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THE MAIN GOLD PRICE DETERMINANTS AND THE FORECAST OF GOLD PRICE FUTURE TRENDS

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ABSTRACT. During the World War I, most of the countries stopped coin production and began converting paper money into gold. Various forms of exchange were later abolished during the "Great Depression" in 1929-1933. Later, gold lost the value of money in most of the economies worldwide. Multiple price rise of gold caused a real rise in the value of gold reserves and their potential ability to cover the balance of payment deficit. At the same time, it shows that gold still plays an important role in terms of monetary aspect. The aim of this study was to determine whether ARIMA models are suitable for determining the short-term volatility of gold prices. The calculations show that ARIMA model is suitable only for short-term gold price forecasts (max. 1 year). Thus, it is necessary to apply other models (multi-regression ones) that also can reveal the relationship between gold price and its determinants.

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Introduction

Over the last few decades, global finance markets have gone through a number of financial crises, the most devastating of which include Mexican peso crisis in 1994, Asian flu in 1997, Russian crisis in 1998, Brazilian crisis in 1999, Argentinian crisis in 2001-2002, the USA financial crisis in 2007 and Greek crisis in 2009. The periods of financial contagion have evidently raised the risk of securities (Vychytilova, 2018; Mačí & Valentová

Hovorková, 2017; Čulková et al., 2015; Vukovic et al., 2017) and returned the interest in gold as in alternative financial instrument since gold has historically been treated as a standard of high value. Of course, other alternative investments should be mentioned here too (Jurevičienė, & Jakanovytė, 2015; Nuhiu et al., 2017; Mouselli et al., 2016; Śliwiński & Łobza, 2017; Nawrocki, 2018). The series of the global financial crises has even augmented the belief that gold can provide investment protection and serve as a perfect risk management tool. As it was noted by (Baur, & McDermott, 2010; Ohanyan, & Androniceanu, 2017), the main difference between gold and other types of assets lies in gold's positive reaction to unwanted shocks at financial markets. Gold value reached its historical heights in the 1980s, when the global economies were facing the threat of stagflation brought about by the petroleum crisis of the 1970s. Similar trends were observed during the 2007 US sub-prime financial crisis which gathered its pace in September 2008, when gold price started soaring (Baur, McDermott, 2010).

Leaning on the assumption that gold can be treated as a store of value, investors need to know what role is played by gold while forming an investment portfolio, i.e., when gold is attributed to one of the assets categories. Considering the inclusion of gold in an investment portfolio is extremely important minding the fact that gold markets (like all other financial markets) are characterised by volatility and speculations.

A growing interest in gold as an investment has prompted conducting this research focused on gold investment, the links between gold and other financial instruments (e.g., securities) and the efficiency of gold as an instrument of financial risk management. Markowitz's (1952, 1959) studies laid the foundations for practical assessment of the benefits gained from an investment portfolio diversification and proved that combination of a few categories of assets may significantly reduce portfolio value fluctuations (Vukovic & Prosin, 2018). The importance of gold as of an investment was highlighted by (Jaffe, 1989; Michaud et al., 2006; Conover et al., 2009; Riley, 2010; Baur, 2013; Bradfield, & Munro, 2016) and many others. The specific role of gold in diversification of portfolio investment was analysed by (Sherman, 1982; Adrangi et al., 2000; Smith, 2002; Liu, & Chou, 2003; Davidson et al., 2003; Lucey, Tulley, 2006 a,b; Ibrahim, 2012; Makiel, 2015; Brycki, 2015; Bundrik, 2016; Yu, H.-C., Lee, C.-J. & Shih, T.-L., 2016; Giannarakis, G., Partalidou, X, Zafeiriou, & Sariannidis, N., 2016) and others. Nevertheless, different scientific studies often provide contradictory results concerning gold investment incentives and an optimal share of gold in an investment portfolio. This contradiction, in its turn, calls for more comprehensive research in this area. ***This article is aimed at*** empirical identification of the main gold price determinants and forecast of gold price future trends. The defined aim was detailed into the following **objectives**: 1) to review the recent gold demand trends; 2) to identify the theoretical gold investment incentives and optimal shares of gold in low-, medium- and high-risk investment portfolios; 3) to select and substantiate the methodology for this research; 4) modelling the autoregressive process, basing on time series observations for the previous years, to identify the main gold price determinants and forecast the gold price future trends.

The methods applied in the research include systematic and comparative analysis of scientific literature, ARMA/ARIMA models, which are flexible forecast models based on the employment of historical information. ARMA/ARIMA models are composed of the autoregressive (AR) process, moving average (MA) process and integration (I) process.

1. Review of the recent gold demand trends

Although in modern economies gold has stopped being used as a tool for daily settlements, its role in the global economy is still significant. The data in the balance sheets provided by central banks and other financial institutions, such as the IMF, show that the above-mentioned institutions accumulate gold reserves and generate nearly one-fifth of the global demand for gold (Balarie, 2017). According to Ghosh et al. (2004), the demand for gold is characterised by two structural components:

1) the need for the direct use of gold (for instance, gold is directly used for jewellery, medal minting, electronic industry, dentistry, etc.);

2) the need for gold as an asset (governments, fund managers, individual investors buy and hold gold as an investment).

The trends of the demand for gold for different purposes have been depicted in Table 1.

Table 1. The trends of the demand for gold in tones and million US dollars (with reference to the data for 2015)

Demand type	**The demand for gold, tonnes**				**The demand for gold, monetary value (mln. US dol.)**			
	2014/Q4	**2015/Q4**	**5-year average**	**Annual change**	**2014/Q4**	**2015/Q4**	**5-year average**	**Annual change**
Jewellery	677.4	671.4	585.0	-1%	26166.5	23885.4	26659.9	-9%
Technologies	90.3	84.5	93.3	-7%	3489.8	3004.8	4314.5	-14%
Investment	169.3	194.6	298.9	15%	6540.4	6922.6	14308.8	6%
Gold bullions and coins	260.9	263.5	328.8	1%	10075.9	9372.7	15343.6	-7%
ETFs and similar financial products	-91.5	-68.9	-29.8	-	-3535.5	-2450.0	-1034.8	-
The demand generated by central banks and other financial institutions	133.9	167.2	133.1	25%	5173.5	5948.7	6115.2	15%
Total demand	**1071.0**	**1117.7**	**1110.3**	**4%**	**41370.2**	**39761.5**	**51398.4**	**-4%**

Source: *compiled by the authors with reference to the data announced by the World Gold Council, 2016, p. 2.*

As it can be seen in Table 1, the total demand for gold in the fourth quarter of 2014 amounted to 1071 tonne (or 41370.2 mln. US dollars), while in the fourth quarter of 2015 it increased up to 1117.7 tonnes (or 39761.5 mln. US dollars; the lower monetary value shows that the price of gold decreased over the period under consideration). Jewellery industries generate the largest share of the total demand for gold; a smaller but also significant share of the total demand is generated by investors in gold bullions and coins. With reference to the data announced in the World Gold Council's report for 2016 (the World Gold Council, 2017), in comparison to 2015, in 2016 a full-year jewellery demand suffered a sharp 15 percent decline, while investment demand increased up to 70 percent, reaching its highest value since 2012.

Summarising, the total demand for gold is gradually rising with 2016 full-year demand reaching its 3-year height of 4.308 tonnes. The annual investment inflows in ETFs and similar financial products are also growing, which is confirmed by ETFs' second highest rate on the statistical record. The declines in the demand for gold generated by jewellery industries and central banks offset the growth in the demand for ETFs, but the annual demand for gold bullions and coins remains broadly stable.

2. The incentives to invest in gold and an optimal share of gold in low-, medium- and high-risk investment portfolios

As it was noted by Balarie (2017), gold is attractive for modern investors since gold prices do not correlate to stock, bond or real estate prices. Some recent scientific studies (Barber, & Odean, 2000; Coval, & Moskowitz, 2001; Mouna, & Jarboui, 2015; Balarie, 2017) disclosed two behavioural patterns which contradict the assumptions of the classical portfolio theory:

1) modern investors fail to diversify their portfolios;
2) asset classes in investment portfolios are unreasonably interrelated.

These findings show that modern investors are inclined to form poorly diversified investment portfolios from a limited number of asset classes (Barber, Odean, 2000). Rather than following rational motives, many investors are likely to select particular asset classes that match their professional area or are close to their living place (Coval, & Moskowitz, 2001). Nevertheless, a rational and well-informed investor should diversify his/her investment portfolio regardless of the level of risk assumed (Mouna, & Jarboui, 2015; Mentel, & Brożyna, 2015).

The literature in economics and finance proposes three main motives to include gold in an investment portfolio for its diversification:

- gold may serve as a hedge against inflation (money devaluation);
- gold may serve as a hedge against exchange rate risks;
- gold may serve as a measure to reduce the overall risk of a portfolio.

The idea that gold may serve as a hedge against inflation is based on the observation that it is wise to hold physical assets (e.g., real estate, merchandise) during inflationary periods. Unlike other kinds of merchandise, gold is durable, transportable, universally acceptable and easily authenticated (Worthington, & Pahlavani, 2007). Historical evidence shows that the rise in an inflation rate causes gold prices to increase (Balarie, 2017). For instance, when in January 2006 the price of gold exceeded $562 per ounce, the average monthly change amounted to 0.20225 percent over the period 1875-2006. It was higher than the average monthly change in the US consumer price index (the latter amounted to 0.2022 percent) over the same period (Worthington, & Pahlavani, 2007). Nevertheless, as it was noted by Aggarwal (1992), gold serves as an inflation hedge only in the long run, while its efficiency in the short and medium run is debatable. Eryiğit (2017) finds precious metals and energy to have large effect on the gold price being gold price main determinants.

The issue of exchange risk management is extremely topical nowadays, when stock return is difficult to forecast, and bond return is comparatively low. In fact, even investors who refrain from direct international investment are facing the threat that the strong correlation between the local asset value and inflation as well as between the local asset value and capital outflows may negatively affect local exchange rates. When the differences in interest rates in developing and developed economies are significant, exchange rate management costs can substantially reduce the return on investment. Historically, employment of other currencies has never been an efficient hedge again exchange rate risk. What is more, the marginal reduction in an exchange rate, which determines a substantial reduction in the potential return on investment, is not always attractive for investors. A potential solution to this situation is employment of gold. As gold is nobody's debenture, it can help investors manage foreign asset risks, especially in the countries where exchange rates are highly volatile, and interest rates are structurally high. With reference to the report of the World Gold Council (2013), gold prices positively correlate to the growth pace in emerging markets, and negatively correlate to the value of the US dollar. At the same time, the cost of investment in gold remain comparatively low.

An increasing role of emerging economies in the global gold market (in particular, over the last 12 years) is another rationale to use gold as a hedge against exchange rate risks. In fact, the correlation between gold and stock prices in emerging markets is much higher than the correlation between gold and stock prices in developed markets. For instance, over the period 2001-2012, the correlation between gold and stock prices in emerging markets was equal to 0.28, while the correlation between gold and stock prices in developed markets was equal to 0.11 (The World Gold Council, 2013).

Finally, inclusion of gold in an investment portfolio should be considered for the reason that gold can serve as a hedge against the overall risk of a portfolio. Menon (2015) provides some arguments why gold can be treated as a highest-class investment:

1) the demand for gold in China, India and other emerging markets is soaring;

2) the growth in the global gold supply is limited since the world has already exploited its most efficient gold mines;

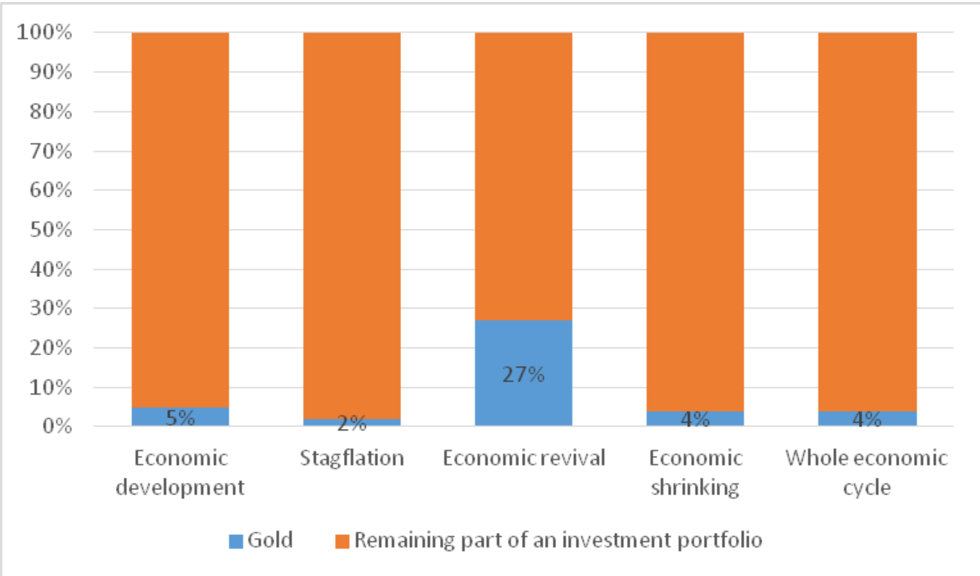
3) gold production costs are expected to rise, which should cause the price of gold to grow.

Gold price is highly interlinked with the inflation expectations driving future monetary development in an economy (Belke, 2017). According to Dar and Maitra (2017), the fact that gold retains its value during the periods of economic crises, when the value of other assets is dramatically decreasing, has been historically proven. In recent years, the values of different assets have started showing stronger correlations. The results of some scientific studies reveal that gold negatively correlates to stock (Baur, & Lucey, 2010; Baur, & McDermott, 2010 and others). Although the US financial markets were coming through a sudden decline from July 2007 to March 2009, gold prices at the same time increased by nearly 42 percent (Baur, & McDermott, 2010). Wang et al. (2016) note that extreme risks are much faster transmitted *after* a crisis than before it, and this feature is linked to the efficiency of gold as a “safe heaven”. The importance of gold in global financial systems is determined by the interest in gold shown by both institutional and individual investors who treat gold as an alternative asset (Shahbaz et al., 2014). The studies focused on the links between gold and different macroeconomic and financial indicators reveal that gold can offset the fluctuations of several macroeconomic and financial indicators, in particular, general prices, stock prices, crude oil prices and exchange rates (Dar, & Maitra, 2017).

Along with the incentives to include gold in an investment portfolio, it is purposeful to research which share of gold could be considered optimal in a low-, medium- and high-risk investment portfolio. Leaning on the resampled efficiency approach, Michaud et al. (2006) estimated that gold should compose 1-2 percent of low-risk investment portfolios, and 2-4 percent of risk-balanced investment portfolios. Having research the US market, the authors (Michaud et al., 2006) found that over the last 32 years gold had been an important structural component of risk-balanced investment portfolios, but the same could not be said about high-risk investment portfolios. Leaning on the portfolio optimisation approach, Artigas (2010) found that gold could mitigate the fluctuations in a portfolio’s value without sacrificing a part of expected returns. The author (Artigas, 2010) concluded that inclusion of gold not only provided a better risk-return balance, but also helped to reduce a potential loss on an investment. A special attention was drawn to the finding that gold was able to reduce the level of financial risks, i.e., the value of VaR coefficient. Artigas’s (2010) study disclosed that even a relatively small share of gold (about 2.5-9 percent) in an investment portfolio might significantly increase a risk-balanced return and diminish a portfolio’s value-at-risk coefficient (VaR) by 0.1-18.5 percent.

The study carried out by Baur (2013) revealed that an optimal share of gold in an investment portfolio should amount to 0-15 percent of a portfolio's efficiency frontier. Gold should compose the maximum share (about 15 percent) of an investment portfolio if an investor pursues a target (desired) return; it should amount to 7-11.3 percent of the total structure of an investment portfolio if an investor pursues a high, but lower than a target return; finally, gold should compose about 4-7 percent of an investment portfolio if an investor pursues a comparatively low return (Baur, 2013).

It should not be overlooked that a stage of an economic cycle can also have a significant impact on the rate of return on a portfolio. With reference to the methodologies introduced by Munro and Silberman (2008), economic cycles can be divided into 4 stages – economic development, stagflation, revival and shrinking. Structural shares of gold in an optimal investment portfolio in different stages of an economic cycle have been depicted in Graph 1.



Graph 1. Structural shares of gold in an optimal investment portfolio in different stages of an economic cycle when a target return is equal to CPI+5%

Source: *compiled by the authors with reference to Bradfield and Munro, 2016, p. 184*.

With consideration of the impact of inflation on the real return on a portfolio during the entire economic cycle, CPI+5% (consumer price index plus 5 percent) was selected as an investor's target return. The data in Graph 1 illustrate that the largest structural share (27 percent) of gold in an optimal investment portfolio is inherent to the stage of economic revival, while the smallest share of gold (about 2 percent) should be included in an optimal investment portfolio during the periods of economic stagflation. In the stage of economic shrinking, the structural share of gold in an optimal investment portfolio should be equal to the average structural share of gold in a portfolio over the entire economic cycle (i.e. it should amount to 4 percent of the total structure of a portfolio).

Summarising, although the demand for gold as an asset is traditionally linked to the attitude that gold may serve as an efficient hedge against inflation, the results of previous scientific studies proved the efficiency of this strategy only in the long run. Since gold is nobody's debenture, it can help investors manage foreign asset risks at low costs, especially in the economies where exchange rates are highly volatile, and interest rates are structurally high. Gold is also considered to be a hedge against the overall risk of a portfolio since it retains its value during the periods of economic crises when the values of other assets are dramatically decreasing; what is more, gold ensures diversification of investment and provides protection against so-called “tail risk”, i.e., against the risk that a portfolio return may deviate from its average within the amplitude higher than three regular values of standard deviation. The negative correlation between gold and exchange rates in developed economies (apart from the US and the US dollar) creates the basis for worrying about particular weaknesses inherent to the global monetary system. Therefore, gold is employed as a measure that can protect investment from extreme changes in the global monetary system. Even if gold cannot be referred to as a perfect substitute to the currencies of developing economies, inclusion of gold in an investment portfolio allows to balance investment risks and earn higher portfolio returns. With reference to Michaud et al. (2006), gold should compose 1-2 percent of low-risk investment portfolios, and 2-4 percent of well-balanced investment portfolios. Inclusion of gold is not so important in high-risk investment portfolios since investors who assume high risks for high return are not inclined to employ any hedges because it would mean the decrease in expected returns. Over the periods of economic development, stagflation and shrinking gold should compose 4-5 percent of the total structure of an investment portfolio, while over the periods of economic revival the structural share of gold should increase to 27 percent. In general, gold may provide some financial benefits if one considers that gold’s main advantage lies not in its capability to raise portfolio returns, but its ability to reduce portfolio risks.

3. Methodological approach

When comparing the results of different scientific studies focused on the benefits of investment in gold, correlations of the price of gold to the prices of other assets, and estimation of the share of gold in an optimal investment portfolio, contradictions of the results can be observed. This is partly determined by employment of different research methodologies. The methodologies commonly employed for the analysis of the investment in gold can be attributed to three main categories:

1) the methodologies that allow to identify the links between gold price variations and the changes in the main macroeconomic indicators (exchange rates, interest rates, income level, political shocks, etc.) (Ariovich, 1983; Dooley et al., 1995; Sherman, 1982, 1983, 1986; Sjaastad, & Scacciallani, 1996 and others);

2) the methodologies focused on the speculations and/or rational assessment of the price of gold (Baker, & Van Tassel, 1985; Diba, & Grossman, 1984; Koutsoyiannis, 1983; Pindyck, 1993 and others);

3) the methodologies that reveal (in)efficiency of gold as a hedge against undesirable economic changes (e.g., inflation, the changes in exchange rates, the changes in stock prices, etc.) in the short and long run (Chappell, & Dowd, 1997; Kolluri, 1981; Laurent, 1994; Mahdavi, & Zhou, 1997; Moore, 1990; Ghosh et al., 2000 and others).

The comprehensive literature analysis allowed to select two methods that enabled to forecast the changes in the price of gold and identify the most significant determinants of gold price variations over the period 1968-2015.

Time series analysis refers to the analysis of the data series extracted from various databases (e.g., trading economics). In this research, employment of the paid data ensured obtainment of the sufficiently long time data series. The model of time data series comprised the following stages:

1. Recognition, i.e., preliminary selection of the model for the analysis. In this stage, the initial data graph was presented, the nature of the trend was identified, and the effect of seasonality (if any) was established.

2. Interim evaluation, i.e., setting of the model parameters. If the selected parameters failed to describe time series with appropriate accuracy, the research was returned to the stage of recognition.

3. Final evaluation, i.e., assessment of applicability of the model by particular criteria.

The method of time data series allowed to:

- develop the structure of ARMA/ARIMA forecasting model;
- ensure stationary;
- assess the parameters of the selected model;
- verify applicability of the model;
- create forecasts by employing adequate models.

ARMA/ARIMA forecasting models are popular for their flexibility. They are based on employment of historical information. ARMA/ARIMA forecasting models comprise an autoregressive (AR) process, a moving average (MA) process and an integration (I) process. The autoregressive process explains time series observations with consideration of historical observations. The autoregressive equation, which describes the value of variable y_t, is expressed as follows:

$$Yt = a_1 Y_{t\ 1} + a_2 Y_{t\ 2} ::: + a_p Y_{t\ p} + ''_t, \qquad (1)$$

where:
y_t – time series observations;
$a_1; :::; a_p$ – parameters of the autoregressive model describing the dependence of each time series value on its historical values;
$''_t$ – random error;
p – sequence of the autoregressive process.

The equation of the moving average process describing value y_t is expressed as follows:

$$Yt = ''_t + b''_{1t\ 1} + b''_{2t\ 2} ::: + b''_{qt\ q:} \qquad (2)$$

Stationary process Y_t is referred to as ARMA (p, q) if it satisfies the equation:

$$Yt = a_1 Y_{t\ 1} + ::: + a_p Y_{t\ p} + ''t + b''_{1\ t} + ::: + b''_{q\ t\ q:} \qquad (3)$$

ARIMA (the AutoRegressive Integrated Moving Average) is an autoregressive integral method of moving averages, which is often employed for time series analysis. It combines the methods of autoregression, differentiation and moving averages. All structural components in this model are based on the concept of random noise (inexplicable dispersal) which distorts the systemic component of a time series. The structural components also react to the mode of the noise. The most general ARIMA model covers all three structural parts, and can be expressed as ARIMA (*p*, *d*, *q*), where p stands for an autoregression series, *d* – for a differentiation series, and *q* – for a number of moving averages.

Construction of autoregressive time series models requires the series to be stationary. In case the requirement of stationarity is not satisfied, different methods of transformation are employed. Differentiation is one of the main methods of transformation. While diversifying any time series in this research, the changes in its informational values were identified, and the series was transformed into a stationary form:

$$Yt(1 - a1L - a2L2 - ... - apLp) = \varepsilon t, \qquad (4)$$

Variable L in equation (4) stands for a lag operator. The feature of a lag operator is expressed as $L_iYt = Y_{t-i}$.

For verification of the stationarity of a time series and development of a differentiation series, the extensive Dickey-Fuller (ADF) test was employed. The hypotheses H0 and H1 were verified: H0 – the process is not stationary; H1 – the process is stationary. For verification of hypothesis H0, the observed probabilities of significance (p) were employed. Almost all statistical software packages were able to estimate these values. H0 was accepted if $p \geq 0$; otherwise, H1 was accepted. Any non-stationary time series was transformed into a stationary series by employing the procedure of diversification:

$$\delta yt = yt - yt-1, \tag{5}$$

If the differences in the first differentiation series were non-stationary, differentiation of the second series was employed, and so forth. The preliminary parameters of ARMA/ARIMA model were selected by analysing ACF and PACF graphs. In MA(q) process, the serial number at which ACF values still significantly varied from zero were selected. In AR(p) process, the serial number at which PACF values still significantly varied from zero were selected. After selection of the preliminary model parameter values p, d and q, the adequacy of these values was verified. The final choice of the model was assessed by AIC (Akaike) criterion which was estimated by the formula:

$$AIC = -2logL + 2k, \tag{6}$$

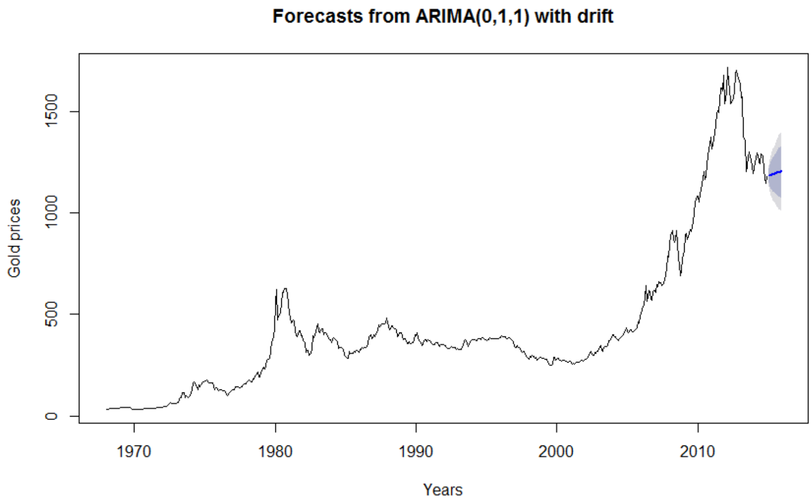
where:
k – the number of the parameters in the model;
L – Gauss-type probability function.

Applicability of the model developed for gold price forecast was verified by employing the following forecast accuracy measures:
MAE – medium absolute error;
MAPE – medium absolute percentage error.

Further in the research, the gold price trends were analysed by applying ARMA/ARIMA model. All the calculations were performed with R software. ARMA/ARIMA models were found to be suitable and applicable only for detection of slight data fluctuations in the short run. At the same time, the sudden changes in the data were difficult to capture.

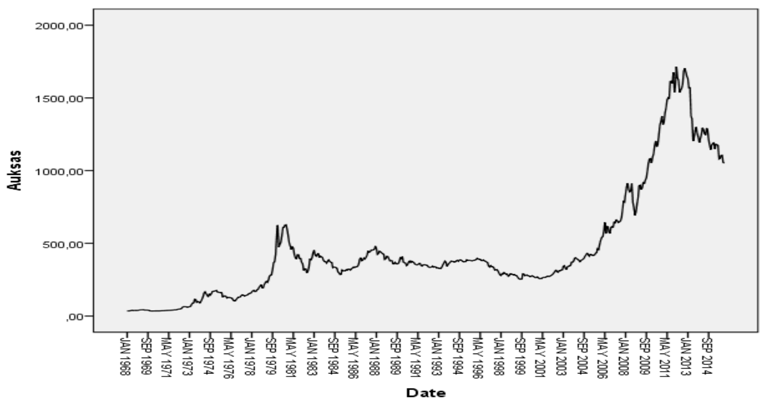
4. The results of the empirical research: gold price forecast and gold price determinants

The forecast of the gold price future trends was started from the analysis of the primary data for the period December 1968 – December 2015 (see Graph 2).



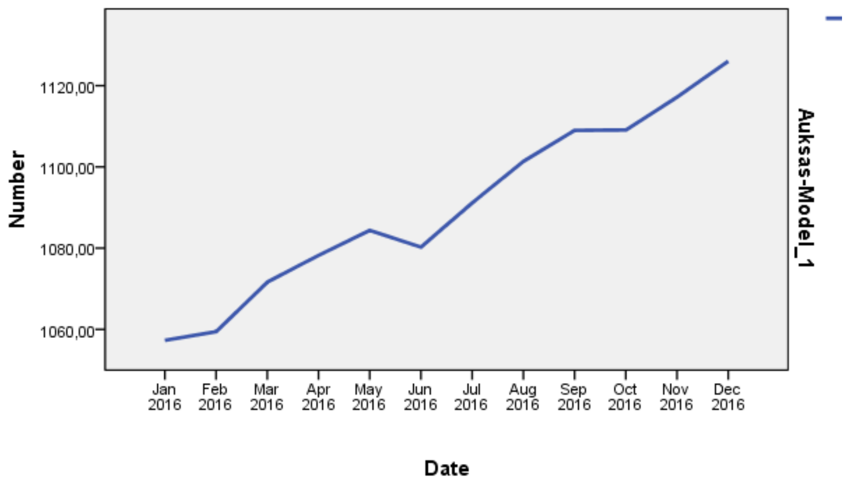
Graph 2. Primary statistical data on the prices of gold for the period 1968-2015
Source: *compiled by the authors*

As in this research we wanted to verify the accuracy of the model and check its applicability for forecasting of the gold price future trends, first of all, we verified the accuracy of the forecast for the period 1968-2015 (see Graph 3).



Graph 3. The continuous data on the price of gold till 2015
Source: *compiled by the authors*

The year 2015 was selected to obtain the data for identification of the errors in the values under consideration (see Graph 4):



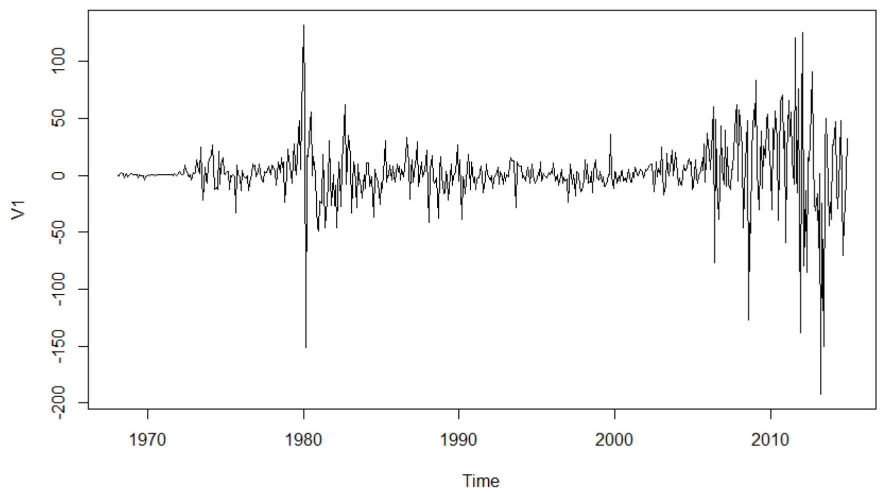
Graph 4. The dynamics of the price of gold in 2016
Source: *compiled by the authors*

The results of the research show that the primary data are not stationary. The initial data graph obviously shows that the average price of gold is changing. This trend can be explained as a result of the sensitivity of other investment instruments to the fluctuations of the price of gold. Nevertheless, the investment in gold stock is considered to be the riskiest since the prices of gold stock rise and fall faster than the price of gold. The investment in gold funds and mutual funds is usually considered more effective than the investment in any physical form of gold because investors do not face the problems of gold storage.

Further in the research, by employing ADF (the Augmented Dickey-Fuller test), we verified the hypothesis that the data were non-stationary. The hypothesis on the data non-stationarity was confirmed. For the development of a stationary time series, the process of differentiation was employed:

$$Ydt = Yt - Yt-1$$

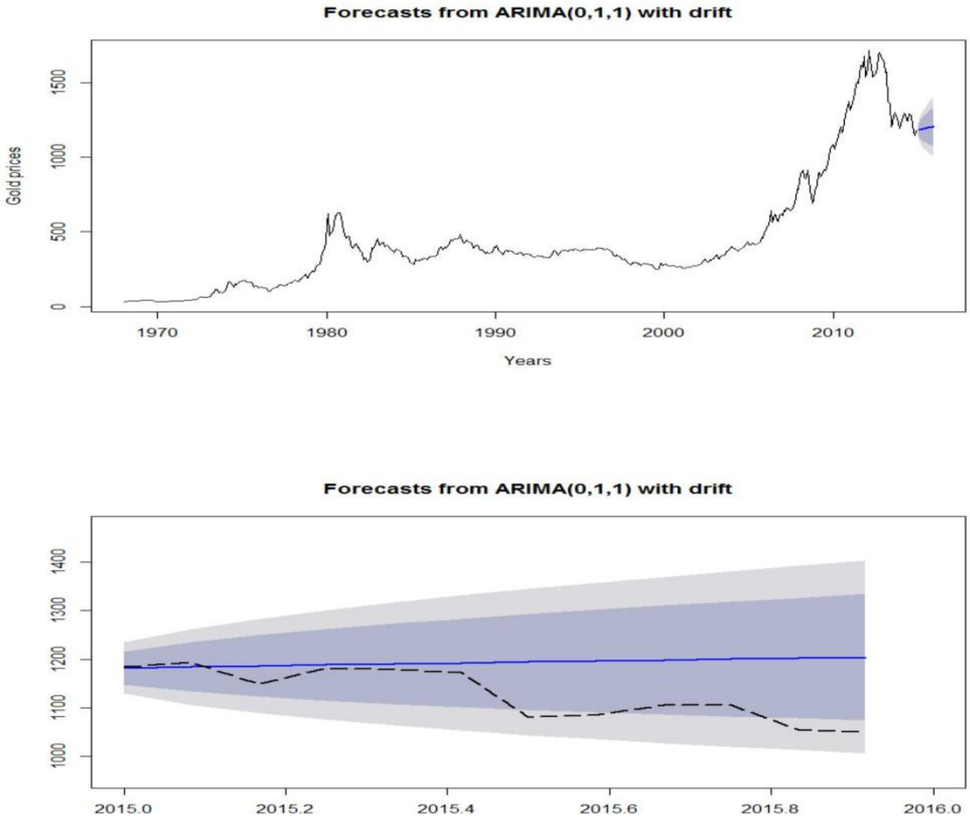
After differentiation of the first series, we obtained a stationary time series with the data fluctuating around the same value – 0 (see Graph 5).



Graph 5. A time series
Source: compiled by the authors

The Dickey-Fuller test, repeatedly applied for verification of the hypothesis about data non-stationarity, allowed to decline this hypothesis. Differentiation of the first series was sufficient to obtain a stationary time series. At the same time, it was established that $d = 1$, and it would definitely be included in the model. For estimation of the other parametrical values (p and q), the graphs of autocorrelation (ACF) and partial autocorrelation (PACF) functions were analysed. In graph ACF, the initial distinguishing values were attributed to parameter q, while in graph PACF, the initial distinguishing values were attributed to parameter p.

Next, the models ARIMA (p,d,q) with different parametrical values were compared. For further research, two models with lowest values of AIC (Akaike) criterion, i.e., ARIMA (0,1,1) with drift and ARIMA (1,1,1), were selected. Verification of the models covered examination of their adequacy and compliance with the requirements for autoregressive models. Gold price forecasts for 2015 from ARIMA (0,1,1) with drift have been depicted in Graph 6.



Graph 6. Gold price forecasts for 2015 from ARIMA (0,1,1) with drift
Source: compiled by the authors

The results of the research show that ARIMA's (0,1,1) with drift MAPE indicator, estimated for the continuous data of 2015, amounts to 6.14 percent, i.e., it does not exceed 4 percent.

The results of ARIMA's (1,1,1) adequacy verification have been presented in Appendix 4. ARIMA's (1,1,1) MAPE indicator, estimated for the continuous data of 2015, amounts to 3.93 percent, i.e., it does not exceed 4 percent. Hence, ARIMA (1,1,1) is more suitable for short-term gold price forecasting than ARIMA (0,1,1) with drift.

For more accurate forecasts, it would be purposeful to include a larger number of variables, to conduct more comprehensive mathematical calculations and to employ a wider variety of multiple regression models, which would allow to identify closer correlations between particular determinants and the price of gold. The analysis of scientific literature has revealed that the price of gold is affected by the fluctuations in the price of silver, the price of platinum, inflation rates, etc. The results of the empirical analysis lead to the conclusion that the model ARIMA (1,1,1) can be treated as suitable for forecasting of the gold price future trends. This study examines the changes in the price of gold over the period January 1968 to December 2015, inclusive. The initial data on the prices of gold over the period under consideration were analysed and used for the gold price forecast.

Conclusion

1. Although the demand for gold as an asset is traditionally linked to the attitude that gold may serve as an efficient hedge against inflation, the results of previous scientific studies proved the efficiency of this strategy only in the long run. As gold is nobody's debenture, it can help investors manage foreign asset risks at low costs, especially in the economies where exchange rates are highly volatile, and interest rates are structurally high. Gold is also considered as a hedge against the overall risk of a portfolio since it retains its value during the periods of economic crises when the value of other assets is dramatically decreasing; what is more, gold ensures diversification of investment and provides protection against so-called "tail risk", i.e. against the risk that portfolio returns may deviate from their average within the amplitude higher than three regular values of standard deviation.

2. When comparing the results of different scientific studies focused on the benefits of investment in gold, identification of the links between gold price and other asset price variations, and estimation of the share of gold in an optimal investment portfolio, contradictions of the results can be observed. This is partly determined by employment of different methodologies, which calls for development of a method suitable for forecasting of the gold price future trends. The comprehensive analysis of scientific literature allowed to select two methods that could help forecast gold price fluctuations and identify the most significant determinants of the changes in the price of gold. These methods include time series analysis and ARMA/ARIMA forecasting models. ARMA/ARIMA forecasting models are popular for their flexibility. ARMA/ARIMA models comprise an autoregressive (AR) process, a moving average (MA) process and an integration (I) process which are based on employment of historical information. In order to conduct a consistent study and obtain accurate and applicable results, the statistical data for the period 1968-2015 was employed for this research.

3. The autoregressive process explains time series observations with consideration of historical observations. ARIMA's (1,1,1) MAPE indicator, estimated for the continuous data of 2015, is equal to 3.93 percent, i.e. it does not exceed 4 percent and is lower than the same indicator estimated for ARIMA (0,1,1) with drift, which proposes that ARIMA (1,1,1) can be treated as a model suitable for forecasting of the gold price future trends. Nevertheless, it should be noted that ARMA/ARIMA models are suitable only for identification of comparatively insignificant data fluctuations in the short run, while sudden data fluctuations are hard to detect. This feature inevitably reduces the efficiency of the models. For more accurate forecasts, it would be purposeful to include a larger number of variables, to conduct more comprehensive mathematical calculations and to employ a wider variety of multiple regression models, which would allow to identify closer correlations between particular determinants and gold price fluctuations.

4. The limitations of this empirical research are linked to the lack of a long dynamic line for gold, silver and platinum prices, money supply and other variables (for the period 1968-2015). The study could have considered various factors determining the price of gold, but due to the gaps in time lags, we eliminated them from our calculations. Further research could address the impact of American, Chinese and European monetary policy measures on the fluctuations of the price of gold.

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