Acta Universitatis Danubius
ŒCONOMICA

An Assessment of the Classical Relationship of Price Fluctuations between the Gold Market and the US Dollar

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Abstract: For many decades, the relationship between the gold market and the US dollar has dominated the international economy. In times of economic and policy uncertainty, the gold price traditionally increased, while in periods of growth and certainty, the US dollar usually appreciated compared to other currencies. This paper aims to re-assess this classic relationship and determine the causality between the gold market and the US currency. To achieve the objective of the study, a quantitative econometric methodology was utilised for the period 1995 to 2020. A Vector Autoregression model was estimated, including three variables: the gold market, US dollar index, and real GDP for the US. Interesting relationships and causalities between the three variables were estimated. The relationship between the gold market and real GDP seems stronger than the relationship between the gold and US dollar indexes. An important implication of this study is that changes in the gold price are not a significant indicator on its owns to track changes in the US currency. The value of the research is in the renewed analysis and updated coefficients on the long and short-run between the classic variables.

Keywords: Econometric analysis; gold market; price fluctuations; US dollar

JEL Classification: C3; E1

1. Introduction

For many years the relationship and coefficient between the gold market and the US dollar have been part of the broader economic and financial academic debate. The study has the aim to assess this classic relationship. Over many decades, the relationship has been seen as negative, with global uncertainty in most cases leading

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to a strengthening in the gold price and a depreciation of the US dollar value. The current COVID-19 pandemic has again sparked the need to assess this relationship in a highly uncertain economic and financial market environment globally. The US dollar is the most universally used currency in the international financial market, and any variations in the monetary policy of the US could have significant impacts on the global financial markets (Kose et al., 2017). According to the Bank for International Settlements (BIS) (2019), the US dollar is the most traded currency globally, with a total share of 88% of the total international foreign exchange derivatives. Significant unpredictability in the commodity market is an important signal for how well the US economy performs and, in particular, the performance of universal stock markets at a particular point in time (Larosei & Molly, 2016).

Gold production and the price of gold have a significant impact on the commodity market because it is an important value chain, contributing to the mining industry and general production and consumption (PWC, 2013). Even though the gold standard ended in 1933 and the US dollar became the primary leading international monetary exchange medium, gold is still a leading commodity indicator for macro-economic policy development (Ocampo, 2016). Given its precious value as an asset and medium of exchange in pre-modern times, this paper aims to illustrate the relationship between the value of the US dollar ($) and the price of gold.

2. Literature Review

Gold has been one of the commodities that made its mark in the world economy, and more importantly, it had a significant impact on monetary economics (Cooper, Dornbusch & Hall, 1982). For an extended period during the late stages of the 19th century and even during the early stages of the 20th century, the gold standard was utilised across the nation's borders. However, the gold standard did not last long and eventually ended in 1933 due to the authority's decision to nationalise private gold stock (Elwell, 2011). According to D'Arista (2009), 1944 saw the end of the gold standard, and the world started adopting the Bretton Woods international monetary system. The goal of the Bretton Woods International Monetary agreement was to adopt the US dollar as a rate of exchange (Igwe, 2018). The reason authorities chose not to reintroduce gold as a fixed currency is that it is impractical and ineffective (Astrow, 2012). Gold still plays a vital role internationally because it serves as a policy indicator in illustrating various monetary and fiscal policy stances (Astrow, 2012).

There tends to be a negative relationship between the prices of commodities and the strength of the US dollar (Atwill & Lieble, 2019). The economy of America and the US dollar can be regarded as the leading indicator for the price of gold per ounce (Dey, 2016). The negative relationship between the gold price and the US dollar is

that a depreciating dollar leads to strengthening the demand for commodities such as gold (Ghosh et al., 2004). According to Arfaoui and Rejeb (2017), if the stock markets are contracting, investors tend to trade in their US shares into the original currency, which has an unfortunate effect on the US dollar. Gold can be seen as a commodity as a "safe haven" because whenever there is uncertainty in the world markets, it dramatically affects the strength of a currency and gold can be seen as an alternative (Coudert & Raymond, 2011). Murach (2019) states that even though people regard gold to be a "safe haven", it can only be regarded as a "safe haven" for a short period, and protection generally disappears between 15 and 20 days. Dey (2016) further states that gold cannot be regarded as an adequate monetary system of exchange but rather an adequate investment resource and an indicator of changes in global economic events.

The US dollar plays a significant role in the financial markets; for example, if the interest rates are low in the United States, investors receive a lower return using embracing the dollar bonds rather than investing, which causes a devaluated currency (Gale, 2009). Central banks hold reserves that include the inventories of dollars, other currencies, and gold to sell what they want to or have to intervene in the foreign exchange market (Dornbusch et al., 2014). Nair et al. (2015) explain that a decrease in the dollar's value increases the demand for gold, whereby the value of the gold expands. The dollar's effectiveness could have a substantial risk of movement through numerous elements such as the level of trade and monetary policy changes. However, the value of gold is mainly determined by global demand and supply (Vinokurov et al., 2017).

2.1. Gold Price versus US Dollar

The relationship between the gold market and the US dollar is further analysed in assessing several empirical studies. Samanta and Zadeh (2012) analysed the relationships between the gold price and the US dollar. They found long-run cointegration between the variables with a coefficient of -1.35, and gold price causes movements in the US dollar. Chang, Huang and Chin, (2013) analysed the relationships between the gold price and the US dollar exchange rate in Taiwan and found that changes in the gold price caused the dollar to move. Joy (2011) investigated the relationship between the gold price and the US dollar over the last 25 years. The results via a multivariate GARCH model indicated a negative correlation. The analysis indicated that the relationship was the most negative in 2008 with the financial crises in three decades. This finding implies that gold plays an important role as an investment *hedge* against the US dollar. Reboredo (2013) studied whether gold could act as a safe haven for the US dollar. The study results include that the two variables are negatively correlated, and gold can hedge against USD rate movements.

Wang and Chueh (2013) tested the dynamic relations between the interest rate, the US dollar, and gold prices. Results indicated that if interest rates are reduced, it influences investor expectations leading to dollar depreciation. Investors then could decide to move investment capital to gold leading to a negative relationship. Lin, Chen and Yang (2016) tested if US dollar value influences the gold price. The study found that the Feds monetary policy is the driver of the correlations between gold and the US dollar and that financial crises accelerate interdependences between the two variables. Capie, Mills and Wood, (2005) tested if gold could act as a hedge against the US dollar over the last thirty years. The study found a negative and inelastic relationship. It concluded that gold has served as a hedge against fluctuations in the dollar's foreign exchange value, mostly unpredictable political attitudes and events. Sujit and Kumar (2011) studied the relationship between gold price, the exchange rate and stock market returns. The result from the study indicated that the exchange rate influenced the gold price and the stock market. Gold prices are denominated in US dollars, and this implies that changes influence the exposure gained from buying /selling gold in the exchange rate for US dollars.

Arfaoui and Rejeb (2017) tested inter-relationships between gold price, US dollar and the stock market. Results indicate that the gold price is affected by changes in USD and stock markets, and the US dollar is negatively affected by the stock market and gold price. Zagaglia and Marzo (2013) tested the relationship between gold and the US dollar. Results showed that, in general, the reaction of gold prices in market uncertainty is minor in extent than the movements in the USD. Mo, Nie and Jiang, (2018) also analysed the linkages between the gold market, US dollar and crude oil market. The study found that a long-run cointegration relationship exists between the variables; the gold–dollar relationship is negative; and evidence of a positive non-linear causal relationship from gold to US dollar and a negative non-linear causal relationship from US dollar to gold. Pukthuanthong and Roll (2011) investigated the gold market versus the US Dollar and other currencies. The hypothesis is that gold and the dollar are negatively related; when the Dollar price of gold increases, the dollar depreciates against other currencies. The results indicate that an increase in the price of gold can be associated with currency depreciation in most countries. The dollar price of gold can be related to dollar depreciation, and the Euro (Pound, Yen) price of gold can be related to Euro (Pound, Yen) depreciation.

Samantal and Zadeh (2012) investigated the relationship between the price of gold, oil, stock prices and exchange rates. Therefore, the study's objective was to investigate the magnitude that these variables are interlinked and whether the unpredictability of one variable can forecast movements in other variables. The time-series data expanding from 1989 to 2009 indicated that the price of gold tends to move in an opposite direction than the price of oil and other exchange rates. Mashayekhi, Ari and Jafari (2013) evaluated the price of gold and the volatility of exchange rates from a descriptive context and the utilisation of the VAR (Vector

Autoregression). The outcome showcased that exchange rate fluctuations primarily determine the price of gold. Authors such as Kim and Dilits (2011) states that there is no causal relationship between the gold price and the dollar. Roboredo and Rivera-Castro (2014) evaluated the important role of gold as a hedge fund against the dollar. The study included a time series period from January 2000 until September 2012, and the empirical findings established that whenever the US$ dollar depreciate, it will have a positive influence on the price of gold and therefore used as a "safe-haven" in reducing the risk of investments.

2.2. Gold Price and Real GDP

Hergt (2013) states that the price of gold fluctuated significantly between 2008 and 2012, which can closely be related to instability (Hergt, 2013). Therefore, the price of gold signals a possible trade-off between the two variables, which means that when the economy is performing exceptional, then investors support stock markets, real estate, and even bonds. However, when the economy is unhealthy, then the target is the gold commodity as an investment (Ackah & Bortei-Dorku, 2009). Khan (2015) states a positive relationship between inflation and gold price, which stipulates that a higher gold price signals higher inflation rates, which show that there could be a negative relationship connecting gold prices and the GDP. Bildiric *et al.* (2016) employed the VAR model to illustrate the relationship between three variables, including real GDP, BDI index, and gold price. The study by Bildirici *et al.* (2016) illustrated that the price of gold could be used as a tool to assess economic activity because it is seen as a "safe" investment in short term economic decline. Therefore, if the price of gold increases, it means there is a decline in overall economic activity. According to O'Connor *et al.* (2015), the demand for gold rises concerning the per capita economic growth mainly because gold is an elective expenditure. The relationship between the price of gold and GDP cannot exactly be explained due to the various factors that contribute to the gold price. Gold demand remained relatively high even after switching to a universal monetary system. The price of gold cannot be used as an essential indicator because it's closely related to other commodity markets. However, leading indicators include stock market prices, total output and global trade volumes (Gault, 2015). The utilisation of a Multivariate cointegration (CVAR) used by Murach (2019) suggests that gold price is closely related to global inflation and liquidity. The study by Murach (2019) states that monetary liquidity often leads to higher inflation, leading to a rise in fixed assets such as gold.

2.3 Real GDP and the US$ index

Kogid *et al.* (2012) state that theory suggests a positive relationship between exchange rates and economic growth. However, exchange rate risks and variability

have a negative effect on the total GDP and economic development. Kogid et al. (2012) further found that dictating the impact of exchange rates on economic growth is a very demanding task. However, the results concluded that there is a positive correlation between economic growth and exchange rates. A study on the real exchange rates and economic growth by Habib, Mileva, and Stracca (2017) indicated that an appreciating currency could positively affect the real GDP. Habib et al. (2017) and Rodrik (2008) explain that a depreciating currency in developing economies could negatively impact developed countries. Authorities have a variety of mechanisms to use to impact the real exchange rate magnitude, which demands inflated savings and modest expenditure compared to revenue (Rodrik, 2008). Barguellil, Ben-Salha and Zmami (2018) state that both the real and nominal exchange rate fluctuations have a detrimental effect on total output. However, it depends on whether the exchange rates are flexible or fixed. Lee and Yue (2017) evaluated the trade-weighted US dollar effect on the environment and real GDP. The empirical findings illustrated that there is a positive correlation between the currency and economic growth. An overall conclusion was that the US dollar index illustrated that if the currency appreciates, the real GDP follows suit. In contrast, a depreciating US dollar causes a reduction in net imports and an increase in exports.

3. Methodology

The methodological segment of the study employs an econometric model to test the relationship between the gold market, real GDP of the USA, and the US dollar index. The research instrument used in this model is the VAR (Vector Autoregressive Model Estimation) due to its vigorous composition of the relationship between various economic variables (Bjørnland, 2000). The popularity of the VAR (Vector Autoregressive Model) is through its ability to check for variance decomposition (measuring the significance of shocks to variables) and the impulse response (measuring the repercussion of shocks on selected variables) (Bjørnland, 2000). Let $\gamma_t = (y1_t, y2_t, y_{nt})$ denote an $(n \times 1)$ vector of time series variables. According to Zivot and Wang (2006) the basic p-lag VAR (Vector auto regression) model can be written in the simplest form as (equation 1):

$$\gamma_t = c + \pi_1\gamma_{t-1} + \pi_2\gamma_{t-2} + \ldots.\pi_p\gamma_{t-p} + \varepsilon_t, t = 1, \ldots, T \quad (1)$$

The following symbol π can be regarded as $(n \times n)$ can be regarded as the coefficient model, while ε_t can be regarded as the white noise vector process. Thus, the general form of VAR model can be re-written in a practical form as:

$$Model\ 1: \Delta_{gold} = \theta_0 + \sum_{s=1}^{3} \theta 1, s^{\Delta} US\$_{t-s} + \sum_{s=1}^{3} \theta 2, s^{\Delta} GDP_{-s} + e_t \quad (2)$$

$$Model\ 2: \Delta_{US\$} = \theta_0 + \sum_{s=1}^{3} \theta 1, s^{\Delta} GDP_{t-s} + \sum_{s=1}^{3} \theta 2, s^{\Delta} gold_{t-s} + e_t \quad (3)$$

$$Model\ 3: \Delta_{GDP} = \theta_0 + \sum_{s=1}^{3} \theta 1, s^{\Delta} gold_{t-s} + \sum_{s=1}^{3} \theta 2, s^{\Delta} US\$_{t-s} + e_t \quad (4)$$

Equations (2) to (4) indicate the equations to be utilised in the VAR (Vector Autoregression). The IRF (Impulse Response Function) will be utilised in order to measure the magnitude of the shocks on variables. The data utilised for the study consists of quarterly time series data running from 1995Q1 until 2020Q1, whereby all of the variables were obtained from various sources. The gold price data was retrieved from ICE Benchmark Administration Limited (2020), GDP was retrieved from the US Bureau of Economic Analysis (2020), and the trade-weighted US$ index was obtained from the Board of Governors of the Federal Reserve System (2020). The variables were all transformed into natural logarithms. The variables are presented as follow:

The second part of the data analysis is the unit root testing of the variables to evaluate whether the variables are stationary or non-stationary. The method using to test for stationarity will include the following equation (5):

$$\Delta Y_t = (\gamma_t - \gamma_{t-1}) = \beta_0 + \beta_1 \gamma_{t-1} + \varepsilon_t \quad (5)$$

And we run a one-sided t-test on the hypothesis that β1 = 0

H_0: $\beta_1 = 0$

H_A: $\beta_1 < 0$.

If β_1 is significantly less than 0, we, therefore, reject the null hypothesis of non-stationarity.

The third aspect of the data analysis was selecting the optimal lag length criteria for the selected variables. Brooks (2015) states that only two methods are utilised to measure the optimal lag length criteria, including cross-equation restrictions and the information criteria. The optimal lag length criteria are utilised in this study. The fourth part of the study was to estimate Johansen cointegration analysis to determine the cointegration of the variables in the long run. The Johansen cointegration test is based on two essential likelihood ratio tests, which includes the maximum Eigenvalue and the trace test, which are illustrated in the two following equations:

$$J_{trace} = -T \sum_{i=r+1}^{n} In\left(1 - \lambda i \quad\right) \quad (6)$$

$$J_{max} = -T\, I_n(1 - \lambda_{r+1}) \quad (7)$$

T is regarded as the sample size, while λ is the largest canonical correlation. The null hypothesis of the trace test for the *r* co-integrating vectors are evaluated against the alternative hypothesis of n co-integrating vectors. The maximum Eigenvalue utilises the null hypothesis of *r* co-integrating vectors against the alternative hypothesis of $r + 1$ co-integrating vectors.

The fifth part of the study will employ the short-run equation known as the Vector Error Correction Estimate (VECM). The Vector Error Correction can be defined as

a series of different variables whereby there is more than one co-integrating vector that adapts to short-run dynamics in the equation (Andrei & Andrei, 2015, 572). The following equation is utilised for the Vector Error Correction Model:

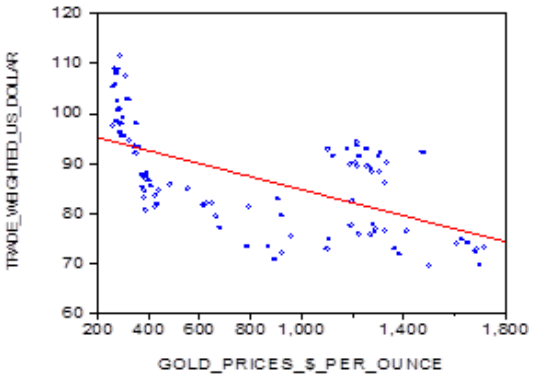
$$\Delta\gamma t = a_1 + a_2\, ec_{t-1} + a_3\, \Delta\gamma_{t-1} + a_4\, \Delta X_{t-1} + \varepsilon t \quad (8)$$

The sixth part of the study will employ the impulse response for the different variables. Ronayne (2011) states that Impulse Response Functions (IRF's) are mainly used to trace the reaction of one variable to an impulse of other shocks. The ultimate goal of utilising the IRF is to indicate the response of one variable on other variables used in the methodology using variable response functions. The seventh part of the study employs the Granger Causality test, which tests the effect that one variable has on the other variables (Lin, 2008). The Granger causality test is popular in most multivariate time series analyses because the test confirms knowledge theory, station margin dynamics, and position steadiness (Siggiridou & Kugiumtzis, 2015). The final part of the paper will focus specifically on the stability and diagnostic testing of the data utilised in the study. According to DeBenedicts and David (2016), diagnostic testing plays a significant role in financial practice and theory. Serial correlation is a residual test used to identify whether the variables used in the time series are closely correlated with one another in a lagged form and can be manifested through the utilisation of the LM test (Williams, 2015). Heteroscedasticity can be defined as circulation with contrasting standard deviations while the residuals' variance is larger than those that are homoscedastic (Klein *et al.,* 2016). Testing whether the data are heteroscedastic or not it has usually acquired utilising the Breusch-Pagan test.

4. Results

4.1. Descriptive Results

Figure 1 illustrates the inverse relationship between the US dollar and the gold price. The basic linear graph illustrates an inverse relationship between the gold price and the dollar's strength, which indicates that if the dollar appreciates, then gold prices tend to decline. The coefficient is equal to -3.633, and the R squared is equal to 0.43, which indicates the inverse relationship between the two variables.

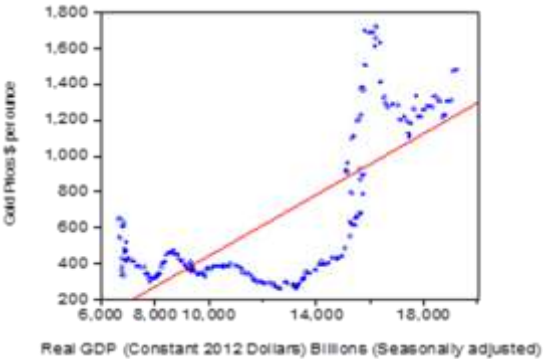


$Y = -3.633x + 22.71$; $R^2 = 0.43$

Figure 1. US Dollar – Gold Price Relationship

Source: E-views

Figure 2 illustrates the relationship between the gold price and the real GDP of the USA. The coefficient indicates a positive relationship between the price of gold and the real GDP, mainly because GDP grew constantly and the gold price also increased steadily over the past few years. Even though there is a positive relationship between the two variables, many factors are still to consider when evaluating the relationship between the gold price and the real GDP. The price of gold is more interlinked with other sections of the economy, such as inflation and the liquidity markets (Murach, 2019).



$Y = 0.3537x + 7.1572$; $R^2 = 0.43$

Figure 2. Gold Price – Real GDP Relationship

Source: E-views

Table 1 is an illustration of the correlation analysis between the various variables utilised in the study. There is a strong negative correlation between the price of gold and the US dollar index with a coefficient of -0.5473 and at-value probability of 0.000. The real GDP and gold price seem to have a positive relationship with a coefficient of 0.7380. However, interestingly enough, there is a negative correlation between the GDP and the trade-weighted US$.

Table 1. Correlation Analysis between Variables

Correlation t-statistic Probability	***Gold Price***	***Trade Weighted US$***	***Real GDP***
Gold Price	1.0000 -------- --------		
Trade Weighted US$	-0.5473 -8.2203 (0.0000)*	1.0000 -------- --------	
Real GDP	0.7380 13.7503 (0.0000)*	-0.5963 -9.3378 (0.0000)*	1.0000 -------- --------

*Note: The P-value is listed in ( ), and a 1% significance indicated as *, while the t-value is listed in [ ].*

Source: E-views

Figures 3 to 5 illustrate the different variables from 1995Q1 until 2020Q1 for the real GDP, gold prices $ per ounce, and the trade-weighted US$. The real GDP (figure 3) illustrates a relatively straight line sloping upwards with a positive gradient. It also indicates the impact of the recession at the end of 2008 and the beginning of 2009, whereby the economic growth declined slightly. The financial recession had a global impact on the world economy, which saw a sharp contraction in total spending, and as a result, the economic growth declined (Keightley, Labonte & Stupak, 2016). Real GDP remained relatively constant after the financial crisis of 2008/9 and illustrated a rather persistent upward slope of total output. (Figure 4) specify the history of the gold price per ounce in US$. History shows that the gold price per ounce was increasing during the Iraq war in mid-2002. The gold commodity was regarded as a commodity of safe haven for investors, and the price of gold continued with its upward trend. Murach (2019) indicates that the price of gold was diminishing in the 1990s and early 2000s. However, bubbles were spotted in 2006 and stages during the 2008/9 financial crisis, as illustrated in figure 5. The price of gold continued to increase even post 2008/9 financial crises and stabilised between 2010 and 2012. However, we saw a sharp decline in the price of gold between 2012 and 2015 and started to increase steadily after 2015. The strength of the US$ can be measured as "the weighted average of the foreign exchange value of the US dollar against other major US trading partners such as Japan, China, Mexico, Canada and the Euro area (Board of Governors of the Federal Reserve System, 2020). The dollar was devaluated heavily between 2002 and 2009. However, after the financial crisis, the dollar seemed to gain value against the other major currencies, especially between 2011 and 2016. The gold price and the trade-weighted US dollar (US$) have an inverse relationship which indicates that the gold can be

regarded as a safe haven for investments if the currency depreciates, as illustrated in (figure 5).

Figure 3. Real GDP (constant prices, billions)

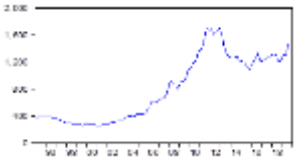


Figure 4. Gold prices $ per ounce

Figure 5. Trade Weighted US$

Source: E-views

4.2. Unit Root Testing Results

Table 2 is an illustration of the unit root testing of the different variables. Table 3 illustrates the unit root testing for each variable which includes both the ADF (Augmented Dickey-Fuller) as well as the PP (Phillip Peron) test, which tested the variables at level I(0) with and without trend and intercept as well as first difference I(1) without trend and intercept. All of the variables indicated in table 3 showcase that the indicators are integrated of order I(1), including the GDP, gold, and the US dollar index.

Table 2. Unit Root Tests on Individual Variables (Augmented Dickey-Fuller test) and (Phillip Peron) Test

Variable (Test type in brackets)	Level I(O)		First Difference I(1)		Test Result
	t-statistic	p-value	t-statistic	p-value	
(ADF) Gold	-1.7337	0.7288	-7.2683	0.0002*	I(1)
(PP) Gold	-1.6605	0.7613	-7.2580	0.0003*	I(1)
(ADF) LUS$	-1.3724	0.8631	-7.2705	0.0002*	I(1)
(PP) LUS$	-1.3723	0.8631	-7.1914	0.0005*	I(1)
(ADF) LGDP	-2.6656	0.2532	-2.5588	0.0109*	I(1)
(PP) LGDP	-2.2240	0.4709	-3.7820	0.0002*	I(1)

**denotes P-value at 1% level of significance and ** at 5% significance.*
Source: E-views

4.3. Lag Selection Criteria Results

Table 3 illustrates the VAR lag order selection criteria whereby the most appropriate lag order selection is 2 lags using both the AIC (Akaike Information Criterion) and Hannan-Quinn Criterion (HQC). According to Brooks (2015:330), the information criteria allow the selection of the optimal lag length. As such, Table 3 illustrates the optimal lag length in the VAR lag length selection. Brooks (2015:340) further states that the verification of an appropriate lag length, the multivariate generalisation of Akaike's Information Criterion, is used on most models. The optimal lag selection for the set of variables is 3 lags, as illustrated in Table 3.

Table 3. VAR Lag Order Selection Criteria

Lag	Lo		lo LR FPO	AIC	SIC	HQ
0	126.1032	N/A	1.50e-05	-2.5916	-2.5109	-2.5590
1	716.4744	1131.027	7.27e-11	-14.8310	-14.5084*	-14.7006
2	731.5404	27.9115	6.40e-11	-14.9587	-14.3942	14.7306*
3	**741.6403**	**18.0735***	**6.27e-11***	**-14.9819***	**-14.1754**	**-14.6560**
4	746.7634	8.8441	6.82e-11	-14.9002	-13.8518	-14.4766
5	756.5495	16.2757	6.74e-11	-14.9168	-13.6264	-14.3954

* indicate the lag order selected by the criterion.
Source: E-views

4.4. Johansen Cointegration Analysis Results

Table 4 is an illustration of the Johansen cointegration analysis. The null hypothesis of no cointegration, i.e. (r=0), can be rejected at the 5% level because the Trace statistic is larger than the critical value at 5% (38.96 > 35.01). The maximum Eigenvalue indicates similar results, which indicates that the Maximum Eigenvalue is larger than the critical value at 5%, i.e. (24.95 > 24.25); hence we reject the null hypothesis of no cointegration among the variables. The cointegration test indicates that there is at least one co-integrating equation which indicates that there is a long-run relationship between the gold price and the other components such as the trade-weighted US$ and real GDP.

Table 4. Johansen Cointegration Analysis

Trace Test					Maximum Eigenvalue				
H_0	H_1	Trace statistic	Critical value at 5%	p-value	H_0	H_1	Maximum Eigenvalue	Critical value at 5%	p-value
r=0	**r=1**	**38.9681**	**35.0109**	**0.0179***	**r=0**	**r≥ 1**	**24.9519**	**24.2520**	**0.0404***
r=1	r=2	14.0162	18.3977	0.1843	r≤	r= 2	10.5216	17.1476	0.3509
r=2	r=3	3.49459	3.84146	0.0616	r≤	r= 3	3.49459	3.84146	0.0616

**denotes the rejection of the null hypothesis of unit root at 5% significance levels, and the rank of cointegration is denoted by "r".*

The long-run cointegration equation is captured in equation 16. The VAR model indicate the three possibilities of the long-run cointegration among the variables

$$model\ 1: Gold = -26.3356 + 3.7044LGDP - 0.6229LUS\$ \quad (9)$$
$$model\ 2: LUS\$ = -33.0614 - 0.3016Lgold + 3.8651LGDP \quad (10)$$
$$model\ 3: LGDP = -11.3754 - 0.8312Lgold + 5.0541LUS\$ \quad (11)$$

The gold price and the GDP have a relatively strong relationship in the long run, meaning that a 1 per cent increase in GDP will lead to a 3.7044 per cent increase in the gold price. However, a 1 per cent increase in the US$ index will cause a -0.6229 decrease in the price of gold. The US$ index and GDP have a positive relationship in the long run which indicates that a 1 per cent increase in GDP will lead to an increase of 3.865 per cent increase in the dollar. GDP and the price of gold have a rather negative relationship, in the long run, meaning that a 1 per cent increase in gold will cause a 0.8312 per cent decrease in the GDP.

4.5. Short-Run Equation: Vector Error Correction Estimate

Table 5 is an illustration of the short-run equation for the equation. All of the variables in the equation indicate a long-run equilibrium, except for the gold price. Therefore, the series indicates that two of the variables trade-weighted US$ and GDP, indicate error correction in the cointegration equation since both the variables have significant t-values and a negative value (Meyer, 2018).

Table 5. Vector Error Correction Estimate of All Variables

Error Correction	**Lgold(Coeff) p-value t-statistic**	**LUS$(Coeff) p-value t-statistic**	**LGDP(Coeff) p-value t-statistic**
CointEq1	**-0.0894 (0.0252)* [-3.4640]**	0.0056 (0.0309) [1.1815]	**-0.000475 (0.00014)* [-3.39342]**
DLgold (-1)	0.1435 (0.1215) [1.1805]	-0.074097 (0.05661) [-1.30887]	-0.005616 (0.01070) [-0.52491]
DLgold (-2)	-0.0144 (0.1271) [-0.1136]	0.018958 (0.05886) [0.32206]	0.014676 (0.01115) [1.31598]
DLgold (-3)	-0.0983 (0.1287) [-0.7640]	0.034675 (0.05868) [0.59095]	**-0.031456 (0.01106)* [-2.84418]]**
DLGDP(-1)	0.5704 (1.4171) [0.4025]	-0.387473 (0.57061) [-0.67905]	**0.295968 (0.10768) [2.74848]**
DLGDP(-2)	-0.7797 (1.4299) [-0.5453]	**1.236850 (0.55847) [2.21473]**	0.166219 (0.10702) [1.55309]
DLGDP(-3)	-0.4019 (1.4593) [-0.2754]	0.034675 (0.05868) [0.59095]	0.005946 (0.10999) [0.05406]

** indicates significance at 5% level.*

Source: Own compilation

4.6 Granger Causality test

Table 6 stipulates the pairwise Granger Causality test for the selected variables. The relationship between the gold price and the US$ indicates that the price of gold will have a significant impact on the value of the US$, which were found in a similar study adopted by Yaya and Lu (2012) in China. The price of gold will have a significant impact on the US$ index, which suggests that a high gold price will have a significant impact on the US$. There is an inverse relationship between the strength of the dollar and the gold price (Shen, 2014; Sjaastad, 2008).

Table 6. Pairwise Granger Causality Test

Null hypothesis	Obs	Probability	Granger-Cause result
LGDP does not Granger Cause Gold Gold does not Granger Cause LGDP	92	0.1539 0.0657	**None**
LUS$ does not Granger Cause Gold Gold does not Granger Cause LUS$	92	0.8207 0.0089*	**Unidirectional** **Gold → LUS$**
LUS$ does not Granger Cause LGDP LGDP does not Granger Cause LUS$	92	0.6008 0.0481**	**Unidirectional** LGDP → LUS$

indicates the rejection of the null hypothesis at **1%** significance, ****5%

4.7. Diagnostic Testing

The hypothesis can be defined as follow:

H_0: Errors are not serial correlated, and no evidence of heteroscedasticity

H_1: Errors are serially correlated, and heteroscedasticity is presented

As shown in Table 7, it is shown that the p-value is above 0.05 for all of the variables, meaning we accept the null hypothesis, meaning that there is no serial correlation and no heteroscedasticity.

Table 7. Results of the Diagnostics Test

Diagnostic test results			
Test	**Item**	**p-value**	**Decision**
Serial Correlation	LM test	0.1614	Do not Reject H_0: No serial correlation
Heteroscedasticity	Breusch–Pagan test	0.3180	Do not Reject H_0: No heteroscedasticity

Source: Own compilation.

5. Conclusion and Recommendations

The findings concluded that the gold price is not a significant indicator to track changes in the value of the US$ dollar. Although the correlation matrix and the graphical representations indicate a moderate negative relationship with a coefficient of -0.6015 between the price of gold and the US$ index, the results indicated that there tends to be a stronger relationship between real GDP and the price of gold. The Granger causality test illustrated that gold prices adjust more quickly over a period of time than the value of the dollar. As suggested by O'Connor and Lucy (2012:1), the negative relationship between the value of the dollar and the gold price is mainly because gold as a commodity can be referred to as a monetary medium of exchange rather than explaining the inverse relationship between the two variables. The results of the VECM (Vector Error Correction Model) pointed out that there is at least one co-integrating equation. However, there is no significant relationship between the gold price and the trade-weighted US$ in the short-run. The impulse responses indicated that any shocks in the price of gold would respond negatively to the currency's value; however, this statement cannot be confirmed in the short and long-run equations. The Pairwise Granger Causality test revealed an interesting discovery that the real GDP tends to move in a unidirectional direction towards the gold price and the value of the US$, which means that overall output in the US economy is a superior indicator to evaluate changes in the gold price and the value of the currency. Gold prices are not a significant indicator to track changes in the value of the dollar. Despite the fact that gold is perceived as the main medium of exchange in pre-modern times, it would currently be unpractical and irrelevant to use gold as a medium of exchange. Therefore, changes in the gold price should not be used as a predictor for the strength of the dollar but rather be seen as an important indicator for gold exporting countries where the majority of their income are related to the buying and selling of the gold commodity. Although there are some signs of an inverse relationship between the dollar and the price of gold, there are also other indicators that one needs to consider in determining the value of the currency, such as the volume of foreign capital, the level of interest rate, total output, current account balances and inflation rates.

The limitation of the study relates to the time-series period, which could be extended. However, more than 25 years of quarterly data provided sufficient data for this study, and more variables could have been included. However, the objective of the study was to focus on the classic relationship. An important implication of this study is that changes in the gold price are not a significant indicator on its owns to track changes in the US currency. The value of the research is in the renewed analysis and updated coefficients on the long and short-run between the classic variables.

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