The Relationship between Crude Oil Prices, EUR/USD Exchange Rate and Gold Prices

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ABSTRACT

This study aims to analyze and measure the nature of the relationship between crude oil price, EUR/USD exchange rate, and Gold price by using monthly data from January 1999 to October 2019. The result of data analysis using Auto-Regressive Distributed Lag (ARDL) shows that there exists a co-integration relationship between the price of crude oil in U.S. dollars per barrel (C.O.), and the interpreting variables in this study, represented in the Euro Dollar Exchange Rate (E.R.) and the Gold Price in U.S. dollars per ounce (G.P.). The relationship that happened only in a short-term one. Granger causality test result shows one-way causal relationship from the Euro/Dollar towards oil prices; that is, the variation in the exchange rate causes changes in oil prices. Also a unidirectional causal relationship has been found between the gold price and crude oil price. The relationship between the study variables is positive.

Keywords: Crude Oil Price, EUR/USD Exchange Rate, Gold Price, Auto-Regressive Distributed Lag
JEL Classifications: C58, Q24, Q43, F31

1. INTRODUCTION

To analyze the relationship between oil prices, the EUR/USD exchange rate and gold prices, this necessarily requires referring to the post-1945 history. This is since before that date, oil production was still in its infancy, led by several major western oil companies. Then, the industry was characterized by underdevelopment in the technology used and low mining capacity, not to mention low oil consumption as a global energy resource. Thus, the ratio of oil consumption to total energy consumption in the world was much lower than the share of coal consumption to total energy consumption in the world. As for oil prices, they were characterized by relative stability. Also, its fluctuations had no significant impact on the international balance of payments of both oil-producing and consuming countries. This relationship became more pronounced after the 1971 collapse of the Bretton Woods (B.W.) system of fixed exchange rates, and the emergence

of the era of floating exchange rates. This was consolidated after having a de-linkage between oil prices and its cheap production costs, following the double increase in crude oil prices by the oil exporters in 1973 and again in 1979 (Terborgh, 2003).

Owing to the international status of the Dollar and its central position in the International Monetary System (an international pricing currency for the majority of basic commodities, including crude oil), we can put forward the main problematic of the research as follows: To what extent fluctuations in the EUR/USD exchange rate can affect crude oil prices?

The objective of this research is to highlight the nature and direction of the relationship between the EUR/USD exchange price and crude oil prices by adopting the dollar exchange rate as an independent variable and oil prices as a dependent variable. We also aim to reveal the strength and durability of the

interdependence between the oil market and the dollar exchange market based on the fact that oil is the main source of energy in the world and is mainly denominated in dollars.

The significance of this research stems from the key importance and the developing role that both the Dollar and the oil play in the international economy. This is in addition to the crystal-clear impact of the Dollar on all international economic and trade transactions, including oil exchanges, without mentioning the relationship between them and the broad controversy in identifying the nature and direction of this relationship.

This paper is based on the following principle hypotheses:
- Changes in the Euro/Dollar exchange rate will lead to significant changes in crude oil prices in the short and long terms.
- There is a causal relationship that is moving from the Euro/ Dollar exchange rate towards crude oil prices.
- There is a causal relationship that is moving from the gold price towards crude oil prices.
- There is a negative correlation between the Euro/ Dollar exchange rate and crude oil prices.

2. LITERATURE REVIEW

For that, we will devote more attention to the role of the movement of U.S. Dollar exchange rate in the direction of oil prices. Many studies related to this issue have been done. Part of them, theoretically and empirically examined the impact of oil prices on dollar real effective exchange rate.

It is obvious that behind the increase or drop of oil prices is more than one factor, though often it is one of them that has more impact than others. In addition to the fundamental market, factors (supply and demand), there are many others. Such as speculation in the crude oil markets, the less predictable factors political instability hurricanes, tsunami, etc. (Mothana, 2012).

The relation between oil price and exchange rates was initially documented by Golub (1983) and Krugman (1983), who put forth compelling arguments as to why the movements in oil price should affect exchange rates, Golub reasons that since oil price is denominated in USD, an increase in oil price will lead to an increase in demand for US-dollars. However, the authors analysis is based on the relationship among portfolio investment preferences of oil exporters and exchange rate movements. Indeed, the rising oil price will increase the portfolio investment possibilities of oil exporters. This approach analysis exchange rate movements are determined primarily by current account movements, If rising oil price leads to deterioration of country's current account, then exchange rates will fall (Arfaoui and Rejeb, 2017).

The influence of oil price instability on other macroeconomic variables gave researchers in the field of economics and finance more courage to investigate its relationship with other macroeconomic variables. Theoretically, it shows that when the prices of the crude oil rise, it affects the output negatively hence increase the cost of production inputs (Brown and Yücel, 2002).

This behaviour will also increase demand for money, which might spur the level of interest and thereby hamper economic growth (Brown and Yücel, 2002). Increase in oil prices could also raise the prices level that might create price wages twists. The level of investment, consumption and stock market prices also could be influenced adversely due to increase in the oil price and this reduces disposable income and increase production cost, if this behaviour remains unchecked, the level of employment will be low as a result of high costs of production. Various empirical researches were conducted on the nexus between oil price and other macroeconomic variables including crude oil prices.

Lizardo and Mollick (2010) in their paper on oil price fluctuations and U.S. dollar exchange rates using U.S. dollar against major global currencies for the period of 1970-2008. Their finding reconfirmed that oil prices affects exchange rates dynamics in the long-run. When oil prices increases, the value of U.S. dollar in relation to oil exporters currencies such as Russia, Canada, and Mexico depreciate. However, the same behaviour leads to depreciation of oil importers currencies relative to U.S. dollar e.g. Japan.

Chen and Chen (2007) used monthly data from 1972 to 2005 and examine the long-run relationship between real oil prices and exchange rates across G7 economies, their findings show that real oil prices influence exchange in the long-run. The result also indicated that real oil prices forecast the future value of exchange rates, which means that it affects its movement for the entire countries under investigation. Lardic and Mignon (2008) also investigate the nexus between oil price and economic activities as measured by GDP. Their findings shows that normal co-integration was excluded; however; asymmetric co-integration exists between oil price and GDP in the U.S., G7, and Euro area economies.

In their study Amano and Norden (1998) on the nexus between oil price and real effective exchange rates in the U.S concluded that there exists a stable link between shocks of oil price and U.S real effective exchange rates for the post-Bretton Woods period. Their results, therefore, show that oil prices might have been the leading source of real exchange rate persistent shocks and that the prices of energy may have essential effects on the forthcoming movement of rates exchange.

Chaudhuri and Daniel (1998) used co-integration methodology and proved that the non-stationary behavior of U.S dollar exchange rates is being derived from the non-stationarity of oil prices. Bénassy-Quéré et al. (2007) showed a long–term relation of the two series in real terms and for causality running from the real price of oil to the real effective exchange rate of the Dollar.

COUDERT, MIHNON, PENOT find that causality runs from oil prices to the exchange rate. "… as we investigate the channels through which oil prices affect the dollar exchange rate, we find out that the link between the two variables is transmitted through the U.S. net foreign asset position." (Coudert et al., 2007). The relationship between real oil prices and the real exchange rate was studied in (Olomola and Adejumo, 2006) in which other important Macroeconomic factors such as production, inflation and money supplies were incorporated in Nigeria. Using the Vector Auto

Regression (VAR) to determine the impact of oil price shock on the Nigerian currency versus the U.S. dollar exchange rate, output, inflation and money supply, they found that the shock of oil prices significantly affect the exchange rate as well as long-term money supply, but not the output and inflation in Nigeria.

On the other hand, many other studies examined the impact of U.S. Dollar exchange rate on oil price, see, e.g. (Alhajji, 2017; Yousefi and Wirjanto, 2004; Krichene, 2005). According to Alhajji, "U.S. Dollar depreciation reduces activities in upstream through different channels including lower return on investment, increasing cost, inflation, and purchasing power. Furthermore, U.S. Dollar devaluation increases demand in countries with appreciated currencies because of an increase in purchasing power and increases demand in the U.S. as tourists prefer to spend their vacations in the USA." In the case of U.S. Dollar depreciation, the revenues of oil-exporting countries, at least those whose local currencies are tied to U.S. Dollar, are more or less decreased. This leads to a deterioration of their terms of trade because they must export more units of crude oil to get the same amounts of imported products, for example, from Europe than they had to before U.S. Dollar depreciation. Therefore, oil-exporting countries are inclined to maintain oil prices high as much as appropriately in proportion to the U.S. Dollar depreciation and alleviate the losses in their oil revenues. Kumar et al. (2011) studies in an attempt to test the dynamic relationship among gold price, stock returns, exchange rate and oil price. The results show that exchange rate is highly affected by changes in other variables. However, stock market has fewer roles in affecting the exchange rate.

Simakova (2011) made a study to examine the characteristics co-movement relationship between the oil price levels and gold price levels for the period from 1970 to 2010 using co-integration test and Granger causality test method. He confirmed that there is reality of a long-term relationship between selected variables. Thai-Ha and Youngho (2011) made a study on "Dynamic Relationships between the Price of Oil, Gold and Financial Variables in Japan: A Bounds Testing Approach" and they confirmed that the price of gold and stock, among others, can help form expectations of higher inflation over time. In the short run, only gold price impacts the interest rate in Japan. Wang et al. (2010) used daily data and time series to study the effects on the price of crude oil, gold, and exchange rate dollars versus different currencies on the stock prices of fluctuations and the long- and short-term relationships.

3. DATA AND METHODS

3.1. Data
To study the impact of the Euro Dollar Exchange Rate and Gold Price on the price of oil in the period 1999-2019 in the world, the monthly data were collected from various sources, as follows:
- Crude oil price (C.O.): the price of a barrel of crude oil West Texas Intermediate U.S.
- Euro-dollar exchange rate (E.R.): the exchange rate of the U.S. dollar against the single European currency (euro).
- Gold Price in U.S. dollars per ounce, denoted as: G.P.

Variables are based on nominal values compounded monthly (01/1999-09/2019), respectively extracted from the International

Energy Agency (IEA) and the Organization for Economic Co-operation and Development (OECD STAT) database. After the conversion of the values of the variables to natural logarithms, their statistical properties can be described in the following table:

Table 1 indicates a description of the model variables, the highest and lowest values achieved by each of the research variables during the study period, as well as the mean and standard deviation.

3.2. Method
To test the long-term relationship between the variables under study, an ARDL methodology was adopted, which was developed (Pesaran et al., 2001). This test is distinguished from other common integration tests in that it does not require that the time series is the subject of the study are all integrated from the 1st degree, the only condition for applying this test is that the time series are not integrated from the second degree or more I (2), and therefore the self-regression method of distributed slowdown accepts stable chains at their levels I (0) or integrated Class I (1) or a mixture of both.

Before starting the analysis of the study equation, it must be ensured that the time series of the study variables are stationary; that is, there exists no unit root problem for all study variables. As for the next step, the Autoregressive Distributed Lag (ARDL) co-integration test will be conducted along with estimating the model in the long and short term in addition to the Granger causality test. Finally, the economic analysis of the results obtained is presented as follows.

(ARDL) model adopts the following form:

$$\ln CO_t = \delta_0 + \sum_{k=1}^{n} \delta_{1k} \Delta \ln CO_{t-k} + \sum_{k=1}^{n} \delta_{2k} \Delta \ln ER_{t-K}$$
$$+ \sum_{k=1}^{n} \delta_{3k} \Delta \ln GP_{t-k} + \pi_1 \ln CO_{t-1} + \pi_2 \ln ER_{t-1}$$
$$+ \pi_3 \ln GP_{t-1} + \varepsilon t \dots \dots \tag{1}$$

Δ indicates the first differences of the variables under study, the parameter of the dependent variable (Crude oil price (C.O.)) slowed for one period to the left of the equation, π represents the parameters of the long-term relationship, while the parameters of the first differences (δ) express the parameters of the short period where δ_0 and ε Indicates segment and random stroke errors, respectively.

The first step in the ARDL bounds testing approach is to estimate equation (1) by Ordinary Least Squares (OLS) in order to test for the existence of a long-run relationship among the variables by

Table 1: Description of the study variables

Variables	Arithmetic mean	Standard deviation	Highest value	Lowest value
LnCO	3.969	0.549	4.889	2.374
LnER	0.175	0.143	0.454	−0.159
LnGP	6.615	0.641	7.479	5.545

conducting an F-test for the joint significance of the coefficients of the lagged levels of the variables, i.e., H0:π1=π2=π3= 0 against the alternative H1:π1≠π2≠π3≠ 0.

We denote the test which normalizes on C.O. by F.Y. (CO\ER, G.P.). Two asymptotic critical values bounds provide a test for co-integration when the independent variables are I(d) (where 0 ≤ d ≤ 1): a lower value assuming the regressors are I(0), and an upper value assuming I(1) regressors purely. If the F-statistic is above the upper critical value, the null hypothesis of no long-run relationship can be rejected irrespective of the orders of integration for the time series. Conversely, if the test statistic falls below the lower critical value the null hypothesis cannot be rejected. Finally, if the statistic falls between the lower and upper critical values, the result is inconclusive. The approximate critical values for the F-test were obtained from (Pesaran and Pesaran, 1997).

4. RESULTS AND DISCUSSIONS

4.1. Stationarity Tests

One of the most important tests adopted in the unit root test is the Dickey-Fuller test. In its simple formula of 1979, known as the Simple Dickey- Fuller (D.F.) test, it is based on the estimation of a First-order Autoregressive Model AR (1), which is formulated as follows:

$$\Delta Xt = \alpha \, x_{t-1} + \varepsilon_t$$

Where ε_t is the stochastic error which is supposed to have the following conditions:

$$E(\varepsilon_t) = 0, \; Var\,(\varepsilon_t) = E\,(X_t - \mu) = \sigma^2, \; Cov(\varepsilon_i, \varepsilon_j) = 0$$

It is then called the White Noise Error Term. If ($\alpha = 1$), the variable (X_t) has the root of the unit and suffers from the problem of non-stationarity or stillness. After subtracting (x_{t-1}) from both sides of the previous equation, it can be formulated as follows:

$$\Delta X_t = (\alpha - 1)X_{t-1} + \varepsilon_t$$

After setting: ($\alpha - 1 = p$), the equation becomes:

$$\Delta X_t = pX_{t-1} + \varepsilon_t$$

Three models are then estimated using the Ordinary Least Squares (OLS) method. They become as follows:

$$\Delta X_t = pX_{t-1} + \varepsilon_t \, ...M \tag{1}$$

$$\Delta X_t = \theta_0 + pX_{t-1} + \varepsilon_t \, ...M \tag{2}$$

$$\Delta X_t = \theta_0 + \theta_1 t + pX_{t-1} + \varepsilon_t \, ...M \tag{3}$$

This is done for testing the following null hypothesis:

$H_0: p = 0$ (1) Null hypothesis

$H_1: p \neq 0$ (2) Alternative hypothesis

If P = 0 is found to be $\Delta X_t = \varepsilon_t$, the series is non-stationary at the level. In case the alternative hypothesis is met, the series is stationary and is said to be of order I (0). The series can also become stationarized after taking the first or second differences, then we say that the series in question is stationary (integrated of order 1), I (2), respectively and so on.

So, the Dickey-Fuller test in its simple formula becomes inappropriate and unreliable in judging whether the series is stationary or not in case of a Serial Correlation. At this point, we have to use the Augmented Dickey-Fuller test which is based on the estimation of the following models:

$$\Delta X_t = pX_{t-1} + \sum_{j=2}^{p} \varphi_j \Delta pX_{t-j+1} + \varepsilon_t \, ...M \tag{4}$$

$$\Delta X_t = \theta_0 + pX_{t-1} + \sum_{j=2}^{p} \varphi_j \Delta pX_{t-j+1} + \varepsilon_t \, ...M \tag{5}$$

$$\Delta X_t = \theta_0 + \theta_1 t + pX_{t-1} + \sum_{j=2}^{p} \varphi_j \Delta pX_{t-j+1} + \varepsilon_t \, ...M \tag{6}$$

This test starts by choosing the optimal lag (p), * which would remove the self-correlation with stochastic errors, using certain statistical tools. The most important of which are the two criteria of (Akaik and Schwarz). In general, D.F. is tested in three stages (Bourbonnais, 2005):

4.1.1. Stage one
Estimation of the models M (3) or M (6) and testing the trend significant level based on the Dickey-Fuller tables, as follows:
1. In case the trend is not significant (θ_1), we proceed to the second stage.
2. If the trend is significant (θ_1), we test the null hypothesis (α=1) or (p = 0) by comparing t-calculé with its tabulated value. Distinguishing between both cases can be through:
   - Acceptance of the null hypothesis and consequently the series under study is difference stationary "D.S."
   - Rejection of the null hypothesis and consequently the series under study is trend stationary "T.S."

4.1.2. Stage two
This stage is only used if the trend (θ_1) is not significant in the previous model. The models M (2) or M (5) are then estimated. Following, the constant term (θ_0) is tested based on the Dickey-Fuller tables as follows:
1. In case the constant term (θ_0) is insignificant, we proceed to study the third stage.
2. If the constant term (θ_0) is significant, we test the null hypothesis (α=1) or (p = 0) by comparing t-calculé with its tabulated value. Then we distinguish between the two 2 cases as follows:
   - Acceptance of the null hypothesis and consequently the series under study is difference stationary "D.S."
   - Rejection of the null hypothesis and consequently the series under study is trend stationary "T.S."

4.1.3. Stage three

This stage is used only if the constant term (c) in the previous model is not significant. We estimate the models M (1) or M (4) and test the null hypothesis of (α=1) or (p = 0) by comparing t-calculé with its tabulated value. We can distinguish between the two cases as follows:

1. Accepting the null hypothesis and consequently, the series under study is difference stationary "D.S."
2. Rejection of the null hypothesis and consequently, the series under study is stationary.

The following is a graphic representation of the study variables after the first differences were made:

The Vector Autoregression (VAR) model adopts the following form:

$$Y\left(\ln CO\right) = \text{Constant} + \beta Y_{t-1}\left(\ln CO\right) + \beta Y_{t-2}\left(\ln CO\right)\ldots$$
$$+ \beta X_{t-1}\left(lnEX\right) + \beta X_{t-2}\left(lnEX\right)\ldots + \beta X_{t-1}\left(lnGP\right)$$
$$+ \beta X_{t-2}\left(lnGP\right)\ldots + \varepsilon t$$

Where Y_t and X_t are (n × 1) vector of time series endogenous variables, ßi are the (n × n) coefficient matrixes and et is the (n × 1) white noise or unobservable vector process with assumptions of no autocorrelation and independent distribution, i.e. et ~ N (0, σ2). To find the most appropriate number of lags to be included in the model, the optimal lag selection tests were performed as shown in Table 4.

Table 2: Augmented Dickey-Fuller unit root test

Variable	ADF Test Stat*	1 % level**	5% level***	P-value
At level l(o)				
Ln crude oil	−2.501273	−2.501273	−2.873045	0.1164
Ln EX	−1.796524	−3.45673	−2.873045	0.3818
Ln G.P.	−0.768916	−3.45673	−2.873045	0.8256
1st Difference I(1)				
Ln crude oil	−10.16566	−3.45673	−2.873045	0.000
Ln EX	−11.58375	−3.45673	−2.873045	0.000
Ln G.P.	−13.10251	−3.45673	−2.873045	0.000

*ADF test statistics of LnCO, Ln G.P. and Ln G.P. **Critical value at 1% level of significance. ***Critical value at 5% level of significance.

Table 3: Phillips-Person unit root test

Variable	P.P. Test Stat*	1% level**	5% level	P-value
At level l(o)				
Ln crude oil	−2.248722	−3.456622	−2.872998	0.1898
Ln EX	−1.670674	−3.456622	−2.872998	0.4449
Ln G.P.	−0.689095	−3.456622	−2.872998	0.8462
1st Difference I(1)				
Ln crude oil	−10.15052	−3.45673	−2.873045	0.000
Ln EX	−11.53216	−3.45673	−2.873045	0.000
Ln G.P.	−13.0753	−3.45673	−2.873045	0.000

*P.P. test statistics of LnCO, Ln G.P. and Ln G.P. **Critical value at 1% level of significance. ***Critical value at 5% level of significance. The estimation results of the ADF test and the P.P. test are summarized in Tables 2 and 3. Based on the statistical values of the ADF test and the P.P. test in Table 1 shows that the crude oil price (OIL), the Euro-dollar exchange rate (EX), and the gold price (GP) are not stationary at the level, but stationary at the first difference. Thus, OIL, EXC and RIC are integrated of order one, I (1).

Our results presented in Table 4 should indicate that the unanimous and Twelve lags were suggested as optimal by all criteria, hence 2 lags were considered. Thereafter, the Johansen Co-integration tests Table 5 was performed to find if the variables are co-integrated and if there is a long-run association among the variables. In case there is a co-integration relationship, we employ the Vector Error Correction (VEC) model, which is a restricted form of the Vector Autoregression (VAR) model. The basic feature of a VEC model is that it includes an error correction term (U(t−1)), which is a one-period lag residual term that guides/restore the system to equilibrium. However, our results of both Unrestricted Co-integration Rank tests (Trace and Max Eigen statistics) show that the null of no co-integration could not be rejected at the 5% benchmarked level of significant.

4.2 Autoregressive Distributed Lag (ARDL) Co-integration Test

The issue of finding the appropriate lag length for each of the underlying variables in the ARDL model is very important because we want to have Gaussian error terms (i.e. standard normal error terms that do not suffer from non-normality, autocorrelation, heteroskedasticity, etc.) To select the appropriate model of the long run underlying equation, it is necessary to determine the optimum lag length(k) by using proper model order selection criteria such as; the Akaike Information Criterion (AIC).

The ARDL model should be estimated, given the variables in their levels (non-differenced data) form. The lags of the variables should be alternated, model re-estimated and compared. Model selection criteria- The model with the smallest AIC estimates or small standard errors and high R2 performs relatively better. The estimates from the best performed become the long-run coefficients.

Table 4: Optimal lag selection

Lags	LR	FPE	AIC	SC	HQ
0	−9.437540	NA	0.000223	0.103216	0.146595
1	1301.222	2577.812	4.53e-09	−10.69894	−10.52542*
2	1325.297	46.75194*	4.00e-09*	−10.82404*	−10.52039
3	1331.773	12.41323	4.08e-09	−10.80309	−10.36930
4	1337.095	10.07050	4.21e-09	−10.77257	−10.20864
5	1341.861	8.899874	4.36e-09	−10.73744	−10.04337

*indicates lag order selected by the criterion, L.R.: sequential modified L.R. test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion, SC: Schwarz information criterion, H.Q.: Hannan-Quinn information criterion

Table 5: Johansen Co-integration Test

Unrestricted Co-integration Rank Test (Trace)				
Hypothesized No. of C.E. (s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None*	0.09874	31.30224	29.79707	0.0333
At most 1	0.016741	5.727703	15.49471	0.7274
At most 2	0.00638	1.574511	3.841466	0.2096
Unrestricted Co-integration Rank Test (Maximum Eigen value)				
Hypothesized No. of C.E. (s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.09874	25.57453	21.13162	0.0111
At most 1	0.016741	4.153192	14.2646	0.8428
At most 2	0.00638	1.574511	3.841466	0.2096

*Hypothesis of no co-integration was rejected by Trace & Max Eigen value test, **MacKinnon-Haug-Michelis (1999) p-values.

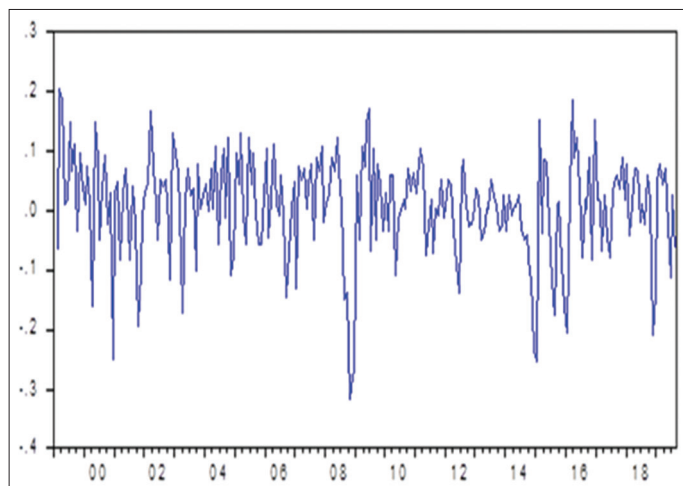**Figure 1:** Graphical representation of the first difference series DLNCO

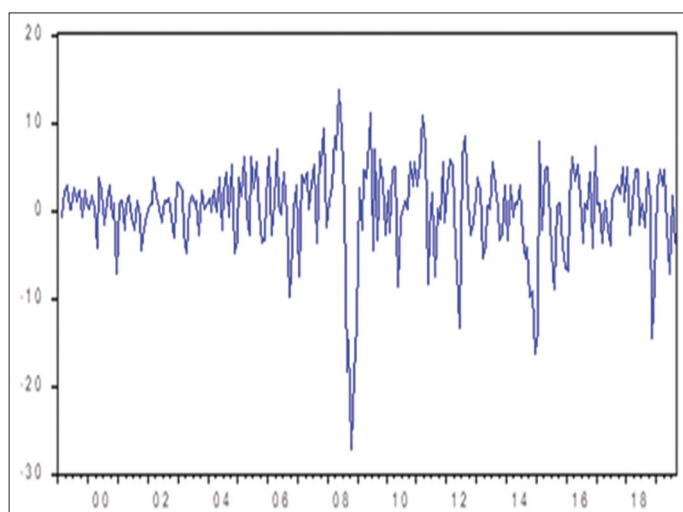**Figure 2:** Graphical Representation of the first difference series DLNER

Figure 3: Graphical representation of the first difference series DLNGP
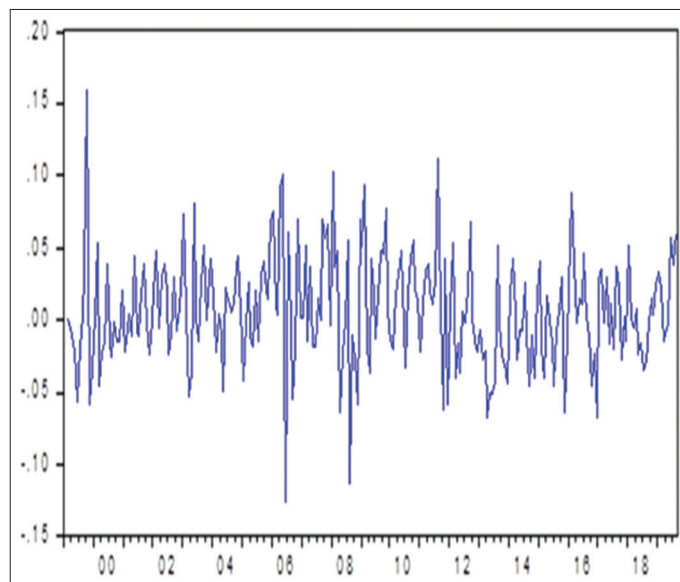

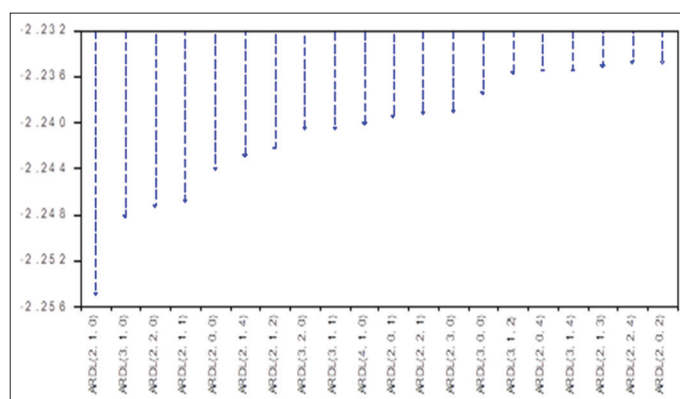**Figure 4:** Results of AIC-based appropriate lag periods test

According to Figure 4 and Table 6, it is obvious that the best models based on AIC are ARDL (0, 1, 2) for variables LNCO, LNER, LNGP, respectively.

4.3. Results from Bounds Tests

Table 7 illustrates the joint integration test using the bound test methodology. Results indicate that the calculated value of F-statistic is greater than the upper limit at the significance levels of 1%, 2.5%, 5%, and 10%

Therefore, the null hypothesis states that there exists no co-integration relationship between the variables it is rejected. Meanwhile, the alternative hypothesis reveals that there exists a long-term balance relationship between the dependent variable and the independent variables is accepted.

Once we established that a long-run co-integration relationship existed, equation (1) was estimated using the following ARDL (0, 1, 2) specification. The results obtained by normalizing crude oil price (CO_t), in the long run, are reported in Table 8.

Table 6: ARDL co-integration test

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
LCRUDE_OIL(-1)	1.137343	0.060725	18.72954	0.0000
LCRUDE_OIL(-2)	−0.259354	0.057523	−4.508684	0.0000
LER	0.678338	0.215719	3.144537	0.0019
LER(-1)	−0.424213	0.220119	−1.927200	0.0551
LGOLD_PRICE	0.041673	0.013813	3.016916	0.0028
C	0.169368	0.062515	2.709241	0.0072
R-squared	0.979378	Mean dependent var		3.982343
Adjusted R-squared	0.978951	S.D. dependent var		0.532531
S.E. of regression	0.077262	Akaike info criterion		−2.259240
Sum squared resid	1.438626	Schwarz criterion		−2.173991
Log likelihood	285.0161	Hannan-Quinn criter.		−2.224918
F-statistic	2289.153	Durbin-Watson stat		1.993298
Prob(F-statistic)	0.000000			

*p-values and any subsequent tests do not account for model selection. Maximum dependent lags: 12 (Automatic selection). Model selection method: Akaike info criterion (AIC). Dynamic regressors (12 lags, automatic): LER LGP. Fixed regressors: C. Number of models evaluated: 2028. Selected Model: ARDL (2, 1, 0) Note: final equation sample is larger than selection sample

4.4. Long-term Equilibrium

After confirming that there exists a co-integration relationship between the price of crude oil in U.S. dollars per barrel (C.O.),

and the interpreting variables in this study, represented in the Euro Dollar Exchange Rate (E.R.) and the Gold Price in U.S. dollars per ounce (G.P.), we measured the long-term relationship within the framework of the ARDL model. This stage includes obtaining the parameters in the long term as shown in Table 8. We have relied on the lag periods according to Schwarz, Bayesian Criterion. The table shows the long-term parameters of C.O. interpretations with the variables under study, where the estimated parameters of C.O. in question. Accordingly, the parameters appeared to be in accordance with the expected signal, and as indicated by previous studies. Additionally, all parameters are found to be statistically significant.

We note that all long-run parameters are statistically significant at a 1% freedom degree and that all term signals are positive; The elasticity of the price of crude oil with the Euro Dollar Exchange Rate $\beta_1 = 2.09033$, which is positive, which explains the direct relationship between the oil price and the Euro Dollar Exchange Rate. This means that the more the Euro Dollar Exchange Rate increases in one Dollar, the more the oil price increases by 2.09033%. The elasticity of the price of crude oil relative to gold, $\beta_2 = 0.339519$ which is positive so that it explains the direct relationship between the price of oil and gold price, meaning that the more the price of gold increases by one unit, the more the price of oil increases by 0.339519%.

4.5 ARDL-VECM Model Diagnostic Tests

After estimating the long-run parameters, we jump to the estimation of the short-run parameters, namely the estimation of the error correction model. The results are shown in Table 9.

We note that all parameters of the error correction model were statistically significant at the 1% and 5% except for gold price as it is not statistically significant. Also, all term signals are positive except for the error correction parameter equal to −0.121439. We notice its significance is at 1% with a negative signal and this increases the long-run equilibrium relationship. The error correction mechanism does exist in the model and the parameter measures the speed of returning to an equilibrium position in the long run so that the value of −0.121439 expressing the speed of returning to the equilibrium position.

Table 7: Results of bound test

Test statistic	Value	K
F-statistic	8.988255	2
Critical value bounds		
Significance	**I0 Bound**	**I1 Bound**
10%	2.63	3.35
5%	3.1	3.87
2.5%	3.55	4.38
1%	4.13	5

Source: Eviews (author' computation)

Table 8: Estimated long run coefficients using the ARDL approach

Long Run Coefficients				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LNER	2.090331	0.365851	5.713606	0.0000
LNGP	0.339519	0.083975	4.043107	0.0001
C	1.399717	0.521746	2.682754	0.0078

4.6 Stability Test of ARDL-ECM

To ensure that the data used in this study is void of any structural changes, we have used such appropriate tests as CUSM and CUSUM of Squares.

The structural stability of the estimated coefficients of the error correction formula for the self-regression model for the distributed time gaps is achieved if the graph of the CUSUM and CUSUM of Squares tests falls within the critical limits at 5% level of significance. In light of most of these studies, we have applied these two tests proposed by Brown, Dublin, and Evans (1975).

Stability of the short-run and long-run coefficients can be seen by CUSUM and CUSUMSQ tests, Figure 5 show CUSUM and CUSUMSQ, respectively. These tests show that our model and its coefficient estimates are stable.

4.7. Granger Causality Analysis

In this finding and analysis part, the study illustrates and discusses the Granger causality of paired variables of crude oil price, Exchange Rate U.S. dollar, gold price.

Causal relationship refers to the direct relationship between the variables and their direction, i.e. the ability of one of the variables to predict in another variable. The following tables show the results of the causality.

As summarized in Table 10, a unidirectional causal relationship has been found between EUR/USD exchange rate and crude oil price, which is significant at 0.6% probability because the p-value is <5%. It indicates that EUR/USD exchange rate affects crude oil price, but crude oil price does not affect EUR/USD exchange

Table 9: Results of estimations of ARDL-based error correction model

ARDL Co-integrating and Long Run Form

Dependent Variable: LNCO

Selected Model: ARDL (2, 1, 0)
Sample: 1999M01 2019M08

Included observations: 247

Co-integrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNCO(-1))	0.259630	0.056768	4.573523	0.0000
D(LNER)	0.666776	0.232100	2.872793	0.0044
D(LNGP)	0.061407	0.137476	0.446671	0.6555
CointEq(−1)	−0.121439	0.020453	−5.937531	0.0000

Cointeq = LNCO − (2.0903*LNER + 0.3395*LNGP + 1.3997)

Table 10: Granger causality test of crude oil price and exchange rate U.S. dollar

Pairwise Granger Causality Tests
Sample: 1999M01 2019M09
Lags: 2

Null Hypothesis	Obs	F-Statistic	Prob.
LER does not Granger Cause LCO	247	7.57318	0.006
LCO does not Granger Cause LER		0.45623	0.6342

Source: Eviews (author' computation)

Figure 5: Plot of CUSUM and CUSUMSQ for coefficients stability for ECM model
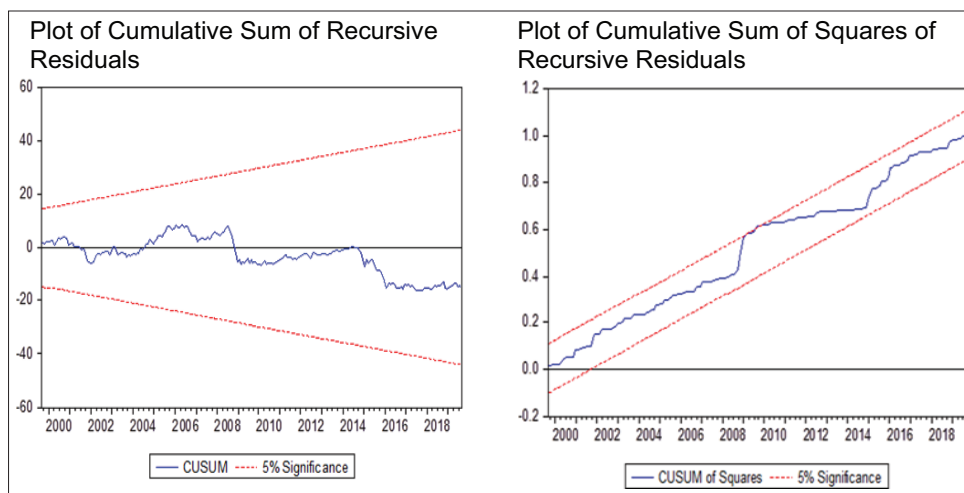

Table 11: Granger causality test of crude oil price and gold prices

Pairwise Granger Causality Tests
Sample: 1999M01 2019M09
Lags: 2

Null Hypothesis	Obs	F-Statistic	Prob.
LGP does not Granger Cause LCO	247	3.99116	0.0197
LCO does not Granger Cause LGP		0.11454	0.8918

Source: Eviews (author' computation)

Table 12: Granger causality test of exchange rate U.S. dollar and gold prices

Pairwise Granger Causality Tests
Sample: 1999M01 2019M09
Lags: 2

Null Hypothesis	Obs	F-Statistic	Prob.
LGP does not Granger Cause LER	247	0.18774	0.8290
LER does not Granger Cause LGP		0.50199	0.6060

Source: Eviews (author' computation)

Table 13: Correlation results between study variables

	Gold price	Crude oil prices	EUR/USD exchange rate
Gold price	1	0.77	0.51
Crude oil prices	0.77	1	0.78
EUR/USD exchange rate	0.51	0.78	1

Source: Eviews (author' computation)

rate. In other words, EUR/USD exchange rate Granger causes crude oil price; however, crude oil price does not Granger cause EUR/USD exchange rate.

As summarized in Table 11, a unidirectional causal relationship has been found between the gold price and crude oil price, which is significant at 1.97% probability, because the p-value is <5%. It indicates that gold price affects crude oil price, but crude oil price does not affect the gold price.

As summarized in Table 12, in either direction, a causal relationship has been not found between the gold price and EUR/USD exchange rate. It indicates that gold price does not affect

effects EUR/USD exchange rate, and also EUR/USD exchange rate does not affect the gold price.

Results also revealed that there is a strong and positive correlation between EUR/USD Exchange Rate and crude oil prices, as shown in the Table 13.

The correlation matrix analysis confirms the positive explanatory relationship between them, given the value of the correlation coefficient, which indicates that more than 77% of changes in oil prices are mostly interpreted by changes in the dollar/euro exchange rate and changes in Gold Price.

5. CONCLUSION

Through this research, we have tried to determine the nature of the relationship between the EUR/USD exchange rate, the price of crude oil and gold price using the analytical and economic measurement methods.

1. By analyzing the relationship between study variables, we have concluded that several possible channels affect through which the dollar-euro exchange rate affects both oil supply and demand, in one way or another, and hence oil prices.
2. There exists a co-integration relationship between the price of crude oil in U.S. dollars per barrel (C.O.), and the interpreting variables in this study, represented in the Euro Dollar Exchange Rate (E.R.) and the Gold Price in U.S. dollars per ounce (G.P.).
3. There exists an impact of the euro/dollar exchange rate on crude oil prices in the short term and in a positive manner, as the improvement in the EUR/USD exchange rate that leads to a rise in crude oil prices.
4. The exchange rate in question explains the long-term changes in oil prices over the short-term, which can be seen by the coefficient of determination or R-squared in the short and long-term models for the study period.
5. Based on the previous conclusion, we confirm that the elasticity of both the demand for oil by the consuming countries and the supply of oil by the producing countries

as a result of the change in the exchange rate of the Dollar is weak in the short term, yet the intensity of this sensitivity increases dramatically in the long run.

6. The Granger causality test has also shown a one-way causal relationship from the euro/Dollar towards oil prices; that is, the variation in the exchange rate causes changes in oil prices.

7. A unidirectional causal relationship has been found between the gold price and crude oil price. It indicates that gold price affects crude oil price, but crude oil price does not affect the gold price.

8. Restoring the long-term equilibrium situation and correcting the imbalance that can occur in oil prices in the short term, as a result of the deviation of the exchange rate at a weak rate of 12.1%.

9. There exists a positive explanatory correlation between study variables given the value of the correlation coefficient.

All in all, there is a long-term and positive equilibrium relationship between the euro-dollar exchange rate, oil prices, and gold price. And that changes in the dollar exchange rate are leading the changes in crude oil prices. Therefore, it can be said that the results are consistent with (Olomola and Adejumo, 2006) and not consistent with other studies that indicate an inverse relationship.

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