Macroeconomics Determinations of Gold Price in United States

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ABSTRACT

Nowadays, gold prices have been volatile, and the wealth of gold investors depend on the movement of gold prices. The purpose of this study is to examine the relationship between gold prices, crude oil prices, inflation rate, real interest rate and stock prices in United States. This study uses monthly data covering the period ranging from January 1990 to August 2018. The Johansen and Juselius (JJ) Cointegration test and Vector Error Correction Model (VECM) are conducted in this study. The result shows that there is a long-run relationship among gold prices, crude oil prices, inflation rate, real interest rate and stock prices. The results show that inflation rate and crude oil prices are significance and positively related to gold prices, while stock prices and real interest rate are negatively affecting gold prices. There are three unidirectional Granger causality and one bidirectional Granger causality in the short run. Only inflation rate Granger cause gold price, which means that inflation rate directly affects the gold prices. This study allows community such as central bank, government, financial institution, economist, investor and policy makers in manipulating and controlling the movement of the gold prices so that they have a better decision making to diversify their risks.

Key Words: Crude Oil Prices, Gold Prices, Vector Error Correction Model (VECM), Granger Causality

INTRODUCTION

According to Andrew (2018), gold is one of the oldest means of exchange and can be considered as one of the precious metal. In fact, gold is both a commodity and a currency because of its intrinsic value. The Classical Gold Standard was the first international monetary system developed. According to Sukri, Zain and Abidin (2015), since thousands of years ago, many people have been fascinated by gold. It is because gold is a light, generally accepted and durable metal. Based on Hashim, Ramlan, Razali and Nordin (2017), many years before, man y people declared that gold was a symbol of prosperity and also wealth. Before fiat money, gold was used as a currency and now it is used as an investment both in computer and jewelry. Based on Eric (2012), most of the businesses are likely to make the gold into jewelry to attract more consumers. Hence, the jewelry is made by consuming around 78% of gold and it is the main use of gold in different cultures.

Gold also helps to offset the big losses that suffer by investors such as the risk of asset depreciation or investment losses, and thus it is also known as a hedging tool. The investors will use gold as an asset to hedge against the highest risk when the economy is unstable or cannot be expected. As a result, gold has become a possible financial staple. Basically, investors invest in gold mainly to hedge against inflation and political turmoil in their investments because gold acts as a commodity which can reduce the portfolio risk. It means that when the rate of inflation increases, then the gold price will also rise. Gold is also classified as a financial asset, in addition regarded as a commodity. That means that gold is a safe storage as it is a store of wealth. Today, gold has attracted many of the investors to keep or invest in it as future assets investment. According to the study by Wang (2013), the future value of gold is more liquid compare to paper money or stock as gold is one of the hedging tools. On the other hand, in year 2018, there was a trade war between China and United States (US). According to Nick (2018), US want to raise 10% to 25%, which is $200 billion of the tariffs on Chinese goods because Washington has increased its control over the increasingly fierce US-China trade war. In response to these 'rumors' China said that they would take appropriate measures. Basically, the investors will seek for the gold to reduce their risk (Nick, 2018). However, based on Figure 1, we can clearly see that the gold price decreased to USD122 per troy ounce from March 2018 to August 2018. It means that gold remain weak, pressed by a weak Chinese Yuan and a strong US dollar. The expectations of higher US interest rates continue with a third 0.25% increase in this year which has already reflected in September and the fourth in December. Thus, the relationship between gold prices and other assets prices assumes that the investors' predictions will towards the unforeseen circumstances. It is

imperative to know how gold prices react to the adjustments in rate of inflation, crude oil prices, stock prices and real interest rate.

Figure 1 demonstrates the fluctuations of gold prices in the end of the month from January 1990 to August 2018. It is shown clearly that the gold price has risen since January 1990 at the price of USD 415.1 per troy ounce. In year 2008, the price of the gold decreased due to the subprime mortgage crisis and the gold buyers who leveraged purchase the gold previously were forced to sell their holdings. Therefore, the gold prices seem to be positively correlated with the negative shocks in stock markets (Baur & McDermott, 2010). Besides, this trend has kept on growing until August 2011, when the gold price has recorded the highest at USD1813.50 because of the standard downgrade and poor rating of US Treasury Bond from AAA to AA+ (Hashim et al., 2017). As a result, the investors lost faith in the US paper money and then increased the demand of gold and eventually its price.

In the year 2015, due to the revitalization of US economy, the interest rate of US has increased. Thus, the gold prices fall and the investors are reluctant to invest in gold thus caused the demand for gold to decline. During the year 2016, the speculation in the energy market, the poor performance of Chinese stock market and also the decision of Britain I leaving the European Union were viewed as the factors causing the spike in the gold price (Dan, 2017).Hence, the gold price increases in early 2016 as many investors thought that gold is safe-haven against the bad economy. However, since September 2016, the gold price has fallen by more than USD200 per ounce as many of the underlying issues in financial markets have disappeared. In March 2018, the gold price started to drop from USD1323.85 to USD1202.45 in August 2018 due to the falling of US bond prices (Adrian, 2018).
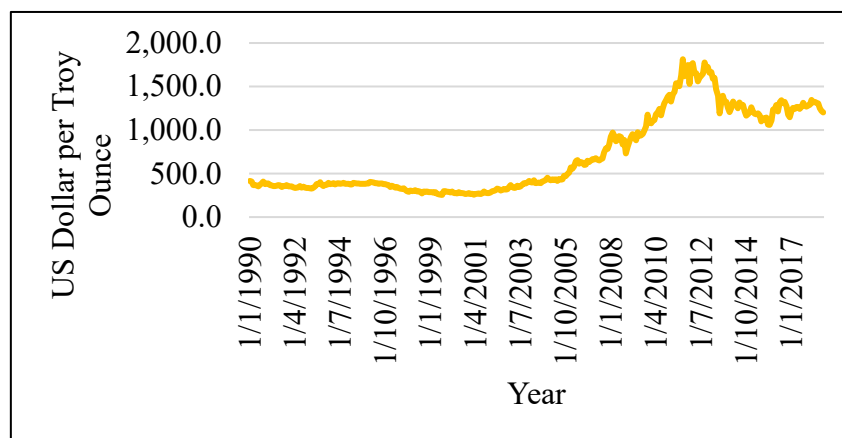

Figure 1: Historical Gold Price (End of period), Jan 1990 – Aug 2018. Source: World Gold Council (2018).

Figure 2 demonstrates the Brent spot prices (crude oil prices) in United States from January 1990 to August 2018. Crude oil is the main source in gold mining and it plays an essential role in the advancement of the world economy. According to GlobalSecurity (2018), the crude oil prices increase is due to the shortage of refineries in order to meet the growing demand for crude oil prices. In July 2008, crude oil price has recorded the highest atUSD132.72 as Saudi Arabia failed to increase its production and demand. In the year 2009, after the subprime crisis broke out, crude oil prices recovered rapidly and fell back to USD68.61 per barrel in June 2009. The price continues to rise and hit a new peak in the year 2011, which mainly due to the growth in the emerging markets such as the Middle East and China (U.S Energy Information Administration, 2018). From June 2014 to January 2016, the crude oil prices exceeded its demand and then fell sharply to USD57.58 per barrel. Since then, the crude oil price has increased until recently in August 2018 as the members of the Organization of the Petroleum Exporting Countries (OPEC) decided to cut the production of crude oil (U.S Energy Information Administration, 2018).

Based on the inflation rate in Figure 3, it shows the fluctuations of inflation rate over time from January 1990 to August 2018 in the United States. The inflation rate in the US remains constant at less than 0.5% in most countries except for a few years. The highest inflation rate is 1.22% in September 2005 due to the recession in the US's economy. Under the economic effects of Hurricane Katrina, the price of oil, gasoline and other energy resources rise sharply (Charles, Darne & Kim, 2015). The lowest inflation rate is -1.92% in September 2008, just before the crash that led to deflation. During the year 2008, the financial institutions around the world collapsed. The demand for consumer products has fallen sharply in recent months, since the credit crisis erupted in mid-September 2008.
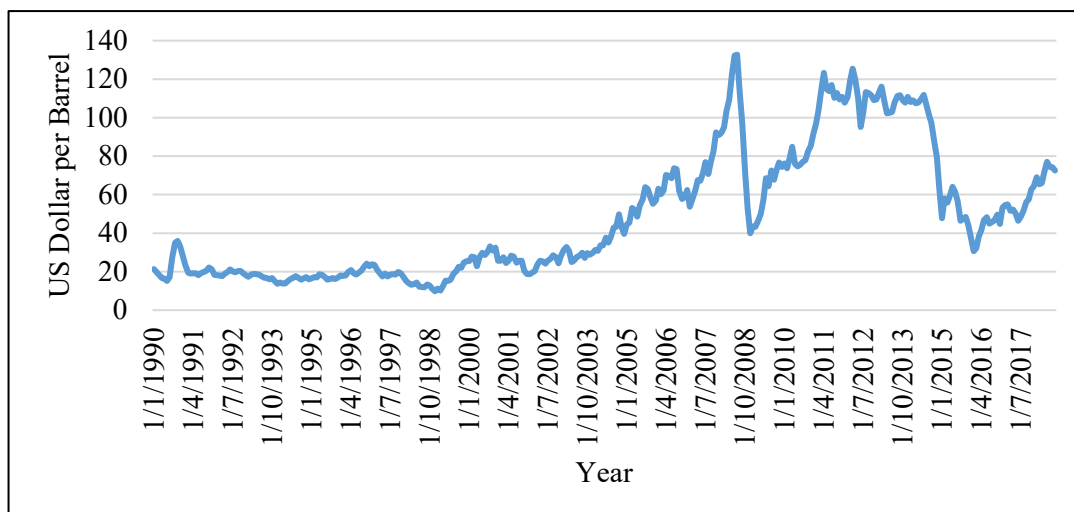
Figure 2: Crude Oil Prices (Brent spot prices), Jan 1990 – Aug 2018. Source: U.S Energy Information Administration (2018).
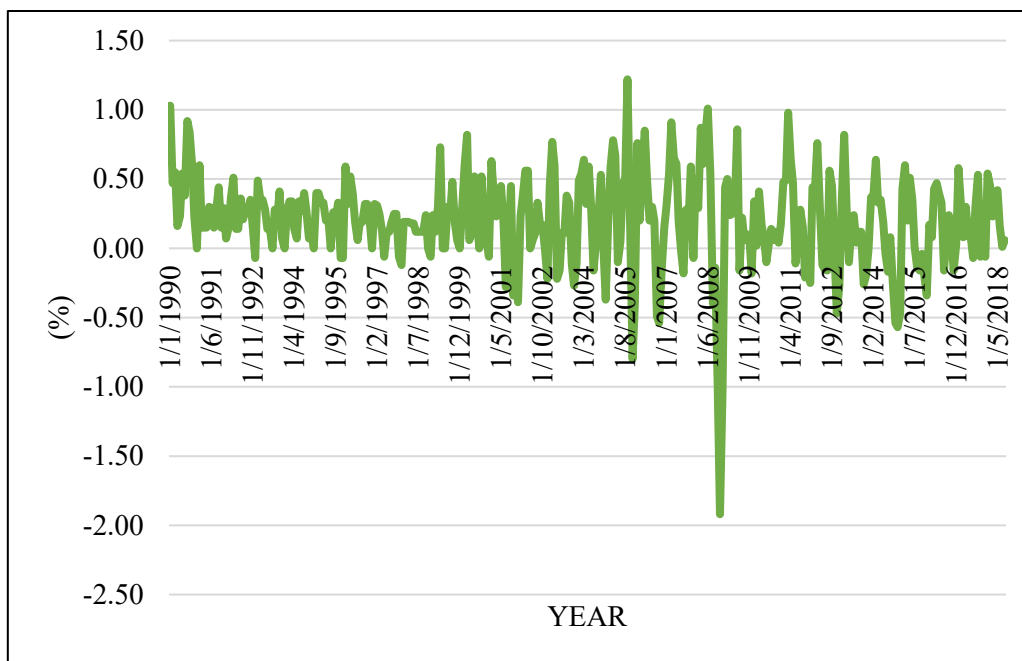
Figure 3. Inflation Rate in United States, Jan 1990 – Aug 2018. Source: StatBureau (2018).

S&P500 Adjusted Close Price (Stock Prices) in United States

Figure 4 demonstrates the volatility of stock prices (S&P 500) in the United States. The Standard & Poor's 500 (S&P 500) index which is a composite index of the US stock market, consists of the market capitalization of the 500 companies recorded on NASDAQ or the New York Stock Exchange (NYSE). It is a benchmark for the investors representing the overall performance of the US stocks and basically, the price of stock index shows an upward trend. From January 1990 to August 2018, the stock price has increased by 781.71% in the S&P 500 index. This shows that the US economy is growing rapidly. However, there is a drop between August 2000 to March 2003 by 44.11% due to Dot-Com Bubble and the tech stocks were getting a hard hit, corporate profits declined, and businesses cut spending. After that, the stocks start to recover. According to John (2018), the financial crisis in the year 2008 caused serious damage to the stock market. The stock price has fallen by 38.5% of its value at the height of the Great Recession.
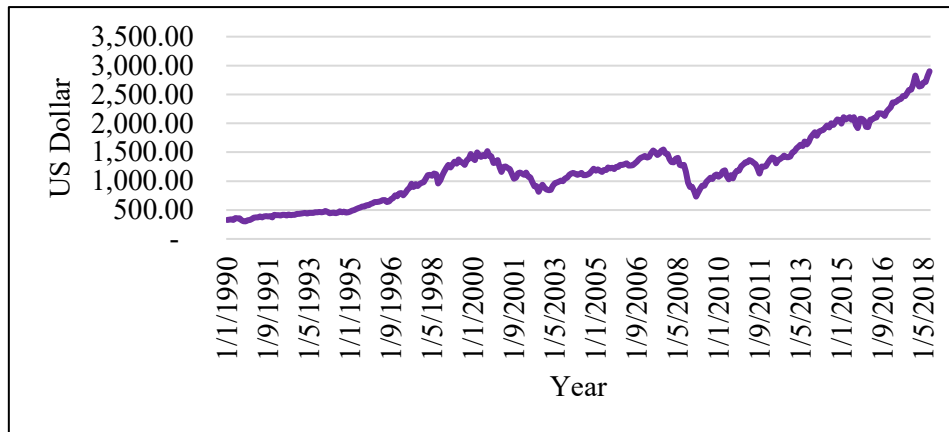
Figure 4. Standard & Poor's 500 Index, Jan 1990 – Aug 2018. Source: Yahoo Finance (2018).

Real Interest Rate in United States

Based on Figure 5 below, it shows the real interest rates (yields on 10-Year Treasury Constant Maturity Rate minus Consumer Price Index for All Urban Consumers) in the United States from January 1990 to August 2018. Overall, it can be noticed that the real interest rates are still stabilizing below 5% to maintain the economy health except for few years. On November and December 1994, the real interest rates are more than 5% due to the Fed raised rates to keep growth and inflation in a healthy range However, due to financial crisis in late 2007, the Fed cuts the nominal rates again then followed by a sharp decrease in the real interest rates and a surge in the gold prices. The real interest rate has risen after the financial crisis as the Fed expanded its mortgage purchasing program and said it would buy USD750 billion in mortgage-backed securities. Since December 2011, the yield has been negative as the investors expected a high inflation in the life of the bond (Richard & Yang, 2013). When there is financial crisis in 2008, the Fed brought down its benchmark rate, which is the rate that is charged by the banks to the borrowers at almost zero in order to encourage lending and stimulate the economy. However, at a high inflation rate of -0.25%, the real interest rate turns negative. Since January 2016, it shows negative as European Central Bank (ECB) introduced negative interest policy and then cut the short- term and long-term interest rate on its deposit facility to below zero. After August 2016, the real interest rate increases again from -0.74% to 0.71% as the Fed increases the interest rate and causes dollar to appreciate against major currencies.
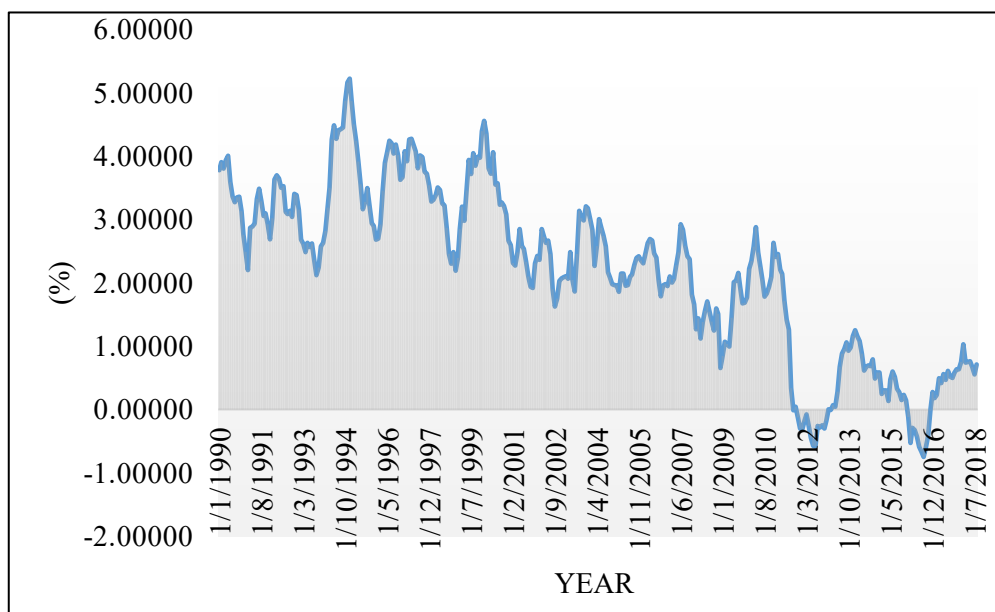
Figure 5. Real Interest Rate, Jan 1990 – Aug 2018. Source: Board of Governors of the Federal Reserve System (2018).

LITERATURE REVIEW

Most of the literatures show that there are certain relationship between gold prices, real interest rate, prices of crude oil, inflation rates and the stock prices. However, the nature of these relationships may vary from one and another due to different data used as proxy of certain variables and also different types of method, time periods and countries used.

Based on the prior studies, the relationship between gold price and inflation is complex. Some researchers support their findings because gold is used to hedge against inflation. For example, Seemuang and Romprsert (2013) and Hashim et al. (2017) found that gold price is statistically significant and positive correlated with inflation in their research. Since gold is a hedge against inflation, higher inflation in the economy will increase the demand for gold in the market. Moreover, Lampinen (2007) found that gold price and US inflation change has a statistically significant and positive short run relationship. He also proved that gold price has a long run relationship with US price level. On the contrary, Sukri et al. (2015) and Ibrahim (2014) found gold price is negatively correlated with inflation rate. On the other hand, Tully and Lucey (2006) and Blose (2010) pointed out that gold prices and inflation rate do not have significant relationship and that unexpected changes in inflation rate would only affect the risk-free rate and gold holding cost, rather than the spot price of gold. Hence, the interaction between gold price and inflation was not yet clear.

Most of the studies conclude that the crude oil will affect the gold prices. In recent years, gold and crude oil the biggest components of commodities, have moved beyond the traditional effects of supply and demand. Hashim et al. (2017) and Sukri et al. (2015) found that gold price is positively correlated with crude oil prices. Besides, Sari, Hammoudeh and Soytas (2010) also pointed out that crude oil prices and gold prices has a significant positive elasticity in the short-run. Narayan, Narayan and Zheng (2010) showed that gold and crude oil prices had a bilateral relationship and can be interpreting by inflation channel. When oil prices rise, it can lead to inflation. Thus, higher oil prices mean higher gold prices. However, it was opposed by Zhang and Wei (2010) and Sari et al. (2010). They found that crude oil price has a positive but not bilateral relationship with gold price. Hence, there is an ambiguity about the relationship between Brent crude oil prices and gold prices.

There are only few of studies that observed the effect of financial market such as stock onthe gold prices. Baur and McDermott (2010), they found that as volatility of stock return increased, gold acted as a safe haven to hedge against uncertainty only in all European markets and United States. The result is supported by Ghazali, Lean and Bahari(2013) who found that gold acts as a weak safe haven for stockholders in developing countries such as Malaysia during market downturn. Besides, Baur and Lucey (2010) concluded that gold price is negatively correlated with stock price and gold only acts as a hedge for stocks in the short-run. Narang and Singh (2012) also found that gold price have no relationship with stock price in the long-run. Most studies have concluded that there is no directional causality in the long run.

In addition, previous researches have summarized the relationship between gold price and real interest rates. According to the World Gold Council (2018), the price of gold responds to the interest rate of the United States through the investment channels, and global investment from all over the world accounts for more than 25% of gold demand. Seemuang and Romprsert (2013) and Zakaria, Shukur and Affandi(2015) concluded that the relationship of US interest rates and gold prices was inversed. Besides, Ghosh, Levin, Macmillan and Wright (2004) found that the variables such as real interest rate would interfere with the equilibrium price of gold and lead to the fluctuation of gold price. The short-term relationship of gold was more significant than the long-term relationship. Hashim et al. (2017) also supported this result, declaring that the most important factor that affect gold price is real interest rate.

METHODOLOGY

As our objective is to investigate the relationship between crude oil prices, inflation rate, stock prices, real interest rate and gold prices. Gold price is the dependent variable and prices of crude oil, real interest rate, stock prices and the inflation rate are the independent variables. Besides, the monthly data is used from January 1990 to August 2018 which consists of 344 observations for each variable. The empirical model employed to investigate the relationship between gold price, stock price, crude oil price, exchange rate and inflation rate can be expressed as follow:

The functional model is as follow:
$$GP = f\left(OIL, INF, SP500, INT\right)$$

To estimate the experiment model, the regression model is performed as follow:

$$LGP_t = \beta_0 + \beta_1 LOIL_t + \beta_2 LINF_t + \beta_3 LSP500_t + \beta_4 LINT_t + \varepsilon_t \qquad (1)$$

where LGP_t = the natural logarithm price of gold in t^{th} month; $LOIL_t$ = the natural logarithm price of crude oil in t^{th} month; $LINF_t$= the natural logarithm rate of inflation rate in t^{th} month; $LSP500_t$ = the natural logarithm price of S&P 500 index in t^{th} month; $LINT_t$= the natural logarithm rate of real interest rate in t^{th} month; β_0 = the constant term; β_1, β_2, β_3 and β_4 = coefficient to measure the impact of crude oil prices, inflation rate, S&P 500 index and interest rate on the gold prices respectively; and ε_t = error term.

Unit Root Test
The empirical testing methods employed is the unit root test to examine the stationary of each variable. The Unit Root test in this study consists of Augmented Dickey-Fuller (ADF) test, Phillips-Perron test and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. ADF tests use parameter autoregressive to approximate the ARMA structure of errors. Hence, higher order of autoregressive process can be applied in the ADF test as follows:

$$\Delta y_t = \delta_0 + \delta_1 t + \delta_2 Y_{t-1} + \alpha_1 \sum_{i=1}^{k} \delta_3 \Delta Y_{t-1} + \mu_t \qquad (2)$$

where Δ symbol is the first difference, k is lag value, variable ΔY_{t-1} express as lagged first differences, μ is the adjustment of error, and Y represents the variable under study. The optimum lag length is selected according to Akaike Information Criterion (AIC).

For PP test, unit root tests might be bias if it did not account for structural breaks that explain for permanent changes in the pattern of time series. The equation of PP test can be written as below:

$$\Delta Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 \left(t - \frac{T}{2}\right) + \mu_t \qquad (3)$$

where Y_t is the time series that represented as μ_t defined as the innovation term, t is represented as the number of observation, $\alpha_0, \alpha_1, \alpha_2$ are the conventional least-squares regression coefficients. Moreover, KPSS is unique whereby this approach testing the unit roots by reversing the null and alternative hypothesis which is different with ADF and PP unit roots and the test can be used to examine the properties of time series data.
The KPSS statistic is based on the residuals from the OLS regression of y_t on the exogenous variables $x_t : y_t = x_t \delta + \mu_t$. The LM statistic is defined as:

$$LM = \frac{\sum_i^t S(t)^2}{(T^2 f_0)} \qquad (4)$$

where, f_0 is an estimator of the residual spectrum at frequency zero and where $S(t)$ is a cumulative residual function:

$$S(t) = \sum_{r=1}^{t} \widehat{u}_t \qquad (5)$$

Based on the residuals $\widehat{u}_t = y_t - x_t^{\widehat{\delta}}(0)$. We note that the estimated use of δ by Generalized Least Square (GLS) detrending as it is based on regression including the original data rather than quasi-differenced data. To specify the KPSS test, the set of exogenous variables x_t and the method for estimating f_0 must be specify.

Johansen and Juselius (JJ) Cointegration Test
After identifying the stationary level of the variables, the Johansen Cointegration Test is conducted to examine the long run relationship between the variables. The system based on the cointegration procedure developed by Johansen and Juselius (1990) to tests the existence of long-run equilibrium. Let x_t be a vector of n time series, the Vector Auto Regression (VAR) can be written as shown below:

$$\Delta x_t = \pi x_{t-1} + \sum_{i=1}^{k-1} \pi_i \Delta x_{t-i} + \varepsilon_i \qquad (6)$$

where x_t = the (5 × 1) vector of an $I(1)$ variable;
π and π_i= a (5 × 5) coefficient matrixes and a (5 × 1) constant vector;
ε_i = error term which is normally distributed at zero mean with covariance matrix of Ω;
k = the lag length; and
Δ = the first difference operator.

Johansen procedure use two like-hood ratio to determine the number of cointegrating vectors which are the trace test and the maximal eigenvalue (λ-max) test.

Vector Error Correction Model (VECM) Granger Causality

After the detection of cointegration, the Vector Error Correction Model (VECM) Granger causality test will be employed to test the short-term relationship among the variables. Although cointegration implies the presence of granger causality, it does not necessarily determine the direction of causality between variables in the short term. The temporal granger causality can be captured by VECM from long-term cointegration vectors (Granger, 1986). Therefore, VECM is a special case of VAR that cointegrates the variables. The VECM granger causality test is to determine the short-run and long-term relationship between gold prices, inflation rate, crude oil prices, real interest rates and stock prices. The error correlation terms (ECTs) are used to avoid misspecification and omissions of constraints. The equation is as follows:

$$\Delta LGP_t = \alpha_1 + \sum_{i=1}^{k} \beta_{\gamma,i} \Delta LGP_{t-i} + \sum_{i=0}^{k} \gamma_{x,i} \Delta LOIL_{t-i} + \sum_{i=0}^{k} \gamma_{x,i} \Delta LINF_{t-i} + \sum_{i=0}^{k} \gamma_{x,i} \Delta LSP500_{t-i} + \sum_{i=0}^{k} \gamma_{x,i} \Delta LINT_{t-i} + \varphi_y ECT_{y,t-1} + \varepsilon_{y,i}$$ (7)

where ECT_{t-1} is the error correction term for one period lagged

β is the parameter

φ_y is measuring the error correction mechanism to long-term equilibrium relationship between the variables.

EMPIRICAL FINDINGS

According to Table 1, for ADF and PP test, all of the variables (LGP, LOIL, LINF, LSP500 and LINT) are non-stationary at level, which means they have a unit root. It is because the *p*-value of all the variables are greater than 5% significance level, so the null hypothesis is not rejected. However, at first difference, since their *p*-value is smaller than 5% significance level, so the null hypothesis is rejected. It means that the variables are stationary after first difference. For KPSS, the same result is obtained since the null hypothesis of KPSS indicated that the variables are stationary, which is opposite to the null hypothesis of ADF and PP. Overall, the time series variables are non-stationary at level but become stationary after first difference, *I*(1). The findings show that all the variables have the same order of integration allowing us to proceed with the Johansen cointegration analysis. The results reflected in the Table 1 shows the common integrational properties of all the series under the investigation and this allow us to proceed with the cointegration tests for the five-dimensional systems which consists of LGP, LOIL, LINF, LSP500 and LINT. Johansen cointegration test was applied in this study to test for the long run equilibrium between these variables.

Table 1. Unit Root Test Results**.**

	ADF		PP		KPSS	
Variables	**Intercept**	**Trend and intercept**	**Intercept**	**Trend and intercept**	**Intercept**	**Trend and intercept**
A: Level						
LGP	-0.263(0)	-1.859(0)	-0.202(1)	-1.859(0)	1.844(15)**	0.357(15)**
LOIL	-1.576(1)	-2.720(1)	-1.353(6)	-2.524(5)	1.789(15)**	0.221(15)**
LINF	-1.990(2)	-2.267(2)	-2.771(13)	-2.052(11)	2.253(15)**	0.406(15)**
LSP500	-2.087(4)	-0.416(4)	-1.588(31)	-3.157(0)	2.074(15)**	0.446(15)**
LINT	-2.193(1)	-1.998(1)	-2.457(9)	-2.297(9)	3.871(0)**	1.352(0)**
B: First Difference						
LGP	-20.613(0)**	-20.623(0)**	-20.624(1)**	-20.635(1)**	0.347(2)	0.145(40)
LOIL	-14.057(0)**	-14.036(0)**	-13.618(11)**	-13.593(11)**	0.060(7)	0.060(7)
LINF	-11.939(1)**	-12.106(1)**	-9.912(20)**	-9.943(23)**	0.380(2)	0.050(13)
LSP500	-12.586(3)**	-12.816(3)**	-37.131(46)**	-48.498(67)**	0.311(42)	0.101(50)
LINT	-13.888(0)**	-13.927(0)**	-14.241(6)**	-14.265(6)**	0.107(9)	0.061(9)

Notes: The ADF, PP and KPSS tests are based on the null hypothesis of unit roots (non-stationary). ** denotes statistically significant at 5% significance level. Lag length for ADF and maximum bandwidth for PP have been chosen based on Schwarz's Information Criteria (SIC) and Newey-West Bandwidth respectively. Figures in parentheses are the lag lengths.

Table 2 indicates the results of Johansen and Juselius Cointegration test. According to the Likelihood Ratio Trace test, the null hypothesis of no cointegrating vector (r = 0) has been rejected under 5% significance level. This indicate that the series has one cointegrating vector. Besides, the Maximum Eigenvalue test also shows one rejection of null hypothesis which are no cointegrating vector ($r = 0$) at 5% significance level. We noted that both of the trace and the maximum eigenvalue test do not lead to the same conclusion. The result of trace shows that there have two cointegrationg vectors ($r = 2$) while maximum eigenvalue shows that there is only one cointegrating vector ($r = 1$). Since maximum eigenvalue is a more powerful test, hence it can be concluded that there is only one long run relationship exists between LGP, LOIL, LINF, LSP500 and LINT. The rejection of the null hypothesis of no cointegration implies that the five variables do not drift apart and share at least a common stochastic trend in the long-run. In short, there is only one cointegrating vector ($r = 1$).

Table 2. Results of Johansen and Juselius (JJ) Cointegration Test.

Null	Alternative	Trace		λmax	
		Unadjusted	95% CV	Unadjusted	95% CV
r = 0	r = 1	84.9844**	69.8189	35.9330**	33.8769
r ≤ 1	r = 2	49.0514**	47.8561	25.2929	27.5843
r ≤ 2	r = 3	23.7585	29.7971	14.1408	21.1316
r ≤ 3	r = 4	9.6177	15.4947	7.0284	14.2646
r ≤ 4	r = 5	2.5893	3.8415	2.5893	3.8415

Table 3 indicates the long-run relationship between the parameters of interest. For normalizing the cointegrating vectors, the estimated sign for the parameter normalizing between LGP, LINF, LOIL, LINT and LSP500 is consistent with the prior expectation. The result shows that LGP, LINF, LOIL, LINT and LSP500 are statistically significant at 5% significance level as the *t*-statistic of LINF (1.9750), LOIL (4.8513), LINT (2.4812) and LSP500(3.9663) are greater than its critical value, which is 1.96. Based on the table above, LINF and LOIL have positive relationship with LGP. This indicates that 1% increase in LINF and LOIL will lead to 4.99% and 1.7% increase in LGP respectively. Besides, LINT and LSP500 have negative relationship with LGP, which indicate a1% increase in LINT and LSP500 will lead to 0.72% and 1.69% decrease in LGP respectively. The normalizing equation is shown below:

$$LGP_t = 15.3104 + 4.987LINF + 1.7007LOIL - 0.7197LINT - 1.6932LSP500$$

Table 3. Normalizing the Cointegrating Vectors.

Variables	LGP	LINF	LOIL	LINT	LSP500	C
Coefficient	-1.0000	4.9869	1.7007	-0.7197	-1.6932	15.3104
t-statistic	-	1.9750**	4.8513**	-2.4812**	-3.9663**	-

Notes: Trace refers to Likelihood Ratio Trace Test while Max refers to Maximum Eigenvalue Test. k represents the optimal number of lag and r represents the number of cointegration vector(s). The lag length chooses according to the Schwartz criterion (SC). ** denotes the rejection of null hypothesis at 5% significance level.

Based on Table 4, the results indicate that there are three unidirectional Granger causality, which are running from (i) LINF to LGP, (ii) LOIL to LINF and (iii) LSP500 to LINT in the short-run. Besides, there is one bidirectional Granger causality between LINF and LSP500. There is only one independent variable that granger caused the gold price, which is the inflation rate. It means that the inflation rate plays an important role in determining the gold prices. Figure: 6 indicates the causality relationship among the variables in diagram.

From Table 4, Error Correction Model (ECT) is applied on ΔLINF and ΔLSP500 as both of the results fulfil all the condition of ECT. The *t*-statistic of LINF is 3.5569 while LSP500 is 3.5997 which are all greater than 1.96. Moreover, the coefficient of LINF (-0.0008) and LSP500 (-0.3375) are significantly negative and less than one. The coefficient of ECT indicates the speed of temporal adjustment to long-run equilibrium in the system which is denoted by the cointegration relationship. In this manner, the adjustment for LINF is about 0.08% monthly and for LSP500 is about 33.75% monthly, which will take 1250 months (104 years) and 3 months (0.24 year) to

adjust to the long-run equilibrium due to the short-run shock. This implies that LINF and LSP500 bear the brunt of short-run adjustment to bring about the long-run equilibrium in the system.

Table 4. Results of Vector Error Correction Model (VECM) based Granger Causality.

Dependent Variables	x^2- statistics (p-value)					ECT	
	ΔLGP	**ΔLINF**	**ΔLOIL**	**ΔLINT**	**ΔLSP500**	**Coefficient**	*t*-statistics
ΔLGP	-	14.578 (0.012)**	5.182 (0.394)	3.493 (0.624)	4.912 (0.427)	0.0044	1.2274
ΔLINF	4.895 (0.429)	-	26.227 (0.000)**	3.824 (0.575)	18.090 (0.003)**	-0.0008	-3.5569
ΔLOIL	2.219 (0.818)	8.145 (0.148)	-	3.800 (0.579)	5.0377 (0.411)	0.0068	-0.9633
ΔLINT	2.268 (0.811)	4.786 (0.443)	3.5311 (0.619)	-	16.071 (0.007)**	-0.0081	-1.3922
ΔLSP500	2.747 (0.739)	22.260 (0.001)**	9.9031 (0.078)	0.571 (0.989)	-	-0.3375	-3.5997

Notes: ** denotes the rejection of null hypothesis at 5% significance level while the number in ( ) represents the *p*-value.
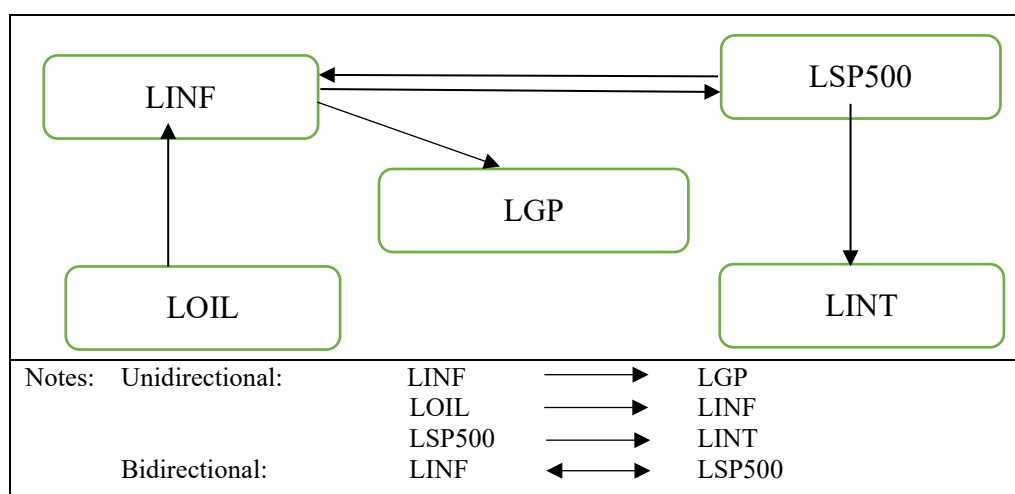
Figure 6. Summary of Short-Run Causality Linkages.

Diagnostic Test

There are three diagnostic tests used in this study, which are Jarque Bera Normality Test, Breusch-Godfrey (BG) Serial Correlation LM Test and White Heteroscedasticity. Based on Table 6, since *p*-value of Jarque-Bera Normality test (0.1783) is greater than level of significance (0.05), so we do not reject the null hypothesis. Thus, we can conclude that the error term is normally distributed. From the model, since *p*-value of BG test (0.8404) is greater than the level of significant (0.05), the null hypothesis will not be rejected. It can be concluded that there is no serial autocorrelation in the residual. Hence, the error term does not exhibit a serial correlation problem. Based on Table 5, since *p*-value of white test (0.3056) is greater than level of significant (0.05), the null hypothesis will not be rejected. Hence, it can be concluded that there has no heteroscedasticity problem in the model.

Table 5. Diagnostic Tests for the Underlying VECM Models.

Diagnostic tests	Probability	Significant	Conclusion
Jarque-Bera Normality Test	118.2177 (0.1783)	Statistically insignificant	Do not reject Ho, Normality distributed
Breusch-Godfrey (BG) Serial Correlation LM Test	18.0461 (0.8404)	Statistically insignificant	Do not reject Ho, No autocorrelation problem
White Heteroscedasticity	3069.072 (0.3056)	Statistically insignificant	Do not reject Ho, No heteroscedasticity problem

DISCUSSION

The primary purpose of this research is to examine the relationship between gold prices (LGP) and its determinants such as crude oil prices (LOIL), real interest rate (LINT), stock prices (LSP500) and inflation rate (LINF) in the United States from January 1990 to August 2018. First, this study starts with the Unit Root test and the empirical result of ADF, PP unit root test shows that all of the variables are non-stationary at level and stationary after first difference. For KPSS, the same result is obtained since the null hypothesis of KPSS is the variable is stationary, which is opposite to the null hypothesis of ADR and PP. Hence, it can conclude that all the time series variables are integrated at $I(1)$. All of the variables are statistically significance at 5% significance level. Overall, the time series variable is non-stationary at level but become stationary after 1st difference, $I(1)$, which proved that integration exist among all of the selected variables from the United States.

After that, we proceed to Johansen and Juselius (JJ) Cointegration test that test the long-run equilibrium between the dependent and independent variables. The results for both trace and maximum eigenvalue test are different. For trace test, there are two cointegrationg vectors (r = 2) while maximum eigenvalue test shows that there is only one cointegrating vector (r = 1). Since maximum eigenvalue is more robust, hence it can be concluded that there is only one long-run relationship between LGP, LOIL, LINF, LSP500 and LINT. In short, there is only one cointegrating vector (r = 1). This is consistent with the past studies. Levin and Wright (2006) proved that gold price had a long run correlation with the price level in United States. Zhang and Wei (2010) also showed that there exists a long run relationship between gold prices and oil prices. The spot and future markets of gold and oil up to maturity of 10 months were cointegrated (Narayan et al., 2010). Ghosh et al. (2004) also found that there is a long-run relationship between real interest rate and gold price. However, some of the previous studies found that there is no long-run relationship between the variables. Narang and Singh (2012) concluded that there is no relationship between stock returns and gold prices such as Sensex return in the long-run period. This may due to the different proxies or methodologies used in the estimations

Next, the results of the normalizing equation shows that the estimated sign for the parameter normalizing between LGP, LINF, LOIL, LINT and LSP500 is consistent with prior researches. LINF is positively correlated with LGP, which means that gold is proved to be an inflation hedge. Seemuang and Romprsert (2013) and Hashim et al. (2017) support this result as gold is used as a hedging tools against inflation. When inflation rate increases, the demand for gold will increase and lead to the improvement in price level of gold. Thus, the investors might be anxious and shift to gold in order to hedge against their risk. Moreover, LOIL and LGP have significance and positive relationship, which is approved by Hashim et al. (2017) and Sukri et al. (2015). It shows that when the price of crude oil rises, the price of gold will also increases as the crude oil is the main resource used in gold mining activity. Increment in the price of crude oil will also lead to either recession or inflation occurs and eventually caused a higher gold prices as demand increases. Narayan et al. (2010) showed that gold and crude oil prices can be interpreting by inflation channel. Hence, LOIL and LINF are positively related to LGP. Furthermore, LSP500 and LGP are negatively related as when the stock prices increase, the gold price will decrease as gold are deem as a more stable hedging tools and haven for stocks. This result is same as the previous studies by Baur and McDermott (2010) as they found that as the stock prices increased, gold acted as a safe haven to hedge against uncertainty mainly in the European and United States markets. The investors face a trade-off between financial securities and commodities since money is limited. In addition, the gold price is negatively correlated to real interest rate, which means that high interest rate will stimulate people to save and slow down their borrowing trends. Thus, the investors will cash out of their gold investments and flee money to capital markets in search of a higher returns. When the demand for gold decreases, the price of gold are expected to also decline. This finding is same as the previous studies made by Seemuang and Romprsert (2013) and Zakaria et al. (2015) who concluded that there is an inverse relationship between the interest rates and the gold prices in the US market.

According to the result, there are three unidirectional Granger causality, which are running from (i) LINF to LGP, (ii) LOIL to LINF and (iii) LSP500 to LINT in the short-run period. Besides, there is one bi-directional Granger causality exists between LINF and LSP500. Only one independent variable does Granger caused gold price, which is the inflation rate. It indicates that the inflation rate plays a vital role in the model and eventually affect the gold prices directly. Lampinen (2007) found that gold price and US inflation change has a statistically significant and positive short-run relationship, which is the same with our final finding. LSP500 is the most endogenous then followed by LOIL, LGP, LINF and LINT. Overall, about the model require an estimated of more than 100 years to settle down and return to the equilibrium by forecasting using the impulse response function.

CONCLUSION

In a nutshell, this research has achieved the general objective of finding the relationship among gold price, inflation rate, crude oil price, stock price and real interest rate during the periods of January 1990 to August 2018. All of the variables have long-run as well as short-run equilibrium relationship with the gold price in the United States. Furthermore, there are some limitations and recommendations have been discussed in order for the future researchers to make improvement and provide more contributions in future study. The findings in this study will be useful as it allow stakeholder such as the central bank, government, financial institution, economist, investors and policy makers in manipulating and controlling the movement of the gold prices. Thus, the economic players will clearly understand on how the macroeconomic variables can affect the gold prices especially as gold are viewed as an important tool to hedge against risk such as inflation and at the same time assist the community especially investors to diversify their risks.

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