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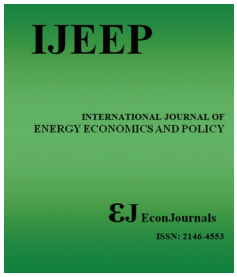
International Journal of Energy Economics and Policy

Provided in Cooperation with:
International Journal of Energy Economics and Policy (IJEEP)

Reference: Pruchnicka-Grabias, Izabela (2021). The relationship between gold and brent crude oil prices : an unrestricted vector autoregression approach. In: International Journal of Energy Economics and Policy 11 (4), S. 276 - 282. https://www.econjournals.com/index.php/ijeep/article/download/11229/5921. doi:10.32479/ijeep.11229.



International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2021, 11(4), 276-282.

The Relationship between Gold and Brent Crude Oil Prices: An Unrestricted Vector Autoregression Approach

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Received: 20 February 2021 **Accepted:** 28 April 2021 **DOI:** https://doi.org/10.32479/ijeep.11229

ABSTRACT

There is an ongoing scientific debate on how gold and crude oil affect each other prices. It is of high importance as both of them are strategic assets. The aim of the study is to check whether prices of these two assets influence each other. If so, if this is a short-term or a long-term relation and what the causality between these assets prices is. Daily data from January 2005 to December 2020 are used. The author applies Johansen cointegration test, Granger causality test and VAR model, denies a long-term and confirms a short term relation between gold and crude oil prices. However, it goes only in one direction that is from gold to crude oil. Such an interaction has significant consequences for investors, traders, producers, authorities, policymakers.

Keywords: VAR, Gold, Crude Oil Price, Granger Causality
JEL Classifications: G15, C51, F37

1. INTRODUCTION

There is an ongoing scientific debate on how gold and crude oil affect each other prices. It is of high significance because of several reasons. First is that volatility of oil prices endangers industrial producers and consumers with the risk of offering their goods at unfair prices, as well as it can change their incentives to invest in production facilities. Besides, volatility of crude oil prices is important for derivatives valuation and constructing hedging strategies as emphasized by Pindyck (2003). Crude oil is a special commodity as it significantly influences economic growth and activity in many countries (Brown et al., 1995; Jahangir and Dural, 2018; He et al., 2010; Difiglio, 2014; Ftiti et al., 2016, Arezki et al., 2017). Furthermore, crude oil is thought to cause inflation (Sek et al., 2015; Brown et al., 1995; Choi et al., 2017; Zivkov et al., 2019). Furthermore, gold plays a role of a safe haven and a hedge asset. Goodman (1956) emphasizes that gold has a monetary status and is an international means of exchange and an inflation hedge, so its price fluctuations are very imnportant for participants of the economic process. Salisu et al. (2020) show that gold can be also a hedge against crude oil price fluctuations. Le and Chang (2011) show that the price of gold can be a signal for high inflation expectations. Sikiru and Salisu (2021) argue that gold can play a role of a hedging instrument and safe haven for tourism stocks, especially during the COVID-19 pandemic. It is both a precious metal and a monetary asset. During a crisis investors increase their risk aversion and they go buying it to save their assets or generate an additional income. However, taking into consideration the above described mechanisms, such transactions may have further consequences for the economy. A review of gold as an investment and its market efficiency is presented in O'Connor et al. (2015).

The aim of the study is to check the relationship between gold and crude oil prices. If it appears, if this is a short-term or a long-term relation and what the causality between these assets is. Both gold and crude oil are an important part of commodity markets all over the word. So, it is desirable to check their relationship in order to be able to forecast the behavior of this significant part of the financial market. Crude oil price is influenced by its supply and demand, economical political and ecological factors, as well as financial markets situation. Since the Johansen cointegration

equation shows no long-term relationship between crude oil and gold prices in the examined period of time, the author conducts Granger causality test and develops a vector autoregresive model (VAR) to show the short-term dependence between crude oil prices and gold prices.

The advantage of the paper is that examined and control variables which were used in the study let conclusions be valid both for European and American investors. There are many studies which apply WTI crude oil to check the relations between gold and oil. This study is different for several reasons. The author uses the American index of 500 biggest companies and Europe Brent crude oil, as well as EURUSD currency rate. Such a choice of variables lets link the European and American markets together making conclusions to be applied to a wide variety of market participants. Besides, using daily data which is not always possible because of their unavaibility lets capture even small fluctuations in the analyzed markets. What's more, the chosen period of time 2005 – 2020 covers both the American crisis and the Covid-19 crisis, as well as other cycles of the global economy. It lets make overall conclusions independent on the economic cycle.

This problem is very important both for policymakers, traders, authorities, producers and investors. Gold is a safe asset which means that during the crises investors buy it and increase its prices. If gold influences crude oil prices, it means that during such a time crude oil prices are increased because of investors buying the safe asset and it results in the price increase of costs of transport and rises prices in the economy, which makes the situation of participants of the economic process worse and deepens the crisis. Besides, the knowledge of relations between gold and oil prices can help authorities monitor commodities markets.

2. LITERATURE REVIEW

There exist many studies on the relationship of gold and crude oil prices, however their conclusions depend on methods applied, control variables chosen for the study, the research period, data frequency or the market examined. The cause for contradictory results may lie in different reactions of investors in different time of the economic reality which is shown by Sheikh et al. (2020). Conclusions on the relationship between gold and oil which are present in the literature can be generally divided into the following groups:

- There is a long term relationship between gold and oil
- There is a short-term relationship between gold and oil
- There is both a long term and a short term relationship between gold and oil or authors do not concentrate on the length of the relation period.

In each of the above defined groups, there are papers where the causality goes from gold to oil, from oil to gold or both. Thus, it is undoubtful that there exists a relationship between gold and oil prices, however there is no unity concerning both the time and the direction of this dependence.

In the first mentioned group, there is a paper prepared by Simakova (2011) who uses monthly data for the period 1970 – 2010, confirms a high correlation of gold and crude oil returns and constructs the vecor error correction model (VEC). The study shows that there is a long term relationship between oil prices and gold. Gold and oil prices relations together with the stock market reflected by S&P index are investigated in Gokmenoglua and Fazlollahi (2015). Authors use the ARDL model with the error correction applied on daily observations for the period from January 2013 to November 2014, report moderate positive correlation between gold and oil prices and find out that there is a long term equilibrium between all these assets. Stoklasova (2018) proves that in the long term gold influences crude oil prices, however the relation does not work in the opposite direction. The author uses monthly data between April 1983 and December 2016. Narayan et al. (2010) confirmed a long-run relationship between gold and oil prices and any of these markets can be used to predict the behavior of another.

In the second group, it is worth mentioning the research conducted by Eryigit (2017) who constructs the VECM model which shows that there is no long-term relationship between gold and crude oil, however there is a short-term one. The research is conducted for different precious metals (gold, silver, platinum, palladium), crude oil and gas with the use of monthly data from July 1990 to February 2014. Le and Chang (2012/2013) conclude that there is no long-term relationship between gold and oil prices, but only a short term one. They apply the monthly data not only for gold and crude oil, but also for American dolar index, LIBOR, world industrial production, world commodity price index, as well as MSCI global equity index between May 1994 and April 2011 and a multivariate VAR model. Wang and Chueh (2013) analyze relations between gold prices, crude oil prices, interest rate and American dolar. They summarize that gold and crude oil prices influence each other positively in both directions in the short period of time. Galyfianakis et al. (2017) makes a vector auto regresive model with such variables as oil, gold, silver, US industrial production,, EURUSD currency rate, as well as a 3-month interest rate and finds a short term relationship between crude oil and gold. Wang et al. (2010) analyze dependencies among such variables as gold, crude oil, currency rates, and stock prices for such countries as United States, Chaina, Taiwam, Japan and Germany and conclude that there is no stable long-term relationship between gold and crude oil prices, however short-term relations occur in Taiwan.

Bildiricia and Türkmenb (2015) confirm both short term and long-term relationship between crude oil and precious metals (also gold). They use monthly prices from January 1973 to November 2013 and construct nonlinear ARDL model and causality tests. Arfaoui and Rejeb (2015) examine relations between gold, crude oil, stock market and American dollar and suggest that gold rate is influenced by crude oil and other factors. Zhang and Wei (2010) check the equillibrium between the gold and crude oil market using the data from the beginning of January 2000 to the end of March 2008. They conclude that there is a positive correalation between these two assets and that crude oil price influences the gold price volatility, however that this relationship does not work in a reverse direction. Reboredo (2013) and Toramana et al. (2011) stress the positive correlation between gold and crude oil. Yıldırım et al. (2020) document effects going from oil to gold markets.

All in all, it is undisputable that gold and crude prices are correlated, although there is no unity on the direction of the impact. There are also different results concerning the time span in which these assets influence each other. If one considers the strategic role of gold and crude oil in the economy, it creates the need of further research in this field.

3. METHODOLOGY AND MAIN STATISTICS FOR EXAMINED VARIABLES

The author uses daily rates of return for gold and Europe Brent crude oil prices. The following control variables were taken to build a model: quotations of the Standard and Poor's 500 index (SP500) and EURUSD currency rate. Time period is from January 2005 to December 2020.

Gold is quoted in American dollars per ounce and prices are indexed since 1999. EURUSD currency rates are FX close prices. Standard and Poor's 500 are close prices. Brent crude oil is quoted in American dollars per barrel. EURUSD and SP500 come from the database: www.stooq.com. Data concerning gold prices come from the World Gold Council. The source of the data on crude oil prices is Thomson Reuters (download from: www.eia.gov). The data were ordered and synchronized by adding the data for missing days under the assumption that if there was no quotation on the given day, the missing day is filled in by the value from the previous day. In most cases, missing days were days when for example there are public holidays in the United States and there are no stock quotations and at the same day the FX market is open and gold quotations are presented.

Table 1 summarizes the most important statistical features of variables. Standard deviations show that crude oil is the most volatile asset of all. It is more than twice as much volatile as gold. The least volatile is EURUSD currency rate whereas SP500 is only a little more volatile than gold and more than twice less volatile than crude oil. Kurtosis for crude oil is much higher than for gold, so it is associated with higher risk than gold not only measured with standard deviation, but also with the fourth central moment of the distribution. Nevertheless, both gold and crude oil have high kurtosis and negative skewness which can be interpreted as high risk.

Table 1: Summary statistics for logarithmic daily returns

Crude Oil				
	Percentiles	**Smallest**	**Mean**	**0.0000455**
5%	–0.035797	–0.2563894	Standard deviation	0.0269719
50%	0	Largest	Variance	0.0007275
95%	0.0337062	0.3016126	Skewness	–2.52275
99%	0.0649383	0.4120225	Kurtosis	106.2913
Gold				
	Percentiles	**Smallest**	**Mean**	**0.0003462**
5%	–0.0175706	–0.0797019	Standard deviation	0.0112626
50%	0.000061	Largest	Variance	0.0001268
95%	0.0175857	0.0601371	Skewness	–0.3736183
99%	0.0305836	0.0684235	Kurtosis	8.499098
EURUSD				
	Percentiles	**Smallest**	**Mean**	**–0.000026**
5%	–0.0091655	–0.0267329	Standard deviation	0.0058172
50%	0.0000754	Largest	Variance	0.0000338
95%	0.0093078	0.0319846	Skewness	0.05828
99%	0.0153686	0.0341572	Kurtosis	5.469529
SP500				
	Percentiles	**Smallest**	**Mean**	**0.0002682**
5%	–0.0182622	–0.0999449	Standard deviation	0.0122825
50%	0.0004159	Largest	Variance	0.0001509
95%	0.0162332	0.1024573	Skewness	–0.5696868
99%	0.0337102	0.109572	Kurtosis	17.64599

As data depicted in Table 2 show, there exists statistically significant week correlation between rates of return on gold and crude oil, gold and EURUSD, crude oil and EURUSD, crude oil and SP500, as well as EURUSD and SP500. There is no statistically significant correlation between rates of return on gold and SP500.

Although rather weak, however positive and significant correlation coefficient (0.1596) between crude oil and gold prices encourages to dwell on the relationship between these two assets. Introductiory characteristics of these assets let conlcude that their skewness and kurtosis are far away from the normal distribution which makes their risk more difficult to monitor and knowledge on their interrelations may help to do it.

4. RESULTS AND DISCUSSION

4.1. Test of the Unit Root

Tests of the unit root for each of the data were conducted with the use of augmented Dickey-Fuller test (Dickey and Fuller, 1979; Harris, 1992). The null hypothesis which is tested says that the data is non-stationary. Results are depicted in Table 3. All variable are stationary in I(0) without any doubts. Next they are transformed to first logarithmic differences to check their stationarity. For all first differenced variables the null hypothesis should be rejected (Table 4) which means that they are stationary in I(1).

Thus, considering the above presented results of the introductory analysis, there are indications to conduct the Johansen cointegration test to check for long-term relations between examined variables.

Table 2: Correlation table for logarithmic rates of returns

	Crude oil	**Gold**	**EURUSD**	**SP500**
Crude oil	1	0.1596 (P=0.0000)	0.1178 (P=0.0000)	0.2435 (P=0.0000)
Gold	0.1596 (P=0.0000)	1	0.2455 (P=0.0000)	0.0209 (P=0.1781)
EURUSD	0.1178 (P=0.0000)	0.2455 (P=0.0000)	1	0.2200 (P=0.0000)
SP500	0.2435 (P=0.0000)	0.0209 (P=0.1781)	0.2200 (P=0.0000)	1

Table 3: Results of unit root tests for variables in I(0)

Variable	**ADF test statistics**	**5% critical value**	**P-value**	**Stationarity**
Crude Oil	–1.926	–2.860	0.3201	Non-stationary
Gold	–1.329	–2.860	0.6160	Non-stationary
EURUSD	–1.961	–2.860	0.3041	Non-stationary
SP500	0.567	–2.860	0.9868	Non-stationary

Table 4: Results of unit root tests for variables in I(1)

Variable	ADF test statistics	5% critical value	P-value	Stationarity
DiffCrude Oil	–65.574	–2.860	0.0000	Stationary
DiffGold	–64.559	–2.860	0.0000	Stationary
DiffEURUSD	–64.853	–2.860	0.0000	Stationary
DiffSP500	–74.417	–2.860	0.0000	Stationary

4.2. Johansen Cointegration Test

In order to test a long term relationship between crude oil and gold prices the author uses Johansen cointegration test. It can be conducted when all variables are non-stationary at I(0) and stationary in I(1) (Johansen, 1988), which is fulfilled for all examined variables. It is widely used in the scientific literature for checking long term relations (Hjalmarsson and Osterholm, 2007; Wang and Wu, 2013; Naser, 2017; Naidu et al., 2017).

Johansen cointegration test is done with the use of two statistics to make it more reliable. These are trace statistics and max statistics. The null hypothesis is that there is no cointegration. The alternative hypothesis for rank zero says that there are zero cointegration equations. The alternative hypothesis for rank 1 says that there is one cointegration equation. The alternative hypothesis for rank 2 or more says that there are two or more cointegration equations. Results of Johansen cointegration test are depicted in Table 5. Trace statistics and max eigenvalue statistics indicate that for zero cointegration equations the null hypothesis should be accepted. Thus, there is no cointegration between crude oil and gold prices. Such results suggest that we cannot confirm long term relationships between examined variables. It means that the proper model to examine the existence of short term relations among variables is unrestricted vector autoregression model (VAR).

4.3. Selection of the Optimum Number of Lags

The optimum number of lags for each asset was selected according to Akaike's Information Criterion – AIC (Akaike, 1974). The following numbers of lags were indicated: crude oil – 2 lags, gold – 1 lag, EURUSD – 1 lag, SP500 – 4 lags.

4.4. Unrestricted Vector Autoregression VAR Model

In order to build an Unrestricted Vector Autregression VAR model, it is necessarry that variables are instationary at level and stationary at first order with no cointegration. These conditions are fulfilled, so VAR model will be a good model to examine relations between crude oil and gold. The optimum number of lags shown by Aike's Information Criterion for crude oil is 2 and for gold is 1. So, for VAR model to assure its utility a higher number is taken. VAR model which is assessed in the paper is:

$$\text{CRUDEOIL} = \alpha_0 + \alpha_1 \text{CRUDEOIL (L1)} + \alpha_2 \text{CRUDEOIL (L2)} + \alpha_3 \text{GOLD (L1)} + \alpha_4 \text{GOLD (L2)} + \alpha_5 \text{EURUSD (L1)} + \alpha_6 \text{EURUSD (L2)} + \alpha_7 \text{ SP500 (L1)} + \alpha_8 \text{ SP500 (L2)} + \xi_{1t} \quad (1)$$

$$\text{GOLD} = \alpha_9 + \alpha_{10} \text{CRUDEOIL (L1)} + \alpha_{11} \text{CRUDEOIL (L2)} + \alpha_{12} \text{GOLD (L1)} + \alpha_{13} \text{GOLD (L2)} + \alpha_{14} \text{EURUSD (L1)} + \alpha_{15} \text{EURUSD (L2)} + \alpha_{16} \text{SP500 (L1)} + \alpha_{17} \text{SP500 (L2)} + \xi_{2t} \quad (2)$$

Table 5: Results of Johansen cointegration test

Rank	Eigenvalue	Trace statistics	5% critical value for trace statistics	Max statistics	5% critical value for max statistics
0	-	67.9615	68.52	33.1518	33.46
1	0.00794	34.8097	47.21	19.1638	27.07
2	0.00459	15.6459	29.68	10.9903	20.97
3	0.00264	4.6557	15.41	4.3511	14.07
4	0.00105	0.3046	3.76	0.3046	3.76

$$\text{EURUSD} = \alpha_{18} + \alpha_{19} \text{CRUDEOIL (L1)} + \alpha_{20} \text{CRUDEOIL (L2)} + \alpha_{21} \text{GOLD (L1)} + \alpha_{22} \text{GOLD (L2)} + \alpha_{23} \text{EURUSD (L1)} + \alpha_{24} \text{EURUSD (L2)} + \alpha_{25} \text{ SP500 (L1)} + \alpha_{26} \text{SP500 (L2)} + \xi_{3t} \quad (3)$$

$$\text{SP500} = \alpha_{27} + \alpha_{28} \text{CRUDEOIL (L1)} + \alpha_{29} \text{CRUDEOIL (L2)} + \alpha_{30} \text{GOLD (L1)} + \alpha_{31} \text{GOLD (L2)} + \alpha_{32} \text{EURUSD (L1)} + \alpha_{33} \text{EURUSD (L2)} + \alpha_{34} \text{SP500 (L1)} + \alpha_{35} \text{SP500 (L2)} + \xi_{4t} \quad (4)$$

where:
α_0, α_1 … α_{35} – model structural parameters
ξ_{1t}…ξ_{4t} – random errors

Parameters of VAR model are depicted in Table 6.

The VAR model shows that gold significantly influences crude oil in L2. The relation between these two variables is positive. However crude does not influence gold in any of lags. Further conclusions will be drawn from Granger causality test showing the direction of relations.

4.5. VAR Diagnostics and Granger Causality Test

A widely accepted method of checking the direction of the dependence between variables often applied in the scientific literature is Granger causalilty test (Granger, 1969). It means that the present value of some variable is determined by past values of some other variables. It is applied here to determine mutual two-way interactions between crude oil and gold prices.

So, in short, Granger causality test requires sationary variables, so all variables were transformed into logarithmic first differences and used in such a form. The test confirms that there is a short run relationship going from gold to crude oil and there is no relationship in the opposite direction. The null hypothesis which is tested is that independent variable does not cause dependent variable. The alternative hypothesis is that independent variable causes dependent variable. Apart from that, Granger causality suggests causality going from gold and crude oil markets to the stock market, from stock market to crude oil, from currency market to gold market, from gold to currency market and vice versa. Although these relations are not a subject of this study, it should be amphasized that they are worth further analysis. Details are shown in Table 7.

Granger causality test proves with P = 0.002 that gold prices influence crude oil prices in the short run. There is no dependence going in the opposite direction (P = 0.556). Granger test confirms that the constructed unrestricted VAR model is well suited.

Table 6: VAR model results

Variable and its lags	Coefficient	Standard error	z	P>|z|
Dependent variable: Crude oil				
Crude oil L1	–0.0379787	0.016196	–2.34	0.019
Crude oil L2	–0.0590858	0.0161219	–3.66	0.000
Gold L1	0.022516	0.0391152	0.58	0.565
Gold L2	0.1362481	0.0386466	3.53	0.000
EURUSD L1	0.0642059	0.0759442	0.85	0.398
EURUSD L2	–0.0904803	0.0767991	–1.18	0.239
SP500 L1	0.1546812	0.0362717	4.26	0.000
SP500 L2	0.0223796	0.0363066	0.62	0.538
Constant	–0.0000585	0.0004167	–0.14	0.888
Dependent variable: Gold				
Crude oil L1	0.0072566	0.0067057	1.08	0.279
Crude oil L2	–0.0001557	0.006675	–0.02	0.981
Gold L1	–0.0453256	0.016195	–2.80	0.005
Gold L2	–0.0103876	0.0160009	–0.65	0.516
EURUSD L1	0.3171513	0.0314433	10.09	0.000
EURUSD L2	0.0112343	0.0317973	0.35	0.724
SP500 L1	0.0096296	0.0150177	0.64	0.521
SP500 L2	0.0093415	0.0150321	0.62	0.534
Constant	0.0003733	0.0001725	2.16	0.031
Dependent variable: EURUSD				
Crude oil L1	0.0010194	0.003504	0.29	0.771
Crude oil L2	0.0063874	0.003488	1.83	0.067
Gold L1	0.0173857	0.0084626	2.05	0.040
Gold L2	0.0128275	0.0083612	1.53	0.125
EURUSD L1	–0.018015	0.0164305	–1.10	0.273
EURUSD L2	–0.0136351	0.0166155	–0.82	0.412
SP500 L1	0.0084408	0.0078474	1.08	0.282
SP500 L2	–0.0105768	0.0078549	–1.35	0.178
Constant	–0.0000337	0.0000902	–0.37	0.708
Dependent variable: SP500				
Crude oil L1	0.0016783	0.007303	0.23	0.818
Crude oil L2	0.0243542	0.0072696	3.35	0.001
Gold L1	–0.0375034	0.0176377	–2.13	0.033
Gold L2	0.0695637	0.0174263	3.99	0.000
EURUSD L1	0.0821905	0.0342444	2.40	0.016
EURUSD L2	–0.006984	0.0346299	–0.20	0.840
SP500 L1	–0.1497507	0.0163555	–9.16	0.000
SP500 L2	–0.0184131	0.0163712	–1.12	0.261
Constant	0.0003074	0.0001879	1.64	0.102

Table 7: Granger causality Wald test results

Equation	Excluded	Chi^2	df	Prob>Chi^2
Crude Oil	Gold	12.575	2	0.002
	EURUSD	2.2431	2	0.326
	SP500	18.199	2	0.000
	All	33.549	6	0.000
Gold	Crude oil	1.1754	2	0.556
	EURUSD	101.83	2	0.000
	SP500	.68128	2	0.711
	All	115.21	6	0.000
EURUSD	Crude oil	3.4018	2	0.183
	Gold	6.2452	2	0.044
	SP500	3.5676	2	0.168
	All	13.445	6	0.036
SP500	Crude oil	11.233	2	0.004
	Gold	21.46	2	0.000
	EURUSD	5.8901	2	0.053
	All	42.1	6	0.000

Another important step of the model diagnostics is to check the autocorrelation of residuals. It is done with two tests that is with Ljung-Box (improved Portmaneau) statistics (Ljung and Box, 1978) and Lagrange multiplier test. Table 8 summarizes the results.

Table 8: Unrestricted VAR model diagnostics

Portmanteau statistics	0.0313
Prob>ch2	0.9845
AIC criterion	–24.20816
Chi^2, L1	20.3803
Prob>ch2, L1	0.20358
Chi^2, L2	19.1594
Prob>ch2, L2	0.26049
AC< L1	0.0021
PAC, L1	0.0021
Q, L1	0.01766
Prob>Q, L1	0.8943
AC< L2	0.0018
PAC, L2	0.0018
Q, L2	0.03127
Prob>Q, L2	0.9845

In both tests the tested null hypothesis is that there is no autocorrelation. The alternative hypothesis is that there is autocorrelation. Both tests show that there are no fundamentals to reject the null hypotheses. Correlogram was also run for autocorrelation (AC) and partial autocorrelation (PAC) showing the same conclusions. Thus it is confirmed that residuals are not autocorrelated which means that they are white noise which is required for the well fitted model.

5. CONCLUSION

Gold and crude oil play a special role on financial markets. Gold is a monetary asset, hedge asset and safe haven. Crude oil influences economic growth. The overall effect of this process depends also on mutual interrelations between these two assets, which is why the author decided to analyze them. Another stimuli for the study were contradictory conclusions on relations between gold and crude oil prices and their causality.

The research question is if crude oil prices depend on gold prices. If so, is it a long term relation or a short term relation and in which direction it works? The conducted research shows that gold prices influence crude oil prices in the short run, however the relations does not work in the opposite direction. Besides, the research shows that there are no relations between these assets in the long period of time. However, such fluctuations, even in the short run may be dangerous if the situation of rising gold prices lasts for a long period of time, which often happens during a crisis when investors shift their assets into safe haven. The study suggests that it would be desirable to look for other kinds of safe assets than gold to avoid deepening the crises more than necessary. The research has a wide influence as it gives implications for investors, traders, producers, authorities and policymakers. Knowing relations and the causality between crude oil and gold prices lets monitor their risk in a more efficient way, which should have a positive effect on the whole economy. Although the relation is only short term, if the crisis lasts for a long time, crude oil prices resulting from rising gold prices may last for a long time and deteriorate the economy in the long run. Another advantage of the study is that examined and control variables which were used here let conclusions be valid both for European and American investors. There are many studies which apply WTI crude oil to check the relations between

gold and oil. This study is different for several reasons. The author uses gold and Europe Brent crude oil prices, as well as control variables such as EURUSD currency rate and the American index of 500 biggest companies. Such a choice of variables lets link the European and American markets together making conclusions to be applied to a wide variety of market participants. Furthermore, the analyzed time period between 2005 and 2020 covers both the American crisis and the Covid-19 crisis, as well as other cycles of the global economy. It lets draw general conclusions independent on the economic cycle.

The research is consistent with for example such studies as Eryigit (2017), Le and Chang (2012/2013). Nevertheless, it gives new conclusions compared to studies by Simakova (2011), (Gokmenoglua and Fazlollahi, 2015), Stoklasova (2018), both concerning the time of dependencies between gold and crude oil as well as their direction. The research conduced by the author confirms some literature results and denies some other. Different conclusions in different studies may be caused by different study periods, methods, control variables or behavior of market participants in different economic conditions. Thus, further research could comprise the dynamic study on changes of gold and crude oil prices relations during different periods of time depending on gold or oil market trends.

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