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A Gold's Price Forecasting Model

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ABSTRACT

This study aims to determine the effect of inflation, the Dollar index, world oil prices, the Dow Jones index, and the economic crisis on the price of gold in the derivatives market. The study period is from January 2003 to December 2020. The research finds that the best model used in predicting gold price is Threshold Autoregressive Conditional Heteroscedasticity (TARCH)(1,2,2) with the lowest Akaike Information Criterion (AIC) value compared to other models and the value of Goodness of Fit highest from 3 other selected models. All independent variables are found to affect the price of gold. The study also found a variant of the gold price determined by the variant as well as the residual price of gold in the previous period. Another interesting finding is that volatility in gold prices has an asymmetric effect on the market. Inflation is statistically significant in weakening the effect of world oil prices on gold prices.

Keywords: Gold Price, Volatility Index, Auto Regressive Conditional Heteroscedasticity (ARCH), Threshold Autoregressive Conditional Heteroscedasticity (TARCH)

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1. INTRODUCTION

Gold is a high-value investment and is considered a safe heaven asset when economic conditions deteriorate (Baur and Lucey, 2010; Beckmann *et al.*, 2015; Beckmann and Czudaj, 2013; Chen and Wang, 2017, 2019; Chkili, 2017; Hood and Malik, 2013; Kong, 2011; Reboredo, 2013; Shakil *et al.*, 2018) and as a hedge against inflation (Beckmann and Czudaj, 2013; Gangopadhyay *et al.*, 2016; Ghosh *et al.*, 2004; Van Hoang *et al.*, 2016; Hood and Malik, 2013; Reboredo, 2013; Seemuang and Romprsert, 2013).

Gold tends to be the safest asset in times of economic crisis but during the financial crisis of 2008, so-called safe-haven gold invested in its dark period, the price of gold fell from $ 1,000/oz in March to $ 700 in October. At that time, people leave gold as a safe investment option, the function of gold as a haven less runs but gold became a good hedging tool during the crisis (Kong, 2011).

The price of gold reached the highest position in 2011 which amounted to $1,900/Troy Ounce. This is due to the economic crisis in Europe and the Fed's policy of Quantitive Easing to buy long-term bonds. The purpose of this policy is to stimulate the economy of the United States that collapsed due to the economic crisis in 2008, consequently, the dollar depreciated. This condition raises the price of gold as investors prefer gold as a safe-haven investment.

After the Fed reduced asset purchases or Quantitive Easing in 2013, the price of gold fell by 27 percent, the policy makes the US economy more stable and increasing. By December 2015 the Fed raised interest rates from 0.25 percent to 0.5 percent, causing gold prices to fall below $1,070 / Troy Ounce as many investors turned to bonds and investments in other financial markets (Chen, 2019; FXStreet, 2020; Maverick, 2018).

The movement of gold prices tends to fluctuate and vary each day. The erratic decline and rising prices of gold, provide a big risk for investors. Therefore, it takes a lot of information to analyze the market movement before deciding on every transaction, it is very important to minimize the risk due to very fast price changes.

Based on the above description, this study attempts to answer (1). Which model can best be used in predicting

the price of gold in the future? (2). Are inflation, the Dollar index, crude oil prices, the Dow Jones index, and the economic crisis affecting the gold price? (3). Is inflation able to moderate the influence of oil prices on gold prices?

2. LITERATURE REVIEWS

In general, the factors affecting the movement of gold prices are inflation, interest rates, bond prices, international stock index, market conditions, demand levels, revenues, crude oil prices, and business cycles (Gangopadhyay *et al.*, 2016). The international stock index has a negative correlation to the gold price, gold becomes a hedge and haven for the stock index in America and Europe. Gold became the strongest risk-free investment for developing countries in the economic crisis (Baur and Lucey, 2010). Crude oil prices positively affect the price of gold, the gold price increase will always be followed by rising crude oil prices. This proves that gold does not function as a hedge against crude oil prices (Reboredo, 2013) but research by Gangopadhyay *et al.* (2016) found oil prices to negatively affect gold. Gold can be a hedging tool as oil prices rise. Investors will prefer to invest in gold.

Robert defines gold as a financial asset that is durable, non-flammable, to be kept inexpensive, and held by many people (McDonald, 2013). Gold is often traded in the form of a certificate of known gold futures. According to (Baur and Lucey, 2010; Beckmann *et al.*, 2015; Beckmann and Czudaj, 2013; Chen and Wang, 2017; Hood and Malik, 2013; Le and Chang, 2011) gold is a haven that can overcome risks in financial markets while (Gangopadhyay *et al.*, 2016; Ghosh *et al.*, 2004; Hood and Malik, 2013; Reboredo, 2013; Seemuang and Romprsert, 2013) argued that gold is a means of hedging inflation. Besides gold can be used as a haven and hedge against inflation. According to (Capie *et al.*, 2005; Samanta and Zadeh, 2012; Weng, 2012) gold is also a means of hedge against exchange rates.

According to Nicholas, inflation is the percentage change in the price index of goods and services in general over some time (Mankiw, 2014). Inflation is an overall increase in price levels caused by simultaneously rising prices and declining value for money (Parkin, 2016).

The Inflation Rate can be estimated by measuring the percentage change in the consumer price index, which indicates the price of a large number of consumer products such as daily necessities (Mankiw, 2014; Parkin, 2016). A high inflation rate will make the dollar weaker that makes gold investment more attractive.

In unstable economic conditions with high inflation rates, investors will tend to invest in gold to avoid inflation risks. Inflation has a positive effect on gold in the long term. The rise in the consumer price index will have a positive effect on gold so that gold can become a hedging tool against inflation (Ghosh *et al.*, 2004).

The US Dollar Index is an index that reflects and measures the strength of the US dollar against six other currencies: Euro, Yen, Pound sterling, Canadian Dollar, Swiss- Franc, and Swedish Krona. The weight of each currency is determined by the US Federal Reserve based on its influence on US trade, the biggest weight being the Euro (57.6 percent), the yen (13.6 percent), the pound sterling (11.9 percent), the Canadian dollar (9.1 percent), Swedish Krona (4.2 percent), and Swiss Franc (3.6 percent).

The dollar index reflects dollar price movements as opposed to gold price movements. If the dollar depreciates, it will make gold cheaper to obtain using foreign currencies. As a result, investors are more interested in buying gold so the demand for gold will increase which in turn will push the gold price up (Chen, 2019; FXStreet, 2020).

Crude Oil Price is influenced by geopolitics, weather factors, and others (Pindyck, 2004). These factors can cause a shift in demand and supply and ultimately change the price of oil. Samanta and Zadeh (2012) define crude oil prices as future contracts that have high liquidity levels and are also the most traded commodities in physical commodities. Changes in oil prices are critical because they can cause uncertainty and imbalance in the economic sector, especially in terms of exports and oil imports. These oil price fluctuations pose a risk to producers and consumers, they can not fix prices constantly due to the high dependence on crude oil.

According to Frank and Keith, the Dow Jones index also known as the Dow Jones Industrial Average (DJIA) is an index of average prices weighted by 30 famous industrial stocks which are the leading shares (Reilly and Brown, 2012).

The financial crisis is often associated with one or more of the following phenomena: substantial changes in credit volume and asset prices; severe disruption to financial intermediation and external financing supplies, changes in the trade balance, and government support (in the form of liquidity and recapitalization support) (Claessens and Kose, 2013).

Much research has been done to determine the factors that affect the price of gold. Le and Chang (2011), Nasrinejad and Raeisi (2013), Seemuang and Romprsert (2013), Tufail and Batool (2013), Sukri *et al.* (2015), Gangopadhyay *et al.* (2016), Van Hoang *et al.* (2016) found that inflation statistically has a significant and positive effect on gold prices. The price of gold moves along with the Consumer Price Index, so to avoid the risk of inflation, gold can be a hedging tool in the long run. Van Hoang *et al.* (2016) found that gold is not a hedging instrument against inflation in the long run but only in the short term for the UK, USA, and India. Their research also found no long-term balance between gold and con-

sumer price indexes in China, India, and France.

Toraman *et al.* (2011), Samanta and Zadeh (2012), Sukri *et al.* (2015) found gold to have a significant and positive influence on oil, so gold is not a hedging tool against oil prices. Nasrinejad and Raeisi (2013), Gangopadhyay *et al.* (2016) found a negative correlation between oil prices and gold prices.

The findings of Hood and Malik (2013), in periods of low volatility and high volatility, reveal that gold does not have effects on US stock markets. Besides, the VIX (Volatility Index) correlation with the overall stock market has a negative relationship even in periods of high volatility (market turmoil).

Nasrinejad and Raeisi (2013), Seemuang and Romprsert (2013) found a strong positive and significant relationship between gold and the Dollar index, while Capie *et al.* (2005) found a negative relationship between the gold price and the Dollar Index.

Some studies found a negative relationship between the stock price index and the gold price Samanta and Zadeh (2012), Tufail and Batool (2013), Gangopadhyay *et al.* (2016), while a positive relationship between the price of gold and stock prices was found by Baur and Lucey (2010), Weng (2012), and Reboredo (2013).

3. RESEARCH METHODS

3.1 Population and Sample

The population of this study is all gold price data, US inflation, crude oil price, Dollar Index, Dow Jones index, and economic crisis. This study uses samples of gold prices, US inflation, crude oil prices, Dollar Index, Dow Jones Index, and economic crisis (Dummy Variables) from January 2003 to December 2018.

3.2 Operational Definition of Variables

To further facilitate understanding, measurement and source of data acquisition need to be done together with the operational definition of the variables used in this study. Table 1 shows the definition of each variable used.

3.4 Data Analysis Method

To get the best model in forecasting gold prices in the future, Steps (1) to (5) were taking into consideration as follows: (1). Regression between independent variables (CPI, OIL, USX, DOW, CRISIS, and CPI*OIL) with the dependent variable (GOLD) using Ordinary Least Square (OLS):

$$GOLD_t = C + \sum_{i=1}^{n} \alpha_i IV_t + e_t \quad (1)$$

where, C is an intercept; α is the coefficient of independent variable; IV is the independent variable (CPI, OIL, USX, DOW, CRISIS, and CPI*OIL); n is the number of independent variables; t is the period time; e is the residual.

For each model tested normality, autocorrelation, heteroscedasticity to residual, (2). The best model is then chosen by looking at the smallest value of Akaike Information Criterion (AIC), (3). Testing ARCH Effect on selected model using ARCH-LM test. If there is ARCH Effect, one can proceed to model ARCH and TARCH. (4). Define the order of the ARCH and TARCH models by looking at the Correlogram of Residuals Squared of the selected model in Step 2, (5). Furthermore, the relationship between independent variables and dependent variables is re-aggregated using ARCH and TARCH models as follows:

ARCH (p) Model,
Mean Equation,

$$GOLD_t = C + \sum_{i=1}^{n} \alpha_i IV_t + e_t \quad (2)$$

Variance Equation,

$$\sigma_t^2 = \beta_0 + \beta_1 e_{t-1}^2 + ... + \beta_p e_{t-p}^2 \quad (3)$$

where β_0 is the intercept of the variant equation; p is the order of ARCH (p) and σ^2 is a variant.

Table 1. Definition of Operational Variables

Variable	Name of Variable	Measurement Scale	Source
GOLD	Gold Price	Ratio	https://www.investing.com
CPI	Inflation	Ratio	https://alfred.stlouisfed.org
OIL	Crude oil price	Ratio	https://www.investing.com
USX	US Dolar Index	Ratio	https://www.investing.com
DOW	Dow Jones Index	Ratio	http://finance.yahoo.com
CRISIS	Economic Crisis	Nominal (1 = Crisis, and 0=Not a crisis)	

Source: Author investigations.

ARCH-M (p, M) Model,
Mean Equation,

$$GOLD_t = C + \gamma(M_t) + \sum_{i=1}^{n} \phi_i IV_t + e_t \quad (4)$$

Variance Equation,

$$\sigma_t^2 = \beta_0 + \beta_1 e_{t-1}^2 + ... + \beta_p e_{t-p}^2 \quad (5)$$

where, M consists of standard deviation (σ); variant (σ^2), and Log variant (Log σ^2) of the residual and γ is the coefficient of M.

The ARCH model developed by Engel (Engle, 1982; Engle *et al.*, 1987) and Generalized AutoRegressive Conditional Heteroscedasticity (GARCH) developed by Tim have the assumption that shocks are symmetrical to volatility, so this sometimes not following the facts that occur (Bollerslev, 1986). Sometimes, the fluctuations that occur from volatility are asymmetrical, where negative events occurring within the market will not always be followed by positive events of equal size at other times.

To find out whether the volatility of the gold price in the market is asymmetric or not, it can be modeled by the TARCH model (Glosten *et al.*, 1993).

TARCH (p,q,r) Model,
Mean Equation,

$$GOLD_t = C + \sum_{i=1}^{n} \alpha_i IV_t + e_t \quad (6)$$

Variance Equation,

$$\sigma_t^2 = a_0 + a_1 e_{t-1}^2 + ... + a_p e_{t-p}^2 + b_1 \sigma_{t-1}^2 + ... + b_q \sigma_{t-q}^2 \quad (7)$$

TARCH-M (p,q,r,M) Model,
Mean Equation,

$$GOLD_t = c + \gamma(M_t) + \sum_{i=1}^{n} \alpha_i IV_t + e_t \quad (8)$$

Variance Equation,

$$\sigma_t^2 = a_0 + a_1 e_{t-1}^2 + ... + a_p e_{t-p}^2 + b_1 \sigma_{t-1}^2 + ... + b_q \sigma_{t-q}^2 + c_1 e_{t-1}^2 d_{t-1} + ... + c_r e_{t-r}^2 d_{t-r} \quad (9)$$

where r is an order of TARCH, d_{t-r} is a dummy variable for $d_{t-r} = 1$, if $e_{t-r} < 0$ is a signal of negative shocks in the market, and $d_{t-r} = 0$ if $e_{t-r} > 0$ is a signal of positive shocks in the market that will affect the volatility of gold prices. Positive shocks will give an effect to residual coefficient (a_p coefficient) and negative shocks will give an effect to the amount of residual coefficient with dummy variable coefficient ($a_p + c_r$). If the coefficient of the dummy variable ($c_r \neq 0$), it indicates the volatility has an asymmetric effect, but if the coefficient $c_r > 0$, the negative shock will increase volatility and leverage effect on order to r (Buguk *et al.*, 2003; Nuryasman and Prasodjo, 2017).

4. RESULT AND DISCUSSION

To answer the problems in this research, firstly model the relationship between independent variables with dependent variables using the models that have been described in the previous section.

Using Equations 1 and 2, the results obtained are shown in Table 2. This table gives a general overview, all the independent variables (CPI, OIL, USX, DOW, CRISIS, and CPI * OIL) statistically affect the dependent variable (GOLD) either with the model using intercept or not. However, both models have heteroscedasticity problems, this is evidenced by the probability of ARCH-Test being smaller than 5%.

Based on these results (the ARCH-Test probability value for both models are smaller than 0,05), it can be concluded that both OLS models have variants that are not constant over time, so it no longer meets the principle of BLUE (Best Linear Unbiased Estimator).

To get the BLUE model first, choose one of the best among the two models above with the smallest AIC value. Of the two models above, the model intercept is relatively better, because it has a smaller AIC value than the model without the intercept (12.660 < 12.755).

Furthermore, to test whether the model can be modeled in ARCH, ARCH-M, TARCH, and TARCH-M models with a specific order, it is tested through a Correlogram of Residuals as shown in Table 3.

From Table 3, it can be explained that the residuals of the OLS model use constants, the spike in lag 1 and 2, so modeling for ARCH, ARCH-M, TARCH, and TARCH-M, can be made by using order one or two.

Using Equations 2 to 9 above, some equations are given by considering; (1). Significance of each variable with a 95% confidence level, (2). Fulfillment of criteria of Normality, Homoscedasticity, and the absence of Autocorrelation, and (3). The model selection is based on the smallest AIC values.

Based on the above considerations, some equations are obtained to predict the price of gold that is influenced by various factors (CPI, OIL, USX, DOW, CRISIS, and interaction between CPI and OIL variables) as shown in Table 4. The model in Table 4 is the best model among many models. But to answer the research problem, which model is the best model to predict gold price in the future, implies chosen one model from four models based on

AIC, the goodness of fit, and Root Mean Square Error (RMSE) criteria.

Based on the results in Table 4, TARCH (1,2,2) was selected from the other three models, since it has the smallest AIC value (11.225), the greatest Goodness of Fit (0.958) compared to the others although the RMSE value is greater (289.324) than ARCH (1) but smaller than ARCH (2) and TARCH (1,1,1) model. Another important reason TARCH (1,2,2) was chosen as the best model because it can explain whether there is asymmetric information in the market.

TARCH (1,2,2) above gives an overview (1). In the mean equation, all independent variables (CPI, OIL, USX, DOW, CRISIS, and interaction between CPI and OIL) have a statistically significant effect on gold price (GOLD) with a confidence level of 1%, even the logarithm of the gold price variation (Log (σ^2)) with a confidence level of 1% also found to affect the price of gold, (2). In the con-

Table 2. Estimation of parameters with ordinary least square (OLS)

Variable	Coeff.	SE	$t_{stat.}$	Prob	Coeff.	SE	$t_{stat.}$	Prob.
Constant					-2,100.400	478.919	-4.386	0.000***
CPI	15.735	1.254	12.550	0.000***	22.518	1.953	11.531	0.000***
OIL	-45.080	4.153	-10.854	0.000***	-20.352	6.884	-2.956	0.004***
USX	-19.896	2.470	-8.054	0.000***	-12.107	2.945	-4.111	0.000***
DOW	-0.041	0.005	-7.653	0.000***	-0.054	0.006	-9.162	0.000***
CRISIS	-196.614	33.355	-5.895	0.000***	-229.215	32.576	-7.036	0.000***
CPI*OIL	0.196	0.020	9.756	0.000***	0.093	0.030	3.058	0.003***
	Goodness of Fit				Goodness of Fit			
R^2	0.891				0.902			
Adj.R^2	0.888				0.899			
AIC	12.755				12.660			
	Classical Assumptions				Classical Assumptions			
LM Test	0.000				0.000			
Prob-JB	0.992				0.350			
ARCH-Test	0.000				0.000			

Source: Authors' results. * indicates significance level at 0.10 level, ** indicates significance level at 0.05 level, *** indicates significance level at 0.01 level.

Table 3. Correlogram of residuals of OLS model

Autocorrelation	**Partial Correlation**		**AC**	**PAC**	**Q-Stat**	**Prob**
.|***** |	.|***** |	1	0.704	0.704	89.640	0.000
.|***** |	.|** |	2	0.630	0.267	161.88	0.000
.|**** |	.|* |	3	0.554	0.088	218.11	0.000
.|**** |	.|. |	4	0.484	0.020	261.20	0.000
.|*** |	.|. |	5	0.428	0.015	295.13	0.000
.|*** |	.|. |	6	0.393	0.040	323.89	0.000
.|** |	*|. |	7	0.283	-0.139	338.84	0.000
.|** |	.|. |	8	0.252	0.012	350.82	0.000
.|** |	.|* |	9	0.255	0.104	363.14	0.000
.|* |	.|. |	10	0.207	-0.025	371.33	0.000
.|** |	.|* |	11	0.230	0.093	381.45	0.000
.|* |	.|. |	12	0.187	-0.045	388.21	0.000
.|* |	.|. |	13	0.199	0.071	395.88	0.000
.|* |	*|. |	14	0.128	-0.141	399.06	0.000
.|* |	.|. |	15	0.108	-0.039	401.36	0.000
.|. |	*|. |	16	0.006	-0.165	401.37	0.000
.|. |	.|. |	17	0.004	0.025	401.37	0.000
*|. |	*|. |	18	-0.109	-0.183	403.77	0.000
*|. |	*|. |	19	-0.159	-0.072	408.87	0.000
**|. |	*|. |	20	-0.224	-0.079	419.08	0.000

Source: Authors' results.

ditional variance equation, there is an asymmetric effect in the world gold market for 2 periods in different directions. This is shown by the coefficients of $(e_{t-1})^2 * (e_{t-1} < 0)$ and $(e_{t-2})^2 * (e_{t-2} < 0)$ not equal to 0. Another finding of this section, the variation of the gold price determined by variations of the previous one and two-period gold price and the residual price of gold of the previous period, (3). The variation of gold price during the study period is determined by inflation variation, oil price, US Dollar index, Dow Jones stock index, global economic crisis, and interaction between world oil price and inflation of 95.80%, while 4.20% change of gold price in the derivative market is influenced by a factor other than the variables used in this study. Besides, the model from Table 4 can be used as a model to predict future gold prices, because this model is the best model chosen from several models based on the criteria of AIC, the significance of independent variables, and the fulfillment of classical assumptions in a model.

This study found that inflation (CPI) has a positive and significant effect on the change of gold price, every 1% increase of inflation will increase gold price about 22.882% or vice versa with other variable assumptions unchanged. This result has an accuracy of 99% confidence level as evidenced by a p-value of 0.000. This finding implies that the higher the inflation the more expen-

Table 4. Model choice results to forecast the price of gold

Information	ARCH (1)		ARCH (2)		TARCH (1,1,1)		**TARCH (1,2,2)**	
	Coeff	P_{Value}	Coeff	P_{Value}	Coeff	P_{Value}	**Coeff**	**P_{Value}**
	Mean Equation		Mean Equation		Mean Equation		**Mean Equation**	
Σ			0.293	0.009***				
Log (σ^2)					147.618	0.000***	139.464	0.000***
C			-1,064.965	0.000***	-3,889.684	0.000***	-3,623.917	0.000***
CPI	12.416	0.000***	15.238	0.000***	23.638	0.000***	22.882	0.000***
OIL	-41.898	0.000***	-35.153	0.000***	14.000	0.000***	6.988	0.000***
USX	-16.636	0.000***	-10.034	0.000***	-12.584	0.000***	-12.603	0.000***
DOW	-0.011	0.000***	-0.028	0.000***	-0.019	0.000***	-0.019	0.000***
CRISIS	-53.202	0.000***	-97.467	0.000***	-56.169	0.000***	-66.130	0.000***
CPI*OIL	0.180	0.000***	0.155	0.000***	-0.073	0.000***	-0.043	0.000***
	Variance Equation		Variance Equation		Variance Equation		**Variance Equation**	
C	1,410.677	0.001***	764.591	0.026**	416.918	0.000***	355.724	0.000***
$(e_{t-1})^2$	1.152	0.000***	0.866	0.001***	0.775	0.000***	0.713	0.000***
$(e_{t-2})^2$			0.301	0.012**				
σ_{t-1}^2					0.652	0.000***	0.873	0.000***
σ_{t-2}^2							-0.200	0.000***
$(e_{t-1})^2*(e_{t-1} < 0)$					-0.783	0.000***	-0.712	0.000***
$(e_{t-2})^2*(e_{t-2} < 0)$							0.009	0.012**
	Goodness of Fit		Goodness of Fit		Goodness of Fit		**Goodness of Fit**	
R-Squared	0.838		0.887		0.955		0.959	
Adj.R-Squared	0.833		0.882		0.954		0.958	
AIC	12.147		11.890		11.273		11.255	
	Classical Assumption		Classical Assumption		Classical Assumption		**Classical Assumption**	
Autocorrelation	ADF Test (-4.112), α (5% = -2.878), Prob. (0.00***)		ADF Test (-4.345), α (5% = -2.878), Prob. (0.001***)		ADF Test (-11.561), α (5% = -2.878), Prob. (0.000***)		ADF Test (-11.639), α (5% = -2.878), Prob. (0.000***)	
Normality	J-Bera (1.633), Prob. (0.442)		J-Bera (1.922), Prob. (0.383)		J-Bera (4.289), Prob. (0.117)		J-Bera (0.879), Prob. (0.644)	
Heteroscedasticity	ARCH Test (2.546), Prob.Chi-Square (0.111)		ARCH Test (0.108), Prob.Chi-Square (0.742)		ARCH Test (2.999), Prob.Chi-Square (0.083*)		ARCH Test (2.729), Prob.Chi-Square (0.099*)	
RMSE	168.165		377,245.000		1,219.412		289.324	

Source: Authors' results. * indicates significance level at 0.10 level, ** indicates significance level at 0.05 level, *** indicates significance level at 0.01 level

sive the price of gold, and when the real inflation of the value of wealth decreases, the capital owner will transfer his capital to the gold commodity as a means of hedging. The transfer of capital to this gold commodity will increase the demand for gold in the derivative market **so** that it will cause the gold price to increase. The results of this study are in line with the findings of Le and Chang, (2011), Samanta and Zadeh (2012), Weng (2012), Nasrinejad and Raeisi (2013), Reboredo (2013), Seemuang and Romprsert (2013), Tufail and Batool (2013), Sukri *et al.* (2015), Gangopadhyay *et al.* (2016) but contrary to findings from investigators Van Hoang *et al.* (2016).

The influence of world oil price (OIL) on gold prices in the derivative market in this study was found to have a positive and significant influence on the 99% confidence level. Any world oil price rising by 1% will drive up the price of gold in the derivative market by about 6.988% or vice versa. This result has an accuracy of 99% confidence level as evidenced by a p-value of 0.000. The results of this study are in line with Le and Chang (2011), Toraman *et al.* (2011), Samanta and Zadeh (2012), Weng (2012), Sukri *et al.* (2015), explained that in the long term the price of crude oil had a positive and significant effect on the price of gold in the derivative market, but contrary to the findings of Nasrinejad and Raeisi (2013), Gangopadhyay *et al.* (2016). Table 5 shows several research results related to the relationship between oil prices and gold prices.

Source: Author's result.

Based on these findings it can be concluded that gold can not be used as a means of hedging against petroleum.

The change of the Dollar index (USX) in this study, statistically has a significant effect on the gold price in the opposite direction. This result has an accuracy of 99% confidence level as evidenced by a p-value of 0.000. With each dollar index increase by 1 point, the price of gold will drop by 12.603 points or vice versa. The decrease in the Dollar index resulted in buying gold with foreign currency forming the Dollar index will be cheaper, this will encourage investors to buy more gold which will eventually increase demand for gold. This increase in gold demand will cause the price of gold in the derivative market to increase, or vice versa. These findings contradict the results of Nasrinejad and Raeisi (2013), Seemuang and Romprsert (2013) studies but support the findings of Capie *et al.* (2005). Table 6 shows several research results related to the relationship between the dollar index and gold prices.

The influence of the Dow Jones index (DOW) on the gold price in this study can not be rejected because the p-value of the Dow Jones Index variable is lower than the 1% at the 99% confidence level. The rise of the Dow Jones index of 1 point will bring down the gold price by about 0.019 points or vice versa. The rise in the Dow Jones index, providing expectations for investors to gain an investment advantage in the stock market, so investors will divert their funds from gold to stocks or bonds. The impact of this condition will cause the gold demand to decrease, so the gold price will decrease or vice versa. These findings can indicate that gold can be used as hedging advice and Safe Heaven from stock.

The results of this study support the findings of Hood and Malik (2013), in periods of low volatility and high volatility, the gold price does not affect the US stock market and findings Samanta and Zadeh (2012), Tufail and Batool (2013), Gangopadhyay *et al.* (2016) explaining that there is a negative relationship between the stock price index and the gold price. The findings of this study are not in line with Baur and Lucey (2010), Weng (2012). Table 7 shows several research results related to the relationship between stock and gold prices.

Based on the results of this study, the economic crisis affects the gold price statistically. This result is supported by a p-value of the economic crisis variable (CRI-

Table 5. Research on the relationship between oil and gold prices

No	Author	Year	Conclusion
1	Le and Chang	2011	Support
2	Toraman et al	2011	Support
3	Samanta and Zadeh	2012	Suport
4	Weng	2012	Support
5	Sukri et al	2015	Support
6	Nasirnejad and Raeisi	2013	Contrary
7	Gangopadhyay	2016	Contrary

Table 6. Research on the relationship between the dollar index and gold prices

No	Author	Year	Conclusion
1	Capie *et al.*	2005	Support
2	Seemuang and Romprsert	2013	Support
3	Nasirnejad and Raeisi	2013	Contrary

Source: Author's result.

Table 7. Research on the relationship between stock and gold prices

No	Author	Year	Conclusion
1	Hood and Malik	2013	Support
2	Samanta and Zadeh	2012	Support
3	Tufail and Batool	2013	Support
4	Gangopadhyay, et al	2016	Support
5	Baur and Lucey	2010	Contrary
6	Weng	2021	Contrary

Source: Author's result.

SIS) of 0,000 lower than the 1%. Based on these findings, it can be explained that there is a marked difference in the price of gold between the crisis conditions and not the crisis. The price of gold during the crisis was lower by about $ 66.130 / Troy Ounce compared to the time of the crisis. This condition proves, that gold can be used as a means of hedging during the crisis but not as an asset that has Safe Heaven. This finding is in line with the results of Kong (2011) research.

The inflation variable (CPI) and oil price (OIL) individually have a positive effect on the gold price, but together the interaction of these two variables is significant in decreasing the gold price. This statement can be proved with a p-value of less than 1%. This can be said, there is a moderation effect between oil prices and inflation on the gold price. If the interaction of oil prices with inflation shows a decline in value, this will push the price of gold to rise, or vice versa. This fact proves that in general, gold can be used as a means of hedging the occurrence of rising oil prices and inflation. The findings of this study indicate that the moderating effect between the CPI and Oil variables harms gold prices. This proves that the moderating effect can weaken or strengthen the relationship between the independent variable and the dependent variable. This finding is in line with the study (Mantari and Nuryasman, 2017), that moderation effects can strengthen and weaken the relationship between an independent variable to a dependent variable.

The volatility of the price of gold in the derivative market during the study period is influenced by the residual price of gold in one previous period in a positive direction. The greater the residuals of the previous gold price, the higher the current gold price, or vice versa. The current gold price volatility is higher by 0.712% if there is an increase in the previous gold residual of 1% or vice versa.

In addition to the above, the volatility of gold prices in the derivatives market is influenced by the variation of the previous period gold price with the positive direction, the current gold price volatility is greater by 0.873% if there is a change of the previous price variation of 1% or vice versa. But inversely with the variation of gold price in two previous periods, if the price of gold in two previous periods increased by 1%, this will cause the volatility of gold price in the derivative market today to decrease by 0.200% or vice versa. This empirical evidence illustrates that the volatility of gold prices in the derivatives market will be more influenced by the variation in gold prices of the previous period.

The implication of these findings, for investors in the short term, should consider more variations of the gold price of a previous period, but in the long run, the variation of the gold price of the previous two periods needs to be another consideration.

Another notable finding in this research is that the world's gold derivatives market is very sensitive to the existence of asymmetric information, bad news, or good news. The residual condition of one previous period has a coefficient value smaller than 0 (-0.712) and the previous two periods have a coefficient value greater than 0 (0.009), both of which are significant at a 99% confidence level. This means that the bad news in the previous period will accelerate the increase (decrease) of gold prices, while the two previous periods with a residual coefficient value greater than 0, will increase the volatility of gold prices in the derivatives market due to negative information. This empirical evidence illustrates that the world gold market has a leverage effect that is extremely vulnerable and sensitive to changes in information related to the demand and supply of gold.

The volatility of gold price in the derivative market in period 1 is high, as evidenced by the value of $a_1 + b_1$ (0.713 + 0.873 = 1.586) is greater than 1 whereas in the second period the price of gold volatility is low due to the value of $a_1 + b_2$(0.713 - 0.200 = 0.513) is smaller than 1 (Piot-Lepetit, 2011).

The magnitude of the effect of negative information on the volatility of gold price in the first period is 0.001 (0.713 - 0.712) smaller than the impact of positive information 0.713. In the second period, the effect of negative information on the volatility of the gold price of 0.722 (0.713 + 0.009) is greater than the impact of positive information. These results indicate that the world gold market in the early periods will be more responsive to positive information and then more react with various negative information.

5. CONCLUSION

The study concludes that the best model for predicting future gold prices is TGARCH (1,2,2). Inflation and oil prices are statistically significant in determining the price of gold. The dollar index, Dow Jones index, and economic crisis statistically hurt the gold price. While the interaction between inflation variables and oil prices hurt world gold prices.

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