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The main determinants of gold price in the international market

The aim of this paper is to identify the main factors which influence the gold price in the international market. According to the main hypothesis, the gold price is determined by the following factors: US$ to EUR exchange rate, log return on S&P 500, brent crude oil prices, yield to maturity of US 10-year Treasury bonds, and gold price history. Econometric methods have been applied and an econometric model has been built and estimated. An econometric analysis has confirmed our hypothesis.

Keywords: gold market, gold price, S&P 500 Index, bond's YTM, exchange rate

JEL classification: C58, F37, G15

Główne determinanty ceny złota na rynku międzynarodowym

Celem pracy jest identyfikacja głównych czynników wpływających na cenę złota na rynku międzynarodowym. Zgodnie ze sformułowaną w artykule hipotezą, głównymi determinantami ceny złota na rynku międzynarodowym są: kurs dolara wobec euro, logarytmiczna stopa zwrotu z indeksu S&P 500, cena ropy naftowej brent, rentowność dziesięcioletnich obligacji skarbowych rządu USA oraz cena złota z poprzedniego okresu. W pracy zastosowano metody ekonometryczne i zbudowano model ekonometryczny. Wyniki estymacji modelu potwierdziły sformułowaną w badaniach hipotezę.

Słowa kluczowe: rynek złota, cena złota, indeks S&P 500, rentowność obligacji skarbowych, kurs walutowy

Klasyfikacja JEL: C58, F37, G15

Introduction

The aim of the research whose results are presented in the following paper was to identify the main factors which in an economically and statistically significant way affect the price of gold in international markets. For the purpose of the research, we have adopted the following hypothesis: the main factors determining the price of gold in international markets include: the US$ against EUR exchange

rate, log return on S&P 500, changes in brent crude oil prices, changes in the yield-to-maturity of US 10-year Treasury bonds, and changes in the price of gold in the previous period. This hypothesis was developed on the basis of conclusions drawn from the economic and financial theory as well as on the basis of a critical analysis of literature on the topic.

In order to verify the above-mentioned hypothesis, we used a statistical and an econometric analysis. An econometric model was developed and tested to obtain the best possible goodness-of-fit.

1. Investment gold (bullion gold), gold market, gold price

1.1. Physical gold as an investment instrument

Investment gold appears in two forms:

- in the form of gold bullion bars of different weight (the basic measure unit here is a troy ounce or *oz t* = 31.1034768 grams and 999.9 hallmark),
- in the form of coins.

In the latter case, it is worth remembering that gold coins also take one of two forms – collector coins or coins produced in a series. The value of the former ones depends on the price of gold and their numismatic value, which is mainly determined by time and non-material factors. In the latter case, the price of gold plays the main role; the role of time is smaller than in the case of collector coins. Usually, one troy ounce contained in coins is of a higher value than in bars.

Since in this paper we are interested in the price of physical gold, we are not going to deal with other forms of indirect investment in gold, such as a purchase of shares in stock-companies, mining companies, processing gold, investment funds investing in gold, futures, or options transactions.

1.2. Gold markets around the world

The global gold market operates 24 hours per day. The so-called over-the-counter trading (OTC) functions during this time in New York, London, Zurich, Hong Kong and Sydney. These cities are the main centres of gold trading. However, it must be borne in mind that there are ca. 40 gold markets worldwide. Apart from the OTC markets, there are also regulated markets. The OTC market is the one in which spot transactions as well as forward and 'paper' transactions of the futures and options type for which investment gold is the base instrument are concluded.

One of the oldest gold markets is the London Gold Fix, where the price of gold is determined twice a day (at 10:30 a.m. and 03:00 p.m.) by the members of the

London Bullion Market Association (LBMA). The following banks are the LBMA members: HSBC, Barclays Capital, Scotia Bank, Deutsche Bank, and Société Générale. The chairperson of the fixing team chooses the opening price based on the dominating market price and announces it to potential clients through the LBMA member banks. During the price fixing process all customer orders are compensated and each customer is in touch with the LBMA members trading on the floor during the process and he can modify or withdraw his purchase or sale orders in the real time. The price determined at the London Gold Fix is the reference price for many financial products, for which gold is the base instrument (e.g. ETF, structured products, derivatives), and for the needs of estimates of the central bank reserves and investment portfolios of institutional investors. From the two prices set during the fixing process, the afternoon one is more widely used [GoldCore, 2013].

One of the most important places where gold is traded is New York where futures transactions are concluded at the commodity exchange – COMEX. We can say that at the beginning of the 21st century the markets in New York and London became competitive as far as their influence on global investment gold prices is concerned. One of the crucial changes in functioning of trade organized by COMEX was a gradual departure from the traditional outcry trading technique in favour of electronic trade by means of a digital platform GLOBEX [Hauptfleisch, Lucey, 2016].

The gold market in Zurich is the European centre of gold refining and the biggest global distributor in the field of physical gold turnover which serves, e.g., gold supplies from South Africa or mediates in trade between London and Asia. Owing to its highly specialized offer and high level of confidentiality, Zurich is the biggest vault of the privately owned gold. This market is not as formalized as the one in London. Three largest Swiss banks are involved in trading in Zurich – UBS, Credit Suisse, and Union Bank of Switzerland – which, on the basis of informal agreements, make up the 'Zurich Gold Pool'. No price fixing is used in this market. The price of gold fluctuates freely over the entire day (from 07:00 a.m. to 04:00 p.m. London Time) [GoldCore, 2013].

The history of the Hong Kong market is more than 90 years long. We can distinguish three segments of this market: traditional market of physical gold (Chinese Gold and Silver Society), the segment in which London and Zurich dealers operate, and the futures exchange (until 2013 Hong Kong Mercantile Exchange). In this way, this is the only market where both the physical gold (on the Exchange and OTC) and futures contracts are traded. In view of the time difference the Hong Kong market enables trading even when in America it does not take place anymore and in London it has not started yet (from 01:00 to 04:30 and from 06:30 to 09:00 London Time). Hence, European gold prices are based on Hong Kong quotes.

Other markets which are worth mentioning here include: Singapore, Shanghai, Dubai, Rio de Janeiro, Bombay (Mumbai), and Tokyo. The market in Sydney is of particular importance due to its geographical location which allows gold trading between the end of transactions in American markets and the opening of transactions in Hong Kong.

In recent years, Moscow is becoming an increasingly important gold market. Owing to its gold resources, Russia has always been an important player in the gold market [GoldCore, 2013].

1.3. Factors determining gold price

As in the case of each price, we should distinguish here short- and long-term factors. Among the short-term factors we can mention: price fluctuations in the market of raw-materials (mainly oil), speculative behaviours of investors, including arbitrageurs (particularly those taking advantage of price differences in Asiatic and European markets, and American ones), speculation, psychological factors (including 'herd' behaviour of investors, which does not always reflect economic rationality), short-term exchange rate fluctuations, information on changed ratings for governments announced by rating agencies, short-term changes in inflation rate, short-term changes in yield-to-maturity stock-exchange indexes, and current information concerning political changes and events (armed conflicts, social unrest, etc.).

In the long run, the price of gold is affected by long-term changes in economic cycle, long-term inflation expectations, long-term trends in yield-to-maturity stock-exchange indexes, yield-to-maturity of US long-term Treasury bonds (they are synonymous with proxy of free risk investment, alternative to gold), forecasts and expectations regarding economic growth in the US economy, OECD economies, China and India, expectations related to exchange rates, and forecasts dealing with the long-term worldwide development of the economic cycle. It is worth remembering that according to Fama's efficient-market hypothesis, investors make their decisions on the basis of commonly available information. Thus, each publicized and disseminated long-term forecast, irrespective of rationality of its assumptions, will be such a basis.

A major influence on the physical gold prices is exerted by prices in futures contracts. The prices in futures contracts are higher than the spot prices as they take a risk premium into account. Changes in gold supply created by major global producers (here named according to their mining outputs: China, Australia, US, Russia, South Africa, Peru, Canada, Indonesia, Uzbekistan, and Ghana) affect gold prices both in the short- and long-term. It must also be considered that supply and demand as well as prices of competitive metals, such as silver, platinum, and palladium also have an impact on gold prices.

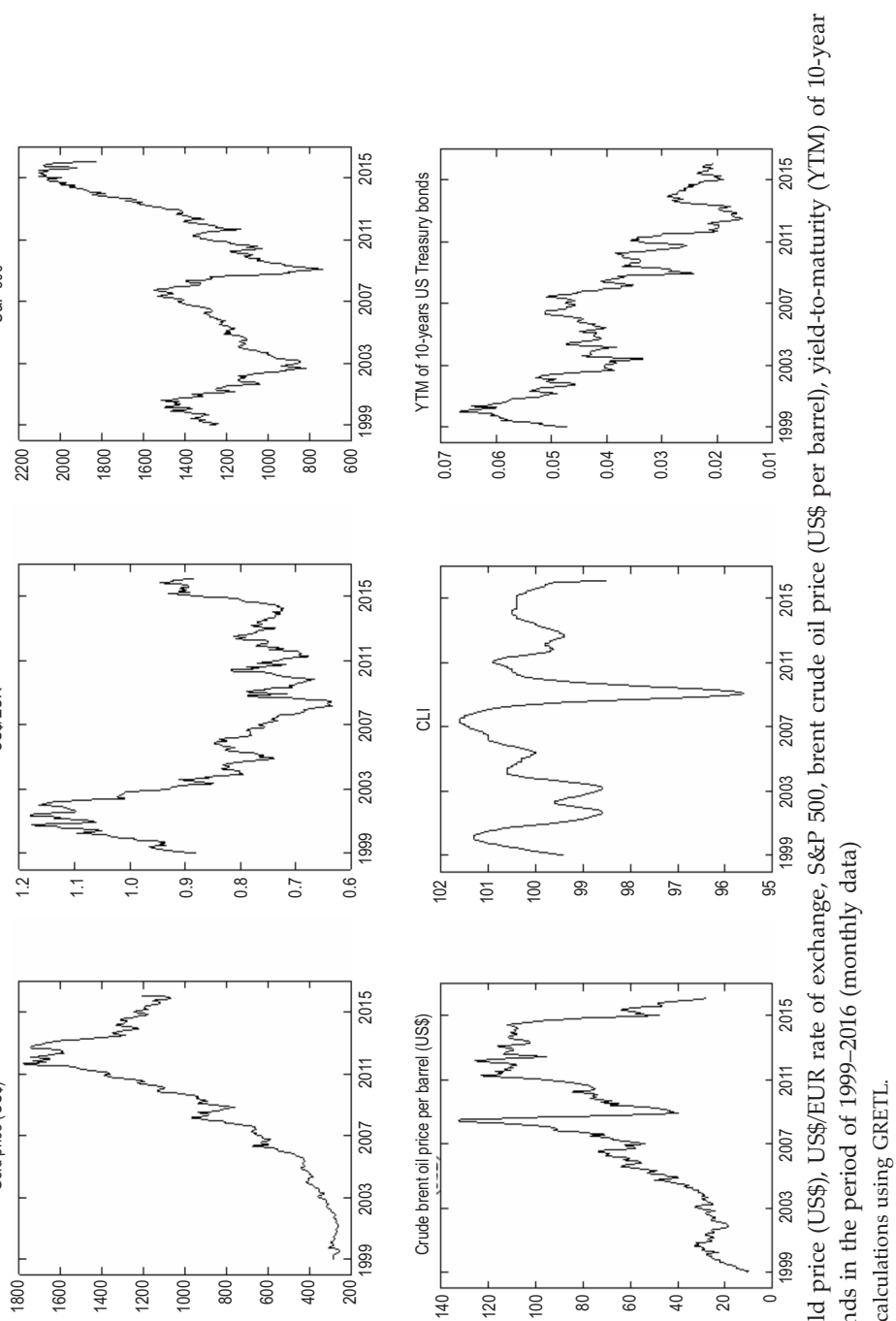

Figure 1. Gold price (US$), US$/EUR rate of exchange, S&P 500, brent crude oil price (US$ per barrel), yield-to-maturity (YTM) of 10-year Treasury bonds in the period of 1999–2016 (monthly data)

Source: Own calculations using GRETL.

Figure 1 shows gold prices, US$/EUR exchange rate, S&P 500, brent crude oil price, composite leading indicator (CLI) and yield-to-maturity of US 10-year Treasury bonds (monthly data; see: Section 3 of this paper). As the Figure indicates, there is a negative relationship between gold prices and the US$/EUR exchange rate, S&P 500 index and yield-to-maturity US 10-year Treasury bonds; the relationship between gold prices and CLI is unidentified, whereas the relationship between gold prices and brent crude oil prices is positive. Obviously, all these must be analysed in view of time series cointegration and a more accurate relationship between these quantities must be defined. To do this, an econometric analysis is going to be used in the next part of this paper.

2. Literature review

There is no such thing as a theory explaining the development of gold prices in international markets. However, there is a number of scientific papers which include results of more or less detailed research based on statistical and econometric methods. In our research, we take into account major factors determining gold price from the point of view of different assumptions and research objectives.

Aggarval, Lucey, and O'Connor [2014] point to irrational behaviours of investors who invest in gold for long periods of time. They are directed by excessive optimism as well as long periods of excessive pessimism which translate into demand for gold and its price at a given supply. Ciner, Gurdgiew, and Lucey [2013] draw attention to a specific characteristic of gold as a financial asset and to significant economic and statistical relationships between gold price on the one hand, and crude oil price and exchange rates on the other. Lucey, Larkin, and O'Connor [2013] indicate a considerable impact of geopolitical changes on financial risk and gold prices. The increased risk leads to a higher demand for gold in the markets and its higher price. Lucey and Li [2014] mention a considerable effect of the markets of other precious metals, such as silver, platinum, and palladium, on gold price.

Research results also reveal that the tendencies in the Chinese gold market in Shanghai do not affect gold prices in the global markets. This is caused by the isolation of this market – for institutional reasons – from other global markets [Lucey, Larkin, O'Connor, 2014]. An analogical situation was proved for the stock (equity) markets by Bukowski [2012], who showed that stock markets in China are little integrated with stock markets in the US and Japan.

Ghosh, Levi, Macmillan, and Wright [2004] showed that there is a significant economic and statistical relationship between inflation and gold price. Increased inflation entails increased gold price which results from a lower real interest rate

and a lesser attractiveness of an alternative to a safe gold investment. However, it is worth mentioning here that lower real interest rates do not have to mean lower real return on stock indices. On the contrary, they may cause, *ceteris paribus*, an increase in the share prices on the stock market. The attractiveness of an investment in shares will decrease the impulse towards higher gold prices. On the other hand, the degree of investors' aversion towards risk must also be taken into account here. Investors treat gold as a safe long-term instrument, whereas shares are considered to be a risky instrument.

An interesting study concerning price oil has been presented by Kiohos and Sariandis. They examined the role of financial factors in the gold market using GJR-GARCH model. Those financial factors were: daily continuously compounded returns for CL Crude Oil Light Sweet Index, S&P 500 Stock Index, 10-Year US Treasury bond, and US$/JPY exchange rate. In the study, daily data for the period from January 1999 to August 2009 was used. As a price of gold, the authors used the daily price of contract GC Gold 100 troy Oz. COMEX. The results of their estimation indicated that crude oil reflects a positive transmission effect of the energy market on the gold market, while S&P 500, 10-year US Treasury bonds, and US$/JPY exchange rate negatively influence the gold market. The authors emphasized that '10-Years Treasury bonds influence negatively the gold market because gold is a hedge against economic or political turmoil, but also because it offers alternative approaches in portfolio management'.

3. Data

Monthly statistical data for the period from January 1999 to February 2016 were used in our work and model. The data concerning particular variables were taken from the following sources:

- gold prices (monthly average) from the London Bullion Association database,
- US$/EUR exchange rates from the stooq.pl database,
- brent crude oil prices (monthly average spot prices) from the US Energy Administration Agency database,
- YTM of US (10-year) Treasury bonds from the Federal Reserve Statistical Releases database,
- S&P 500 index from the stooq.pl database,
- data regarding CLI indices from the OECD Statistics database.

4. The Model

An econometric model has been constructed which describes relationships between the US$/EUR exchange rate, S&P 500 index, brent crude oil price, YTM of US long-term Treasury bonds, and gold price lagged by one period. The model looks as follows:

$$\Delta \ln GOLD_t = \alpha_t + \beta_t \Delta \ln USDEUR_t + \phi_t \Delta \ln SP_t + \\ + \gamma_t \Delta \ln O_t + \lambda_t \Delta \ln Iu_t + \rho_t \Delta \ln GOLD_{t-1} + \varepsilon_t \quad [1]$$

The following symbols were adopted for the model:

$GOLD_t$ – gold price,
$USDEUR_t$ – US$ exchange rate expressed in EUR,
SP_t – S&P 500 index,
O_t – brent crude oil price,
Iu_t – yield-to-maturity of US long-term Treasury bonds,
ln – log differences of variables,
Δ – first differences of variables.

The independent variables were chosen on the basis of the correlation matrix. We chose only these independent variables which were most correlated with gold price (see: Tables 1 and 2). As we found out that time series were non-stationary, we used log differences of variables, whereas in the case of yield-to-maturity of US long-term Treasury bonds we applied first differences of variables.

The model was estimated with the use of GARCH (0.1) method. It means that in fact the Arch(1) model was used. Attempts at using a standard GARCH (1.1) method were successful, however, in view of the Akaike criterion and the log likelihood criterion, the model based on ARCH(1) estimate turned out to fit better.

As Table 1 contents indicate, the lowest degree of correlation with price gold occurs in the case of the CLI variable. Consequently, this variable was eliminated in the specification of the model equations. Table 2 shows correlation of variables in the form of log differences, except for yield-to-maturity of US long-term Treasury bonds which is in the form of first differences. Here the signs correspond to the theory, and the degree of correlation between independent variables and gold price is acceptable.

Moreover, an analysis proved that the series of variables are non-stationary and only the application of logarithmic increments (log return) as well as first differences in the case of YTM of US long-term Treasury bonds allowed to eliminate the unit root and obtain co-integration of time series (see: Table 3b). The application of a variable of gold price changes lagged by one period makes sense from the point of view of the so-called market memory, which is typical of financial markets.

Table 1. Correlation coefficients (observation period from January 1999 to February 2016)

GOLD	US$EUR	SP	CLI	Iu	–
1.0000	-0.6173	0.4165	-0.0161	-0.8711	GOLD
–	1.0000	-0.0821	-0.1014	0.5294	US$EUR
–	–	1.0000	0.4460	-0.3594	SP
–	–	–	1.0000	0.2614	CLI
–	–	–	–	1.0000	Iu

* 5% critical value (two-tailed) = 0.1367 for n = 206

Source: Own calculations using GRETL.

Table 2. Correlation coefficients (observation period from February 1999 to February 2016)

ld_GOLD	ld_US$EUR	ld_SP	ld_O	d_Iu	–
1.0000	-0.2754	-0.1593	0.1455	-0.1869	ld_GOLD
–	1.0000	-0.2836	-0.1467	0.1099	ld_USDEUR
–	–	1.0000	0.1394	0.1975	ld_SP
–	–	–	1.0000	0.3139	ld_O
–	–	–	–	1.0000	d_Iu

* 5% critical value (two-tailed) = 0.1371 for n = 205

Log differences for variables except *Iu* – when applied first differences

Source: Own calculations using GRETL.

5. Model estimation results

Model estimation points to a statistically significant relationship between the applied independent variables and gold price. Time series of variables are co-integrated, and analysis of residual distribution indicates a relatively high goodness-of-fit to normal distribution (see: Table 3b and Figure 2). Signs at variable coefficients also correspond to the theory of economics and the results of empirical tests carried out by other authors.

Table 3a. Estimation GARCH (0.1) (observation period from March 1999 to February 2016)

	Coefficient	Std. Error	z	p-value	
const	0.00522989	0.00273048	1.9154	0.0554	*
ld_US$EUR	-0.397057	0.0910961	-4.3587	0.0001	***
ld_SP	-0.194225	0.0763131	-2.5451	0.0109	**
ld_O	0.0725465	0.0303266	2.3922	0.0167	**
d_Iu	-3.06873	1.34992	-2.2733	0.0230	**
ld_GOLD_1	0.144622	0.076156	1.8990	0.0576	*
alpha(0)	0.00118684	0.000223169	5.3181	0.0001	***

	Coefficient	Std. Error	z	p-value	
alpha(1)	0.0911852	0.0903624	1.0091	0.3129	
Mean dependent variable		0.007049	S.D. dependent variable		0.040325
Log-likelihood		389.1755	Akaike criterion		-760.3510
Schwarz criterion		-730.4879	Hannan-Quinn criterion		-748.2708

* Symbols ***, **, and * denote significance at 1%, 5%, and 10%, respectively
T = 204
Dependent variable: ld_GOLD
QML standard errors
Unconditional error variance = 0.00130592
Likelihood ratio test for (G)ARCH terms:
Chi-square(1) = 3.29336 [0.0695607]
Test for normality of residual – Null hypothesis: error is normally distributed
Test statistic: Chi-square(2) = 43.5688
with p-value = 3.46062e-010

Source: Own calculations using GRETL.

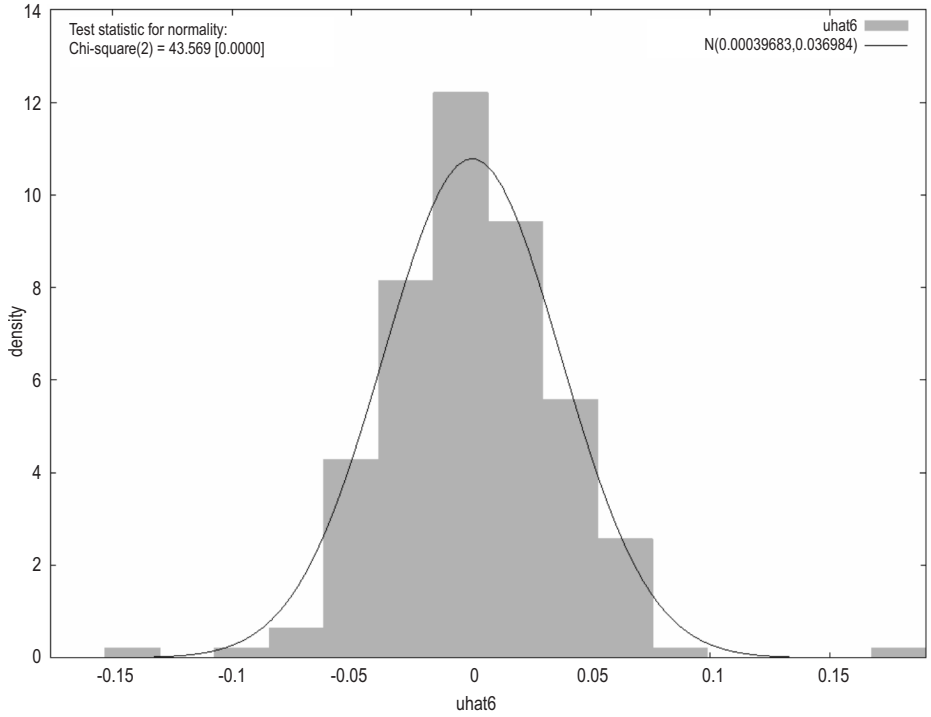

Figure 2. Test statistic for normality

Source: Own calculations using GRETL.

The model estimation results (see: Table 3a) show that the US$/EUR exchange rate and YTM of US Treasury bonds have the greatest impact on gold price change return. The impact of oil price on gold price is weaker.

Table 3b. Results of Engle-Granger cointegration test for variables: ld_GOLD, ld_US$EUR, ld_SP, ld_O, d_Iu

Testing for a unit root in uhat (test with constant and linear trend)
Augmented Dickey-Fuller test for uhat including 0 lags of (1-L)uhat (max was 1, criterion AIC) sample size 204
unit-root null hypothesis: a = 1
Model: (1-L)y = (a-1)*y(-1) + e
1st-order autocorrelation coefficient for e: 0.006, estimated value of (a-1): -0.928793
Test statistic: tau_ct(5) = -13.1482, p-value 4.694e-017, critical value = -3.99% at 1% significance level 1%, critical value = -3.43 at 5% significance level
The unit-root hypothesis is rejected for the residuals (uhat) from the cointegrating regression. Tested variables are cointegrated

Source: Own calculations using GRETL.

Conclusions

The analysis which was carried out with the use of econometric methods for this paper's purposes allows us to formulate the following conclusions confirming the hypothesis adopted at the beginning:

- there is a statistically significant negative relationship between gold prices and the changes in the US$/EUR exchange rate, in log return on the S&P 500 index, and in the YTM of US 10-year Treasury bonds,
- there is a statistically significant positive relationship between brent crude oil prices and gold price,
- there is a statistically significant relationship between gold price changes over period *t* and gold prices over period *t*-1,
- the impact strength of the factors that affect the gold price change rate can be ranked as follows: the rate of changes in the YTM of US 10-year Treasury bonds, the rate of changes in the US$/EUR exchange rate, gold price changes in the previous period, and the rate of changes in brent crude oil prices.

It must be emphasised that the results of our analysis confirmed the theory and the results of research of other authors presented in the literature review in this paper.

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