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Modeling and Forecasting Gold Prices

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Abstract
The aim of this paper is to explore the reasons of gold price volatility. It analyses the information function of the gold future market by open interest contracts as speculation effect, and further fundamental factors including inflation, Chinese yuan per dollar, Japanese yen per dollar, dollar per euro, interest rate, oil price, and stock price, in the short-run. The study proceeds to build a Dynamic OLS model for long-run equilibrium to produce reliable gold price forecasts using the following variables: gold demand, gold supply, inflation, USD/SDR exchange rate, speculation, interest rate, oil price, and stock prices. Findings prove that in the short-run, changes in gold price does granger cause changes in open interest, and changes in Japanese yen per dollar does granger cause changes in gold price. However, in the long-run, the results prove that gold demand, gold supply, USD/SDR exchange rate, inflation, speculation, interest rate, and oil price are associated in a long-run relationship.

Keywords: Dynamic OLS, Exchange Rate, Gold Future Market, Gold Price, Oil Price, Open Interest

1. Introduction

Gold is a precious metal that has been used throughout history as a type of payment and has maintained its value over time. Long ago, gold was an indication of wealth (billionaire), used in rituals, decorations, and jewelry. So far, the role of gold has changed from “store of value” to “safe investment” against financial losses and inflation hazards. The fear and uncertainty in the global economy pushed the gold price upwards, turning it to the most attractive asset for investors during all periods of crisis whether economic, financial or political. Hence, the price of gold is the mirror of the world economic situation.

Moreover, gold has unique attributes which set it apart from other commodities and contributes to economic growth for many countries worldwide. Nowadays, gold is applied widely in industry used in health, electronics, and chemical industries. However, the use of gold as an investing metal is more attractive. Indeed, the gold price is exposed to sudden and large shifts which may affect markets globally. So, understanding the factors influencing gold price volatility is important in both economic and financial terms. The gold price cannot be controlled, but it can be estimated and forecasted to develop future decisions accordingly. Forecasting the gold price became a hot topic since the collapse of the Bretton Woods System of fixed exchange rates in 1971-1973 and the implementation of the floating exchange rate regime, as the president of United States Nixon stopped the convertibility of USD into gold. Since then, several models were introduced to explain the gold price movements and predict their future values.

In recent years, the global financial crisis which affected the entire economy has experienced high levels of uncertainty and volatility in stock markets, which led to severe consequences that they were even compared to those of the Great Depression 1930. In this sense, investors began to search for alternative ways to protect their assets against ongoing market declines by adding up gold to an investment portfolio for diversification purposes. This yellow metal became an investment target for each investor which presents a source of saving and refugee in periods of crisis. Consequently, the gold price increased rapidly amidst this crisis and reached approximately 1,800 $ per ounce by the end of 2011. Then, which factors account for the gold price fluctuations?

A widely accepted hypothesis considers that variations in gold demand and supply may influence gold prices. Besides, inflation is expected to have an impact on gold prices. Since gold is denominated in dollar, taking advantage of any decrease or increase in the gold price depends absolutely on the situation of the dollar, thereby the exchange rate of the dollar against other currencies influences the gold price. As per speculation, the use of gold contracts as financial papers is considered to have a significant impact on the dynamics of gold prices. Moreover, rising interest rates may have a great effect on gold prices. Furthermore, energy prices are strongly linked to gold prices suggesting that oil prices are likely to have an impact on gold prices. As well, stocks appear to have a strong connection with metals, therefore, stocks may influence the price of gold.

In this context, this paper investigates whether the volatility of the gold price is permanent or not? It explores then the short-run relation between the gold price and each of the following variables: inflation, speculation, Chinese yuan per dollar, Japanese yen per dollar, dollar per euro, interest rate, oil price, and stock price. Afterwards, it develops a dynamic OLS model where the following variables: gold demand, gold supply, inflation, USD/SDR exchange rate, speculation, interest rate, oil price, and stock price are employed and associated in a long-run relationship. These factors together enable the model to perform well and yield a strong forecasting power.

The paper is organized as follows. Section 2 reviews the literature on gold price variation models. Section 3 presents the statistical characteristics of the gold price series, investigates the efficiency of the gold market, and models the gold price volatility. Section 4 analyses the fundamental factors of the gold price. Section 5 tests for the short-run relation using the granger causality test, followed in section 6 by a model for gold price equilibrium in the long-run. The seventh and last section concludes. All the tests are performed using EViews.

2. Overview of Empirical Studies on Gold Prices

Studies concerning gold prices and the factors influencing their variations have been reviewed by many researchers in the last decades, and it remains one of the hot topics in the global economic and financial studies. Researches on gold price determinants can be classified according to three main approaches.

The first approach deals with modeling gold price variation in terms of historical prices to predict future prices. Abdullah (2012), constructed ARIMA model to forecast gold bullion coin prices from 2002 to 2007, and the results showed that ARIMA (2, 1, 2) is the suitable model to be used. Khan (2013), developed an ARIMA forecasting model for gold price over the period 2003 to 2012, and the results suggested that ARIMA (0,1,1) is the appropriate model to be used. As well, Davis, Dedu, and Bonye (2014), built ARIMA model to forecast gold prices covering the period from 2003 to 2012, and they found that the best model is ARIMA (7,1,10). Guha and Bandyopadhyay (2016), forecasted the price of gold using ARIMA model in India from 2003 to 2014, and the results showed that ARIMA (1, 1, 1) is chosen to predict future values of gold. Yet, this technique is used in the short-run only. Tripathy (2017), forecasted the gold price of India using ARIMA model from 1990 to 2015, and the results suggested that ARIMA (0,1,1) is the most suitable model to be used.

The second approach is concerned with modeling gold price movements in terms of variation in main macroeconomic variables, classified as bivariate and multivariate analysis. Šimáková (2011), analyzed the relationship between gold and oil prices from 1970 to 2010, where causal links between gold and oil price levels were identified using granger causality test and a long-term relationship between oil and gold is revealed using Johansen co-integration test, but for examining the short-term fluctuation in co-integrated time series EC model, CPI and GMI (gold mining index) are incorporated, and VEC model is confirmed. Apergis (2014), examined the predictive ability of gold prices for the Australian dollar exchange rate with respect to the U.S. dollar exchange rate. Using an EC model spanning from 2000 to 2012, the results showed the existence of co-integration between the AU dollar/U.S. dollar exchange rate where the coefficient on gold prices is correctly signed and statistically significant. Cai, Cheung, and Wong (2001), studied the macroeconomic announcements on gold prices from 1994 to 1997. Using fractionally integrated GARCH (FIGARCH) model and flexible Fourier form (FFF) regression they found that employment reports, GDP, CPI, and personal income have significant effects on the gold market's return volatility. They also noted that the gold market price volatility exhibits long memory properties. Levin and Wright (2006), developed a theoretical framework to examine the determinants of gold price in the short-run and in the long-run from 1976 to 2005. Using co-integration regression techniques, they found a long-term relationship between the gold price and the U.S. price level. However, concerning short-run relationships, there was a statistically significant positive relationship between gold price movements and changes in U.S. inflation, U.S. inflation volatility, and credit risk and found a statistically significant negative relationship between changes in the gold price and changes in the U.S. dollar trade-weighted exchange rate and the gold lease rate.

The third approach focuses on modeling the gold price movements in terms of variation in macroeconomic and financial variables such as speculation in gold price movements and financial indexes as well. Baker and Van Tassel (1985), build a model able to forecast the gold price using regression analysis from 1973 to 1984, the results showed that changes in the gold price can be explained by changes in commodity prices, U.S. prices, dollar value, and future inflation rate. Moreover, speculative bubbles were significant with positive coefficients, supporting the hypothesis that the gold price was pushed above its trend by speculation. Lawrence (2003), investigated the relationship between gold and financial variables from 1975 to 2001 using VAR model. The results showed no statistically significant correlation between returns on gold and changes in macroeconomic variables as GDP, inflation and interest rates where changes in macroeconomic variables have a much stronger impact on other commodities than they do on gold. Tully and Lucey (2007), investigated the macroeconomic influences on the gold market from 1983 to 2003. Using VAR analysis, the results show that FTSE cash, dollar, pound and U.S. interest rates, UK consumer price index influences the gold price whether cash or futures, where the U.S. dollar is the main.

In this study, a gold price model is constructed where physical, macroeconomic, and financial factors influence the gold price. In this new model, the gold price is determined by eight explanatory variables. These variables are gold demand and supply, dollar exchange rate, inflation, open interest, interest rate, oil price, and the stock price.

3. Gold Price Statistical Characteristics and Volatility

The gold market is composed of a physical gold market (commodity) in which gold bullions and coins are sold and bought and a paper gold market (currency or monetary asset), which entails trading in claims to physical stock instead of stock themselves.

The "London OTC Market", the "U.S. Futures Market" (COMEX) and the "Shanghai Gold Exchange" (SGE) are the three primary gold trading hubs. These markets account for over 90% of the trading volume in the world, accompanied by smaller secondary markets worldwide. These secondary markets include Dubai, India, Japan,

Singapore, and Hong Kong. Notably, world gold prices are moving together nowadays, as there is no longer place for arbitrage.
Figure 1 shows the monthly variations of gold price where two significant jumps in gold prices are observed. The first jump was in early January 1980, when gold prices reached $630 per ounce and dropped dramatically in the same year due to high inflation, high oil prices, the intervention of Soviet Union in Afghanistan, and the impact of Iranian revolution which increases the demand for this precious metal. The second jump in gold prices started in 2009 following the worst financial crisis since the Great Depression. It continued to rise continuously as the highest price of gold in the second jump reached approximately $1800 per ounce by the end of 2011. After that, it declined gradually and remained slightly fluctuating to the present.

Figure 1*:* Monthly Variations of Gold Price from January 1979 to January 2019.
Source: Author calculations based on data collected from World Gold Council (WGC)

3.1 Descriptive statistics

The descriptive statistics of the gold series (in Log form) from January 2002 to June 2019 provided in table A.1 in the appendix, exhibit non-Gaussian characteristics with negative skewness (-0.706275) which may lead to negative findings. Besides, the value of kurtosis is less than three (2.107577), demonstrating higher investment risk. Moreover, the series is not normally distributed according to Jarque-Bera test results, since the calculated probability is less than 5% (0.000005).

3.2 The Gold Market Efficiency

The efficiency of financial markets is one of the most important areas of research and interest in finance. Although market efficiency can be considered from different perspectives, the finance literature has concentrated mainly on "informational efficiency". This study considers gold as a financial asset and explores its price from the Efficient Market Hypothesis (EMH) viewpoint.

In particular, this part examines the gold market efficiency regarding information contained in successive price changes in the gold series. Various statistical tests can be performed to identify whether the gold price is efficient or not. In this context, this paper tests for weak-form market efficiency by adopting the most common and famous method "Random Walk model" which has emerged in the beginning by Jules Regnault, (1863) then investigated and tested by Louis Bachelier, (1964). The Random Walk tests for stationarity in the time series data are as follows. The "Augmented Dickey-Fuller test" (ADF) and "Phillips-Perron test" (PP) used to detect the presence of a unit root which follows a null hypothesis stating that data series contains a unit root "H0: $Y = 0$". Likewise, the KPSS test is complementary to ADF and PP tests, however, it adopts a null hypothesis of a stationary process.

Moreover, the existence of calendar anomalies plays a significant role on the market efficiency basis. If seasonal patterns are identified, the likelihood of abnormal returns through market timing strategies would probably occur. Indeed, there have been a few data anomalies uncovered that call into question whether gold prices do incorporate all historical data. The weekend and January effects have been widely investigated for stock markets, but commodity markets have not received much attention in this regard.

3.2.1 The Weekend Effect

This part is an attempt to investigate the weekend effect on gold prices, in which years of 2008 and 2019 are particularly selected. The weekend effect is the finding that gold prices tend to fall on Mondays and rise on Fridays, a result that seems to contradict the weak form of EMH. Figures 2 and 3 below illustrate that traditional weekend effect rarely exists in the gold market so that Friday does not show the highest price and Monday does not show the lowest price all the time.

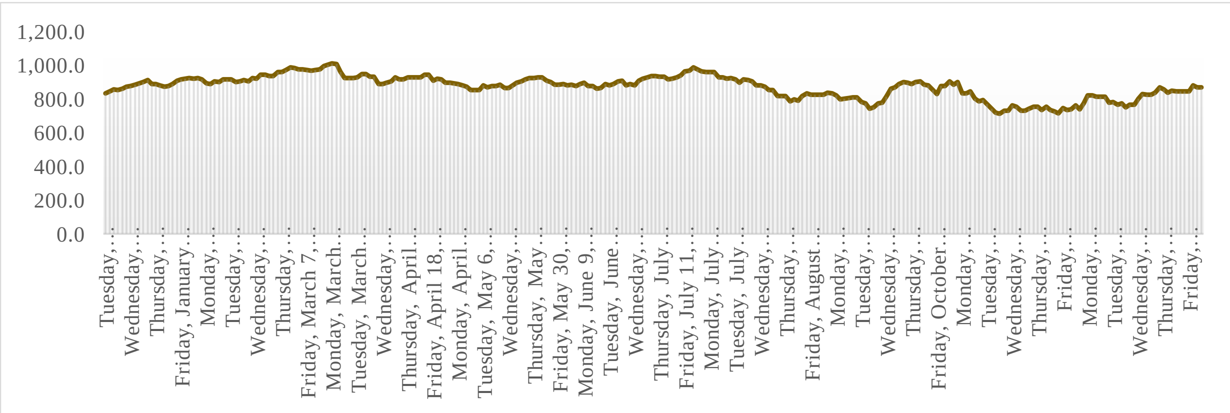


Figure 2: Daily Variations of Gold Prices (2008).

Source: Author calculations based on data collected from WGC

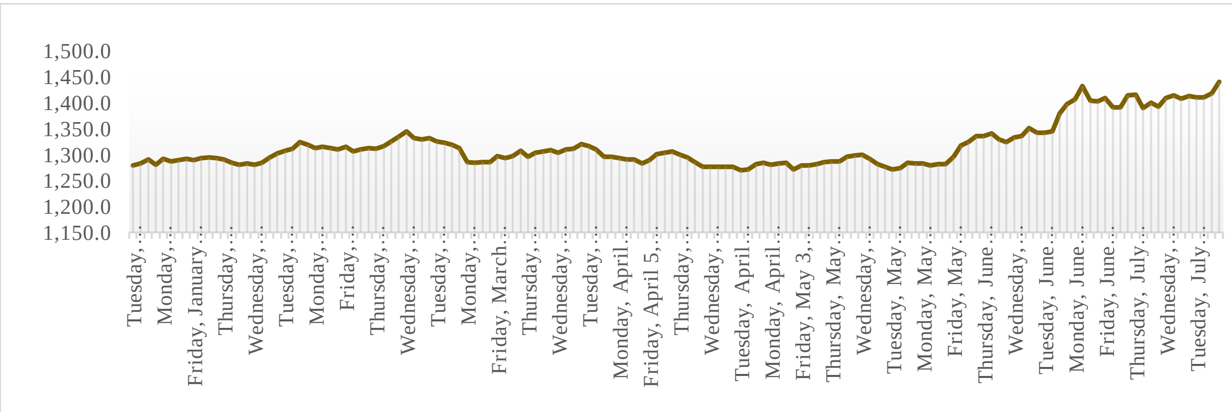


Figure 3: Daily Variations of Gold Prices from January 2019 to June 2019.

Source: Author calculations based on data collected from WGC

3.2.2 The January Effect

One of the biggest challenges facing the EMH has been the discovery of the so-called January effect. The January effect is the finding that gold prices in January are relatively high compared to other months of the year. Figure 4 below shows an extremely weak presence of January effect on gold prices from 2002 to 2019.

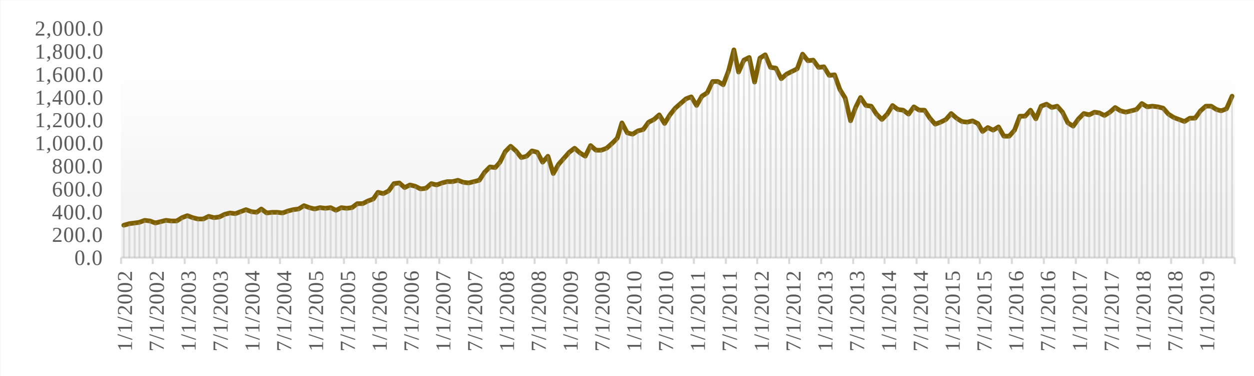


Figure 4: Monthly Variations of Gold Prices from January 2002 to January 2019.

Source: Author calculations based on data collected from WGC

3.3 Volatility Measure and Formulation

A highly volatile market appears to change significantly over a relatively short period. In reality, volatility is related to risk and exists due to uncertainty in the future. The difference between market prices and the economic fundamentals validates the rational valuation of assets. The standard deviation of the annualized returns is considered a very useful tool to measure volatility. Thus, the volatility measure of the gold price series mainly depends on the returns of the data ($R_t = \log p_t - \log p_{t-1}$).

Bollerslev (1986), first proposed the GARCH (Generalized Autoregressive Conditional Heteroscedasticity) model, which has become popular due to its explanatory power in forecasting volatility of returns. This model is used to check if the variance of returns is stationary and whether price levels return to the mean value. It examines an equation specification for the mean of the return series in logarithms (equation 1) and an equation for the conditional variance of the returns (equation 2):

$$R_t = \log p_t - \log p_{t-1} = c + \varepsilon_t \quad (1)$$

$$\sigma^2_t = \omega + \alpha \varepsilon^2_{t-1} + \beta \sigma^2_{t-1} \quad (2)$$

Where $\varepsilon_t \sim N(0, \sigma^2_t)$ and $\sigma^2_t = E(\varepsilon^2_t)$.

From a financial perspective, this specification can be further explained once the agent trader forecasts the time frame of variance by creating a weighted average of a long-term average (the constant), the predicted variance from the previous period (the ARCH term: α), and the information concerning the volatility reported in the preceding period (the GARCH term: β). If the return on asset is excessively high in an upward or downward direction, the trader eventually raises the variance forecast for the upcoming period.

3.4 Estimation Results

3.4.1 Test Results

The ADF, PP, and KPSS tests show that at level, there is a unit root in the gold price in log form. ADF, PP, and KPSS test results shown in table 1 and 2 suggest that taking in differences, the gold price series become stationary. In other words, the series is integrated of order 1 (I (1)).

The tests are re-conducted on a weekly and daily basis, and same results are obtained as presented in tables A.2, A.3, A.4, A.5 in the Appendix. Consequently, the gold price series data whether monthly weekly or daily are integrated of order 1 (I (1)), thus tend to be efficient in their weak form.

Table 1: ADF and PP test results for monthly gold price series in log, from January 2002 to June 2019

			Log (p)	
			T-Statistic	***Probability***
Augmented Dickey-Fuller test statistic	At level	None	2.046946	0.9905**
		Trend & intercept	-1.399284	0.8587**
		Intercept	-2.126279	0.2347**
Phillips- Perron test statistic	At level	None	2.365697	0.9958**
		Trend & intercept	-1.244372	0.8980**
		Intercept	-2.275774	0.1809**
Augmented Dickey-Fuller test statistic	First difference	None	-15.72447	0.0000*
		Trend & intercept	-16.25756	0.0000*
		Intercept	-16.07991	0.0000*
Phillips- Perron test statistic	First difference	None	-15.72925	0.0000*
		Trend & intercept	-16.43795	0.0000*
		Intercept	-16.16896	0.0000*

*Source: Calculated by the author using EViews, data collected from WGC. ** Probability >0.05 then Null Hypothesis is accepted. * Probability < 0.05 then Null Hypothesis is rejected.*

Table 2: KPSS test results for monthly gold price series in log, from January 2002 to June 2019

			Log (p)
			T-Statistic
At level	Trend & intercept	KPSS test statistic	0.426523**
	Intercept	KPSS test statistic	1.484051**
First difference	Trend & intercept	KPSS test statistic	0.077490*
	Intercept	KPSS test statistic	0.490464*

*Source: Calculated by the author using EViews data collected from WGC. ** Probability >0.05 then Null Hypothesis is accepted. * Probability < 0.05 then Null Hypothesis is rejected.*

After confirming the stationary of the gold price series, this study continues toward conducting the GARCH model. The test results as reported in table A.6 in the Appendix shows that equation (3) below represents GARCH (1,1) model estimations for equation (2). Notably, the value in parentheses denotes the coefficient probabilities.

$$\sigma^2_t = 0.000421 + 0.158134\, \varepsilon^2_{t-1} + 0.681695\, \sigma^2_{t-1} \quad (3)$$

$$(0.1899) \quad (0.0489) \quad (0.0002)$$

3.4.2 Results Analysis

According to the probability values in equation (3), the ARCH and GARCH coefficients of α and β are significant at 5% and 1% respectively. The sum of ARCH and GARCH ($\alpha + \beta$) is 0.158134 + 0.681695 = 0.839829, which means that volatility shocks are quite persistent, and therefore the gold price is volatile.

4. Factors Influencing Gold Price

This section explores the driving factors influencing gold price including gold demand, gold supply, dollar exchange rate, inflation, speculation, interest rate, oil and stock prices.

4.1 The Gold Demand

In many geographic zones and sectors, the demand for this rare and valuable metal is obtained. China and India, with their increasing economic power, are at the top of gold consumption countries. The strong culture and religious importance are one of the components of gold demand in East Asia, India and the Middle East, rather than its direct relation to world economic drifts (Šimáková, 2011).

The amount of gold is now purchased from a much-diversified array of buyers and investors as the gold market booms around the globe. According to the World Gold Council, the major source of gold demand is gold jewelry. Recently it has declined, however, it still contributes to approximately 50% of total demand. This is followed by investment demand, with demand for gold rising by almost 235% over the past three decades, due to its unique characteristics as an asset class, which played a central role in protecting and enhancing the performance of the investment portfolio. As well, central banks in emerging markets have raised their official purchases of gold, especially after the financial crisis in 2008, which shows additional important source of annual gold demand nowadays, prompted by its role in protecting against economic shocks. Further, gold can be used in technology as it contributes to innovations in electronics, industrial and dental production.

Figure 5 depicts the monthly changes in the gold price and gold demand from January 2002 to January 2019. Generally, there is a positive relationship between the gold price and gold demand. Yet, an inverse relation is obtained in the global financial crisis. When the crisis exploded in 2007-2008, the banks ended up with a serious. liquidity problem. However, much of their assets were employed in long-term investments. For this reason, they tried hard to find a temporary solution: borrow gold and sell them directly in the market to secure the need for dollar liquidity. Therefore, the demand for gold has increased, whereas gold price has decreased in contrast to what investors anticipated due to temporary sale of gold.

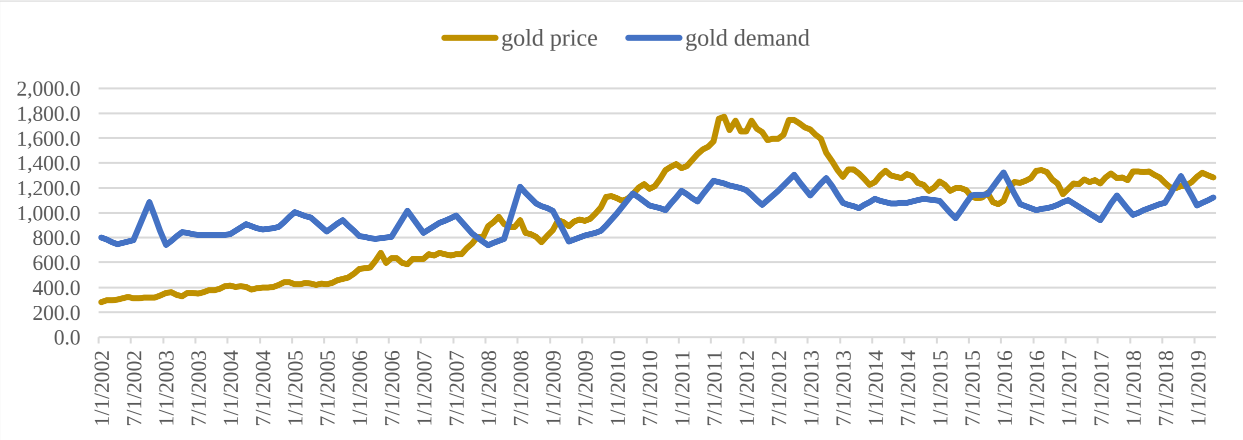


Figure 5: Relation Between Gold Price and Gold Demand.

Source: Author Calculation, based on data collected from WGC

4.2 The Gold Supply

The largest source of gold supply stems from mine production according to the world gold council. Yet, annual demand requests more gold than it has recently been extracted, and this gap is filled by recycling gold. Since gold is seen as indestructible metal, almost all the gold mines are reachable in one way or another and can be accessed for recycling. Hence, "**recycling**" is another source of gold supply that responds most quickly to the gold price and economic crisis. The bulk of recycled gold approximately 90% stems from jewelry, while the remaining is from gold extracted via technology.

Central banks' gold reserves are one of the world's leading sources of gold supply. As reported by the world gold council in March 2019, the United States compared to other countries, holds the highest amount of gold reserves in its central bank. Other major countries that possess gold bank reserves on an individual basis are Germany, France, and Italy nearly 3000 tones, equivalent to that of the International Monetary Fund.

4.3 Relation Between Gold Price and Inflation

Since gold acts as a hedge against inflation, there is a positive relationship between the gold price and inflation. However, a negative relation is obtained in the middle of the global financial crisis 2007-2009. During recession, the demand for consumption as well as investments in stocks drops, thereby a persistent fall in the consumer price index takes place, which leads to a decline in the intrinsic value of asset prices indicating that the economy is experiencing deflation. On the other hand, the gold price increases since investors shift toward a secure alternative which is gold.

4.4 The Impact of Dollar Exchange Rate

Gold is priced in U.S. dollars as well as contracts. A decline in the dollar value against other currencies can be interpreted as gold price increase and vice versa. Thereby, the strong dollar maintains the actual value of gold and keeps the price of gold under control. That is to say, gold can protect investors with dollar holdings against exchange rate risk (Baur & McDermott, 2010).

The dollar's value is important for two main aspects. Firstly, dollar-denominated assets present an attractive investment for investors and fluctuations in the dollar's value constitute a major part of the opportunity cost of gold holding. Secondly, if gold prices are stable in foreign currency, the increase in dollar value will lead to a decline in the dollar gold price. Consequently, if the price of gold is settled in dollars, then it's expected to have an inverse relationship with the value of the dollar (Baker & Van Tassel, 1985).

4.5 Speculation Factor

Speculation on future levels of gold holdings is considered a critical factor as well. In the end of Bretton Woods agreements, futures markets for financial instruments have emerged. Speculative activities in gold futures contracts have been increasing recently as interest in gold as an investment asset keeps growing. Throughout time, the total number of outstanding contracts referred to "open interest" has increased as well as the number of traders. These gold contracts considered as financial papers determine the flow of money into the futures market and the dynamics of gold prices. The higher the number of open interest, the higher the volume of trading in the futures market, and thus more speculation. Indeed, large purchases of gold futures contracts by speculators have created additional demand for gold, driving up the gold price for future delivery.

4.6 Relation Between Gold and Interest Rates

Since rising interest rates make bonds and other fixed-income investments more attractive, and increases the opportunity cost of holding gold which causes portfolio shifting, weakness in gold should follow. As well, an increase in interest rates leads to an increase in the dollar value pushing the gold price downwards. Thereby, one would expect interest rates to have an impact on gold prices.

4.7 Relation Between Gold and Oil Prices

In the global economy, it's apparent that market interconnectivity patterns exist also in the commodity sector, particularly gold and oil. Gold as the most commonly traded precious metal and oil as the most exchanged raw material plays a central role in forming the economy. Historically, the relation between gold and oil started when the Middle East producers requested gold in return for crude oil. Back in 1933, it was the first oil concession in Saudi Arabia that could only be sold in return for gold. Later, gold and oil markets have undergone enormous developments following several historical events, and a major relationship between both commodities ceased to be verified only at the payment level. Gold, oil and other commodities are primarily denominated in U.S. dollars nowadays (Šimáková, 2011).

4.8 Relation Between Gold and Stock Prices

Another key point is that gold performance is mostly compared with stocks, although these asset classes are essentially different. Some consider gold as a store of value that has no growth, while stocks are considered a return on the value on the other side. In times of economic stability and growth, both bonds and stocks generally perform much better, however, gold is viewed as the asset to be held during uncertainty and crisis periods. In general, there is a positive relation between gold and stock prices. However, the stock price decreased sharply during the global financial crisis 2007-2009, while the gold price increase. This is mainly due to investors' desire to shift toward gold which represents a safe haven for them.

5. The Short-Run Relationship: Granger Causality Test

5.1 Methodology

A well-recognized approach used to test statistically whether one variable leads another or vice versa is known as "Granger Causality Testing". Granger causality test is a bi-directional test, first identified by Granger (1969), which entails utilizing F-statistics to test whether the current variable "y" can be explained by the past values of "y" and whether adding lagged values of variable "x" can provide better explanations.

$$X_j = c_1 + \sum \alpha_j X_{t-1} + \sum \beta_J . Y_{t-1} + u_t \quad \textbf{(4)}$$

Where, j = 1 to (p). According to Granger's point of view, variable "x" is a cause of variable "y" if "x" is suitable to forecast "y" while taking into consideration only the past values of "y". In this sense, "x" helps to improve the precision of prediction of "y". Otherwise, "y" does not Granger cause "x". The granger causality test examines the null hypothesis of "Ho: no granger causality of one variable on the other".
Another key point is that granger causality tests are highly sensitive to lag length selection and to methods used to deal with non-stationarity of the time series. Thus, granger causality is performed after applying the stationarity test and determining the lag length of the selected variables.

5.2 Variables for Granger Causality

The variables for testing the granger causality are as follow:

- **Monthly Consumer price index** as a proxy for inflation collected from OECD from January 2002 to April 2019, totaling 205 observations.
- **Weekly Open interest** as a proxy for speculation on gold contracts collected from CFTC and worked on calculating their monthly average from January 2002 to April 2019, totaling 205 observations.
- **Monthly Brent spot oil price** collected from EIA from January 2002 to April 2019, totaling 205 observations.
- **Monthly Chinese Yuan to one U.S. dollar exchange** rate collected from FRED from January 2002 to April 2019, totaling 205 observations.
- **Monthly Japanese Yen to one U.S. dollar exchange rate** collected from FRED from January 2002 to April 2019, totaling 205 observations.
- **Monthly U.S. Dollar to One Euro exchange rate** collected from FRED from January 2002 to April 2019, totaling 205 observations.
- **Monthly U.S. treasury bills interest rate** collected from IMF from January 2002 to April 2019, totaling 205 observations.
- **Monthly NYSE index** collected from Yahoo finance from January 2002 to April 2019, totaling 205 observations.

5.3 Test Results

5.3.1 Stationary Test Results

The first step is to examine whether individual series are stationary. The stationarity test results according to Augmented Dickey-Fuller (ADF), and Phillips Peron (PP) are reported in tables 3 and 4. The findings indicate that all variables are stationary at first difference, I (1). This study considers the series is integrated of order 1, to proceed with the Granger causality test.

Table 3: Results of ADF Test

	Calculated ADF in levels		Calculated ADF in first differences	
Variables	T-statistic	Probability	T-statistic	Probability
CPI	-0.704172	0.4107	-8.440051	0.0000*
Log open	1.264625	0.9476	-8.362851	0.0000*
Yuan-Dollar	-1.432143	0.1416	-7.531339	0.0000*
Yen-Dollar	-0.796346	0.3700	-11.49112	0.0000*
Dollar-Euro	0.130441	0.7226	-10.52942	0.0000*
T-Bills	-1.143882	0.2298	-4.648406	0.0000*
Log oil	0.449935	0.8106	-10.82450	0.0000*
Log NYSE	1.199127	0.9409	-12.41550	0.0000*

*Source: Author calculations using EViews. *Shows the statistical significance at the 1% level of significance*

Table 4: Results of PP Test

	Calculated PP in levels		Calculated PP in first differences	
Variables	T-statistic	Probability	T-statistic	Probability
CPI	-1.279732	0.1847	-8.719069	0.0000*
Log open	1.007558	0.9173	-16.00550	0.0000*
Yuan-Dollar	-1.642956	0.0947	-7.559368	0.0000*
Yen-Dollar	-0.771550	0.3810	-11.57232	0.0000*
Dollar-Euro	0.140825	0.7258	-10.51835	0.0000*
T-Bills	-0.890066	0.3295	-7.674354	0.0000*
Log oil	0.603908	0.8461	-10.71795	0.0000*
Log NYSE	0.994075	0.9154	-12.56417	0.0000*

*Source: Author calculations using EViews. *Shows the statistical significance at the 1% level of significance*

5.3.2 Causality Test Results

The lag length that minimizes the Akaike information criterion is considered for each equation. The Granger causality test results reported in table 5 indicate that CPI, open interest, yuan dollar, dollar per euro, oil price, NYSE, and treasury bills does not granger cause the gold price. On the other hand, results indicate that changes in gold price does granger cause changes in the open interest and changes in Japanese Yen per dollar does granger cause changes in gold price in the short-run.

Table 5: Granger Causality Test Results

Null Hypothesis:	***Obs***	***Lags***	***F-Statistic***	***Prob.***	***Null hypothesis***
D(CPI) does not Granger Cause D(logGold)	205	2	0.38731	0.6794	Accepted
D(logGold) does not Granger Cause D(CPI)			0.23710	0.7891	Accepted
D(logOpen) does not Granger Cause D(logGold)	205	2	0.18234	0.8335	Accepted
D(logGold) does not Granger Cause D(logOpen)			**3.48544**	**0.0325***	**Rejected**
D(Yuan-dollar) does not Granger Cause D(logGold)	205	2	0.20999	0.8180	Accepted
D(logGold) does not Granger Cause D(Yuan-dollar)			0.74293	0.4770	Accepted
D(Yen-dollar) does not Granger Cause D(logGold)	205	2	**0.59389**	**0.0293***	**Rejected**
D(logGold) does not Granger Cause D(Yen-dollar)			0.44973	0.6384	Accepted
D(dollar-euro) does not Granger Cause D(logGold)	205	2	0.31687	0.7288	Accepted

D(logGold) does not Granger Cause D(dollar-euro)			0.01284	0.9872	Accepted
D(logOil) does not Granger Cause D(logGold)	205	2	1.11345	0.3305	Accepted
D(logGold) does not Granger Cause D(logOil)			1.74844	0.1767	Accepted
D(logNYSE) does not Granger Cause D(logGold)	205	2	1.17817	0.3100	Accepted
D(logGold) does not Granger Cause D(logNYSE)			1.82420	0.1640	Accepted
D(TBILLS) does not Granger Cause D(logGold)	205	2	0.93165	0.3956	Accepted
D(logGold) does not Granger Cause D(TBILLS)			0.73956	0.4786	Accepted

*Source: Author calculations using EViews. * Probability < 0.05 then Null Hypothesis is rejected.*

5.4 Results Analysis

The test results indicate that the volatility of the gold price generates speculation in gold futures markets. When gold is cheap to be sold in the future and when the price of gold is expected to be high, the demand for gold increases accordingly. In other words, the impact of future price on spot price is moderated by the variations in gold demand and gold supply moderates. Therefore, the short-term impact of speculation in the gold futures market is reflected by the variations in gold demand and gold supply.

6. Gold Price Equilibrium Model

This section examines the long-run relationship between the gold price and the fundamentals factors chosen theoretically.

6.1 Model Explanation

The gold equilibrium model represents the relation between the gold price as a dependent variable and a set of independent variables: gold demand, gold supply, inflation, exchange rate, speculation, interest rate, oil price, and stock price. After selecting these variables, the model of gold price determination is represented in the following equation:

$$\boldsymbol{Gold_t = b_0 + b_1 Demand_t + b_2 Supply_t + b_3 Inflation_t + b_4 Exchange_t + b_5 Speculation_t + b_6 TBills_+ b_7\ Oil_t + b_8 NYSE_t + U_t \ldots} \quad \textbf{(5)}$$

Where U_t is the noise disturbance term at time t. Gold is the world gold price, in millions of dollars. Demand is the world gold demand. Supply is the world gold supply. Inflation is measured by the consumer price index. The exchange rate is the dollar value in terms of SDR. Speculation is the total open interest. TBills is the U.S. treasury bill rate. Oil is the Brent oil spot price, in millions of barrels. NYSE is the New York stock exchange composite index.

The microeconomic theory indicates that an increase in gold demand rises the gold price, while an increase in gold supply reduces it. Thus, the regression coefficient associated with the demand is expected to be positive, whereas the coefficient associated with the supply to be negative.

Besides, a negative relationship between USD/SDR exchange rate and gold prices is expected. Since gold is priced in dollars then appreciation in the dollar value against other currencies everything being equal makes gold more expensive, causes a decrease in the gold demand as well as gold prices. Another way of thinking is that an increase of the USD/SDR exchange rate value increases the gold price, thereby increasing the gold production by producers. Consequently, the gold price decreases in response to a drop in production.

Moreover, the sign of the inflation coefficient is expected to be positive as gold presents a hedge against inflation. This means that investors prefer to purchase gold to protect the decline in their assets value as the overall prices increase, and thus gold prices increase too.

Additionally, the sign of the speculation coefficient is expected to be positive. Indeed, high gold price volatility implies profit opportunities, and future contracts become important financial assets for the speculator. Therefore, an increase in speculation denotes an increase in future demand on gold contracts and hence in future gold prices, which creates pressure on the spot gold market to raise the spot gold price.

One would expect a negative relationship between interest rates and gold prices in two ways. Rising interest rates cause the opportunity cost of holding gold to increase and thus portfolio shifting, driving the gold price downwards. The other way, an increase in interest rates leads to an increase in the dollar value which causes the gold price to fall.

Furthermore, the oil coefficient sign is expected to be positive. Energy prices are strongly linked to gold prices, when the price U.S. dollar drops, the value of assets dominated in U.S. dollars increases, same as gold and oil prices.

As per the NYSE index, the coefficient sign is expected to be positive or negative. Typically, when the value of the U.S. dollar decline, gold price and stock price increase due to a deep connection between stocks and metals, which indicates a positive relation. However, stocks witness a decline in prices while investors shift to gold as a safe haven in times of crisis and economic shocks, which implies a negative relation.

Above all, it is important to note that political and historical events are omitted from the model as they are indirectly included in the demand for gold. Normally, any financial or economic shock contributes to an increase in gold demand, thereby increasing the gold price.

6.2 Definition of Variables

Gold price: is the price at which gold is being traded on the gold market.
Gold demand: is the global amount of gold purchased at a given price. It includes jewelry consumption, technology fabrication, investments, and net purchases by central banks.
Gold supply: is the global amount of gold offered for sale at a given price. It includes the total of mine production, net producer hedging, and gold recycling.
Inflation: is measured by the consumer price index.
Dollar Exchange rate: is the exchange rate value of the dollar against other currencies. In this study, the USD/SDR exchange rate is employed as a proxy for the exchange rate since it maintains a higher efficiency in estimating the model.
Gold speculation: is the act of buying or selling (short selling) gold depending on the expectation of price movement. In this study, the open interest on COMEX is used as a proxy for speculation on gold contracts by referring to Commitment of Traders (CoT) report.
Interest rate: is measured by the monthly treasury bill rate.
Oil price: is the spot price of a barrel of crude oil benchmark. In this study, Brent spot price (dollar per barrel) is used, which represents a pricing benchmark for two-thirds of crude contracts globally and considered as the most commonly used indicator of oil.
New York Stock Exchange Index (NYSE): The NYSE Composite Index is an index that measures the performance of all stocks listed on the New York Stock Exchange.

6.3 Data Sources

Table 6 represents the variables included in the model and the source of data. This study collected all variables from the sources and worked on calculating their monthly average accordingly. The data used in this part cover the period from January 2002 to April 2019. Note that, all variables are in log form except for the dollar exchange rate, treasury bills and CPI.

Table 6: Source of Data

Variable	***Source***
Gold price	World Gold Council (WGC)
Gold demand	World Gold Council (WGC)
Gold supply	World Gold Council (WGC)
Consumer price index	Organization for Economic Co-operation and Development (OECD)
Dollar exchange rate	International Monetary Fund (IMF)
Open interest	Commodity Futures Trading Commission (CFTC)
Treasury bills	Federal Reserve Economic Data (FRED)
Oil price	U.S. Energy Information Administration (U.S. EIA)
NYSE index	Yahoo Finance

Source: Prepared by the author.

6.4 Econometric Methodology

The methodology of this study is mainly based on the estimation of the Dynamic Ordinary Least Square (DOLS) method developed by Saikonnen (1991) and Stock and Watson (1993), preceded by Johansen co-integration test (1988).

Engle and Granger (1987) introduced the concept of co-integration to address the problem of determining the "long-run equilibrium" relationships in economics. A long-term relationship, from a statistical point of view, suggests that variables move together and thus correcting the short-term disturbances from the long-term pattern.

Afterwards, this paper proceeds to construct a DOLS model, which seeks to obtain better forecasting results using a set of explanatory variables. That is to say, the endogeneity of any of the regressors will no longer have any asymptotic impact on the estimates while employing the dynamic OLS testing, and thus improves the robustness of the model.

However, it is necessary to conduct a unit root test on each variable to find the order of integration. If all variables are integrated of order one, we can test for co-integration and then estimate the DOLS.

6.5 Test Results

6.5.1 Stationarity Test Results

The stationarity test results according to ADF and PP tests as reported in tables A.7 and A.8 in the Appendix indicates that all variables at level show a unit root, and confirm that all variables are integrated of order one, I (1).

6.5.2 Co-integration Test Results

Since all variables in the model are integrated of order one I (1), the co-integration test is then applicable. Johansen test is carried out with the appropriate number of lags to eliminate serial correlation. According to Schwarz information criterion (SC), and Hannan-Quinn information criterion (HQIC), two lags are found to be the most parsimonious lag length for the selected variables. Consequently, co-integration test is performed including 2 lags with intercept and linear deterministic trend. The Johansen co-integration test depends on the Maximum Eigenvalue of the stochastic matrix and the likelihood ratio test, in turn, depends on the Trace of the stochastic matrix.

Table A.9 in the Appendix displays the results of the two Johansen tests Maximum Eigenvalue and Trace Test Likelihood co-integration tests. The Trace Test indicates 3 co-integrating equations as the null hypothesis of r =

3 is rejected, meaning that there are 3 long-run equilibrium relationships between the variables. Whereas, the Maximum Eigenvalue test indicates 2 co-integrating equations as the null hypothesis of r = 2 is rejected, meaning that there is 2 long-run equilibrium relationship between the variables.

6.5.3 Dynamic OLS Model Estimation

After confirming a long-run relationship between variables using co-integration tests, the DOLS method is used to estimate the long-run elasticity of this model. This method is more accurate as it eliminates the endogeneity problem between the dependent and independent variables by taking the leads and lags of the first differenced regressors. Besides, white heteroscedastic standard errors are used so that bias is reduced and approximated t-statistic performs much better. Notably, the R-squared is 95.96%, which means that the DOLS model fits well with the observed data, and the independent variables can explain about 96% of the gold price change.

Table 7: Dynamic OLS Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LDEMAND	0.532590	0.116287	4.579943	0.0000*
LSUPPLY	0.416728	0.155733	2.675907	0.0082*
CPI	-0.054134	0.008671	-6.243386	0.0000*
SDR	2.227701	0.492222	4.525801	0.0000*
LOPEN	0.686564	0.060327	11.38075	0.0000*
LOIL	0.543405	0.040659	13.36508	0.0000*
LNYSE	0.102972	0.064594	1.594134	0.1127
TBILLS	-0.051361	0.009381	-5.474997	0.0000*
C	-13.11912	0.574880	-22.82060	0.0000

*Source: Author calculations using EViews. *Shows the statistical significance at the 1% level of significance*

The model estimations using DOLS method:

$$\mathbf{LGOLD = 0.53*LDEMAND + 0.42*LSUPPLY - 0.05*CPI + 2.23*SDR + 0.69*LOPEN + 0.54*LOIL + 0.1*LNYSE - 0.05\ TBILLS - 13.12} \quad \mathbf{(6)}$$

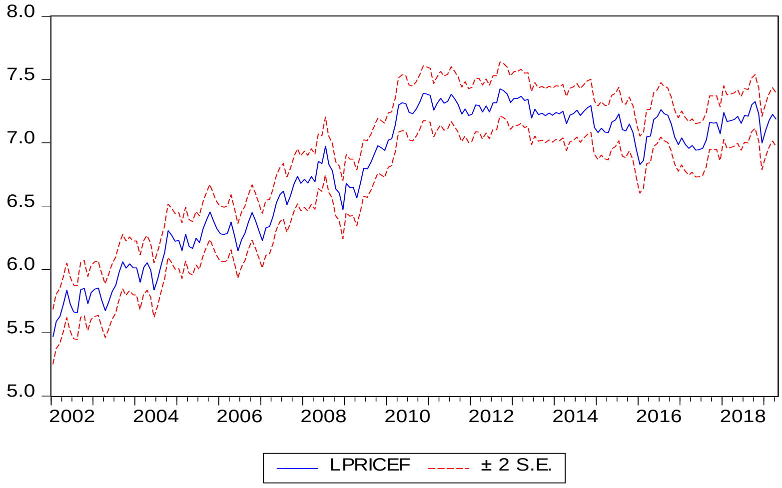
6.5.4 Residual Diagnostics

The majority of the studies do not consider testing the residuals when conducting the Dynamic OLS model. Yet, this study applies the normality test since it is considered a necessary condition for forecasting used to determine whether residuals are normally distributed under the null hypothesis of "Ho: residuals are normally distributed". If this assumption is satisfied, residuals then follow a normal distribution.

The results of the normality test show that the probability of the Jarque-Bera test is 0.484971 (more than 5%), thus the null hypothesis is rejected and the residuals are normally distributed. After checking the normality test, the model can be used for forecasting.

6.5.5 Dynamic Forecasting

Using the DOLS estimation equation, the study proceeds to forecast the gold price. As shown in figure 6 the estimated model lays between 2 standard deviations. On the other hand, the gap between the actual price and forecasted price represented by the Root Mean Squared Error = 0.12 is quite small. Thus, the predictive power of our regression model is satisfactory.



Forecast: LPRICEF	
Actual: LPRICE	
Forecast sample: 2002M01 2019M04	
Included observations: 208	
Root Mean Squared Error	0.117275
Mean Absolute Error	0.094731
Mean Abs. Percent Error	1.411810
Theil Inequality Coefficient	0.008626
Bias Proportion	0.000107
Variance Proportion	0.000011
Covariance Proportion	0.999882
Theil U2 Coefficient	3.011882
Symmetric MAPE	1.411294

Figure 6: Dynamic Forecasting.
Source: Author calculation using EViews

6.6 Results Analysis

The findings show that gold demand, gold supply, inflation, exchange rate, open interest, interest rate, and oil price are significant for gold price determination. The model shows that the dollar exchange rate is the main factor influencing changes in the gold price in the long-run with the highest coefficient (2.22).

As expected, an increase by 1% in the gold demand increases the gold price by 0.53%. Besides, an increase by 1% in the open interest contracts increases the gold price by 0.7%, indicating that more participants are entering the market involving additional buying. Moreover, results prove that oil and gold prices are positively related, thereby an increase by 1% in the oil price increases the gold price by 0.54%. Furthermore, an increase by 1% in the interest rate decreases the gold price by 0.05%.

Unfortunately, some signs contradict theoretical assumptions. Unexpectedly, an increase of 1% in CPI decreases the gold price by 0.05%. Indeed, this situation is observed during a recession or financial crisis when strong deflationary forces hit the economy pushing investors to a safe alternative that is gold. Unexpectedly, an increase in USD/SDR exchange rate which means appreciation in the dollar value against major currencies by 1% implies an increase of the gold price by 2.22%. This means that when the dollar value increase, investors tend to purchase gold for investment purposes, and thus the gold demand as well as the gold price increase, and this can be explained by the positive relation between the open interest and gold price as a speculation effect. Unexpectedly, an increase of 1% in gold supply increases the gold price by 0.42%. This means that the gold supply is following the gold demand with the gold price, and the latter is directed by other factors than the gold supply.

Regarding the gold price and stock impact, coefficients are minimal and not significant. Yet, the sign is negative as expected, meaning that a decline in the dollar value makes gold and stocks move in the same direction, opposite to the dollar direction.

7. Conclusion

Several incidents have exposed gold price to sudden shifts, prompting us to investigate the factors affecting the gold price either upwards or downwards. Accordingly, this study attempts to develop a model able to forecast the gold price. In particular, it examines whether gold price volatility is permanent and then explores the factors influencing changes in the gold price.

The bi-direction Granger causality test results for monthly time series data proved that changes in gold price does granger cause changes in the open interest and changes in Japanese Yen per dollar does granger cause changes in gold price in the short-run. Thus, we conclude that changes in open interest caused by speculation are moderated by changes in gold demand and supply which impact the gold price.

This study takes into consideration the joint impact of economic and financial factors on the gold price and constructs a gold price determination model. The findings of DOLS model showed that the gold price, gold demand, gold supply, inflation, USD/SDR exchange rate, open interest on gold contracts, interest rate, and oil price are associated in a long-run relationship and that dollar exchange rate is the main factor influencing the changes in the gold price in the long-run.

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Appendix

Table A.1: Descriptive Statistics of the monthly gold series considered in log from January 2002 to June 2019.

	Log(P)
Mean	6.783882
Median	7.042394
Maximum	7.503014
Minimum	5.642970
Std. Dev.	0.528559
Skewness	-0.706275
Kurtosis	2.107577
Jarque-Bera	24.42751
Probability	0.000005
Observations	210

Source: Author Calculation using EViews based on data collected from WGC.

Table A.2: ADF and PP test results for weekly gold price series in log from 1-1-2002 to 16-7-2019.

			Log (p)	
			T-Statistic	***Probability***
Augmented Dickey-Fuller test statistic	At level	None	1.993145	0.9894**
		Trend & intercept	-1.498025	0.8299**
		Intercept	-2.075096	0.2550**
Phillips- Perron test statistic	At level	None	2.372652	0.9961**
		Trend & intercept	-1.302490	0.8865**
		Intercept	-2.236071	0.1937**
Augmented Dickey-Fuller test statistic	First difference	None	-31.01284	0.0000*
		Trend & intercept	-31.21171	0.0000*
		Intercept	-31.15379	0.0000*
Phillips- Perron test statistic	First difference	None	-31.24811	0.0000*
		Trend & intercept	-31.86392	0.0000*
		Intercept	-31.61646	0.0000*

*Source: Author Calculation using EViews based on data collected from WGC. ** Probability >0.05 then Null Hypothesis is accepted. * Probability < 0.05 then Null Hypothesis is rejected.*

Table A.3: KPSS test results for weekly gold price series in log from 1-1-2002 to 16-7-2019.

			Log (p)
			T-Statistic
At level	Trend & intercept	KPSS test statistic	0.856009**
	Intercept	KPSS test statistic	3.019760**
First difference	Trend & intercept	KPSS test statistic	0.072681*

	Intercept	KPSS test statistic	0.454332*

*Source: Author Calculation using EViews based on data collected from WGC. ** Probability >0.05 then Null Hypothesis is accepted. * Probability < 0.05 then Null Hypothesis is rejected.*

Table A4: ADF and PP test results for daily gold price series in log from 1-1-2002 to 19-7-2019.

			Log (p)	
			T-Statistic	***Probability***
Augmented Dickey-Fuller test statistic	At level	None	2.066130	0.9912**
		Trend & intercept	-1.462943	0.8421**
		Intercept	-2.101967	0.2440**
Phillips- Perron test statistic	At level	None	2.061710	0.9911**
		Trend & intercept	-1.461436	0.8426**
		Intercept	-2.102838	0.2437**
Augmented Dickey-Fuller test statistic	First difference	None	-67.29361	0.0001*
		Trend & intercept	-67.38703	0.0000*
		Intercept	-67.35895	0.0001*
Phillips- Perron test statistic	First difference	None	-67.29274	0.0001*
		Trend & intercept	-67.38645	0.0000*
		Intercept	-67.35828	0.0001*

*Source: Author Calculation using EViews based on data collected from WGC. ** Probability >0.05 then Null Hypothesis is accepted. * Probability < 0.05 then Null Hypothesis is rejected.*

Table A.5: KPSS test results for daily gold price series in log from 1-1-2002 to 19-7-2019.

			Log (p)
			T-Statistic
At level	Trend & intercept	KPSS test statistic	1.939591**
	Intercept	KPSS test statistic	6.872727**
First difference	Trend & intercept	KPSS test statistic	0.051337*
	Intercept	KPSS test statistic	0.347653*

*Source: Author Calculation using EViews based on data collected from WGC. ** Probability >0.05 then Null Hypothesis is accepted. * Probability < 0.05 then Null Hypothesis is rejected.*

Table A.6: Estimation of GARCH Model.

Dependent Variable: LGP-LOG(GP(-1))
Method: ML ARCH - Normal distribution (BFGS / Marquardt steps)
Sample (adjusted): 2002M02 2019M06
Included observations: 209 after adjustments
Convergence achieved after 17 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)

GARCH = C(1) + C(2)*RESID(-1)^2 + C(3)*GARCH(-1)

Variable	Coefficient	Std. Error	z-Statistic	Prob.
Variance Equation				
C	0.000421	0.000322	1.310918	0.1899
RESID(-1)^2	0.158134	0.080277	1.969865	0.0489
GARCH(-1)	0.681695	0.181872	3.748209	0.0002

R-squared	-0.023710	Mean dependent var	0.007692
Adjusted R-squared	-0.018812	S.D. dependent var	0.050075
S.E. of regression	0.050544	Akaike info criterion	-3.162562
Sum squared resid	0.533935	Schwarz criterion	-3.114586
Log likelihood	333.4877	Hannan-Quinn criter.	-3.143165
Durbin-Watson stat	2.165418		

Source: Author Calculation using EViews based on data collected from WGC.

Table A.7: Results of ADF Test.

	Calculated ADF in levels		Calculated ADF in first differences	
Variables	T-statistic	Probability	T-statistic	Probability
Log gold	2.548553	0.9975	-12.24357	0.0000*
Log demand	0.637209	0.8531	-5.725711	0.0000*
Log supply	1.100507	0.9294	-5.315183	0.0000*
CPI	-0.704172	0.4107	-8.440051	0.0000*
SDR	-0.686740	0.4185	-11.24409	0.0000*
Log open	1.264625	0.9476	-8.362851	0.0000*
T-Bills	-1.143882	0.2298	-4.648406	0.0000*
Log oil	0.449935	0.8106	-10.82450	0.0000*
Log NYSE	1.199127	0.9409	-12.41550	0.0000*

*Source: Author calculations using EViews. *Shows the statistical significance at the 1% level of significance*

Table A.8: Results of PP Test. *Source*: Author calculations using EViews.

	Calculated PP in levels		Calculated PP in first differences	
Variables	T-statistic	Probability	T-statistic	Probability
Log gold	2.270725	0.9946	-12.30086	0.0000*
Log demand	0.578668	0.8406	-6.919393	0.0000*
Log supply	0.595535	0.8443	-5.239194	0.0000*
CPI	-1.279732	0.1847	-8.719069	0.0000*
SDR	-0.638312	0.4398	-11.30151	0.0000*
Log open	1.007558	0.9173	-16.00550	0.0000*
T-Bills	-0.890066	0.3295	-7.674354	0.0000*
Log oil	0.603908	0.8461	-10.71795	0.0000*
Log NYSE	0.994075	0.9154	-12.56417	0.0000*

*Source: Author calculations using EViews. *Shows the statistical significance at the 1% level of significance*

Table A.9: Co-integration Test Results. *Source*: Author calculations using EViews

No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.**
Hypothesized		**Trace**	**0.05**	
None *	0.304778	268.3723	197.3709	0.0000
At most 1 *	0.255189	193.8499	159.5297	0.0002
At most 2 *	0.183690	133.4517	125.6154	0.0152
At most 3	0.140258	91.84478	95.75366	0.0901
At most 4	0.121086	60.86463	69.81889	0.2098
At most 5	0.088925	34.40558	47.85613	0.4798
At most 6	0.039775	15.31392	29.79707	0.7594
At most 7	0.030429	6.993382	15.49471	0.5784
Hypothesized		**Max-Eigen**	**0.05**	
None *	0.304778	74.52237	58.43354	0.0007
At most 1 *	0.255189	60.39819	52.36261	0.0062
At most 2	0.183690	41.60696	46.23142	0.1441
At most 3	0.140258	30.98015	40.07757	0.3619
At most 4	0.121086	26.45905	33.87687	0.2935
At most 5	0.088925	19.09166	27.58434	0.4075
At most 6	0.039775	8.320535	21.13162	0.8831
At most 7	0.030429	6.334797	14.26460	0.5706

** denotes rejection of the hypothesis at the 0.05 level*