of Futures Markets*, vol. 10, pp. 103-111.

PINDICK, R., ROTEMBERG, J. (1990). The excess co-movement of commodity prices, *Economic Journal*, vol. 100, pp. 1173-1189.