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The impact of US dollar exchange rates on oil prices in international markets, Standard study using Autoregressive-Distributed Lag model with distributed time gaps (ADRL) During 2000-2018

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ABSTRACT: This study aims to know the extent of the effects of the US dollar exchange rate on world oil prices, this was done through a standard study in which we used the auto regression methodology for the distributed time gaps applied to annual time series the exchange rate of the us dollar against the euro and changes in oil prices from 2000 to 2018.
The study found a long-term inverse relationship between the US dollar exchange rate and oil prices, Which means that oil prices in international markets are affected in the long run by exchange rate changes, and since this relationship is inverse and significant, in the long run, oil prices rise in international markets during periods in which the value of the US dollar falls against the euro, and for the short run, there is an inverse and non-significant relationship between the variables.

KEYWORDS: Oil prices, US dollar, exchange rates, ARDL model.

1 INTRODUCTION

Oil is one of the main engines of the world economy, it is one of the main materials that have a global impact, whether economically or politically, and is one of the most traded strategic commodities globally, where the price of oil is fluctuating up and down from time to time, due to the linking of the price of a barrel of oil to the forces of supply and demand and the free market mechanism.

Oil prices are affected by a set of factors, regardless of the factors affecting the volume of demand for oil and its derivatives, as non-oil elements influence it, Since the beginning of the 21st century, with the emergence of the euro as a single currency; noticeable that the financial surpluses of the oil exporting countries have increased, as well as in some emerging countries, as the fluctuation of the US dollar price against other currencies in the international exchange rate, especially with the euro, has resulted in a significant impact on the volume of demand.

Questions arise regarding the adoption of the euro instead of the US dollar in pricing crude oil on world markets to reduce fluctuations in oil prices, and some economists believe that the currency in which crude oil is priced is not affected in relation to that raw material whether the US dollar, the euro, the Japanese yen, or other international currencies are adopted.

From this standpoint, the following problem has been raised: **What is the relationship between the exchange rates and the oil prices?**

- **Research hypotheses:** To answer the previous question, the following hypothesis was asked:
  - There is an inverse causal relationship going from the exchange rate of the US dollar against the euro to the international oil price in the short and long run.

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- **The importance of research:** Oil is extremely important considering the most important energy sources in the world, and in light of the challenges and stakes imposed by the fluctuations and collapses of oil prices in recent years, it was necessary to discuss the implications of this issue through studying the effects of changes in the US dollar exchange rate on world oil prices.
- **Research Objectives:** This research aims to:
  - Knowing the effect of US dollar exchange rate changes on oil prices in international markets.
  - Indicate the nature of the relationship between the US dollar exchange rate and international crude oil prices.
  - **The approach followed in the study:** To answer the problem of research and test its hypotheses, we will try to rely on descriptive and analytical approaches, as this study aims to know the changes in the exchange rate of the US dollar against the euro and the development of oil prices in the international market during 2000-2018, also we will apply one of the economic measurement techniques represented by the ARDL auto-regression model with the distribution of time gaps, in order to measure the impact of the US dollar/euro exchange rate changes on oil prices in international market.
  - **Previous studies:** Given the importance of the topic to the link of oil prices to the price of dollars, this topic has brought the attention of researchers and economic academics, and below we will present the most important recent studies that dealt with the topic of the impact of the US dollar exchange rate on international oil prices:
  - A study by Nikbakht in 2009 examined the existence of a stable long-run relationship between oil prices and exchange rates of OPEC currencies against the US dollar exchange rates, by using monthly data during 2000-20007, the study found that the dollar exchange rates are a very influential source for global oil price movements, and there is a long-run correlation between the two variables.
  - A study by Melhem Sadek in 2007 examined the existence of a stable long-run relationship between oil prices and the exchange rate of the dollar against the euro during the period 2000-2006 monthly data by using the common model of integration and causality of Granger, the results of the study indicated that the dollar's decrease by (1%) it coincides with the increase in oil prices by (1.95%) in the long run.

In this paper, we will study the effect of dollar/euro exchange rate changes on oil prices in international markets, by using an empirical study using the ARDL Auto-regression model with a time gap distributed over the period 2000-2018.

2 AN ANALYTICAL STUDY OF THE EVOLUTION AND TRENDS OF THE US DOLLAR EXCHANGE RATES AGAINST THE EURO DURING 2000-2018.

The exchange rate of any currency is the value of the currency of a country against the currency of another country or economic region, most of the exchange rates of international currencies are subject to supply and demand in the market1, the US dollar exchange rate reflects the value of the dollar in relation to the value of another foreign currency, and the United States adopts the flexible exchange rate method where most exchange rates are determined by the foreign exchange market or the so-called Forex so we note these fluctuations in the US dollar exchange rate in close time periods, and are subject to The evaluation process is based on many factors, the most important of which are the Fed's interest rates, its debt levels and the strength of its economy, the US dollar is the currency most sought by investors as a store of value.

The US dollar is the currency most requested by investors as a store of value. The dollar assumed this role when the United States of America decided to end the ability to convert the dollar into gold in 1971[2].

And To know the directions of changing the dollar exchange rates, we follow the development of the dollar exchange rate against the euro, as the euro is one of the strongest currencies.

[1] Michael Kramer, Exchange Rate Definition, Apr 19, 2019, available on: https://www.investopedia.com/terms/e/exchangerate.asp
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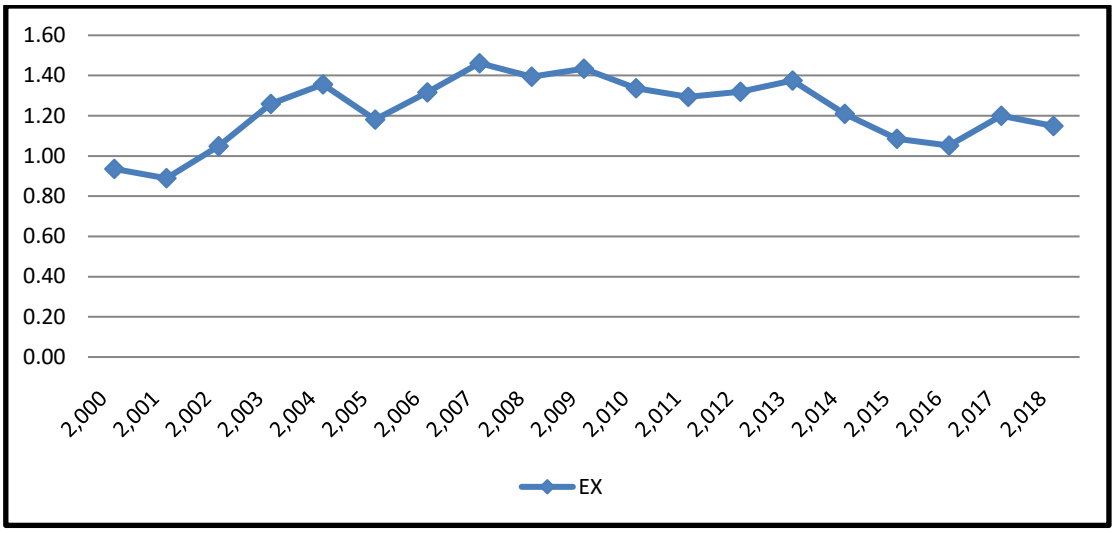

Fig. 1. The development of the US dollar exchange rate against the euro during 2000-2018

Source: https://www.worldforexrates.com
https://www.x-rates.com/graph/?from=USD&to=EUR&amount=1

From Fig 1 we notice that the dollar exchange rate against the euro during the period 2000-2002 ranged between 1,0854 and 1,0617 euro, The reason for the relatively high dollar against the euro during these years is the fact that the euro was a virtual currency before 2002 and linked the European national currencies with fixed exchange rates against the euro and the decline of some of these currencies before the actual issuance of the euro as a single currency has led to a depreciation of the euro[3].

After the year 2002 to the year 2018, we notice that the exchange rate of the dollar against the euro fell to less than 1, where the average exchange rate of one dollar was about 0.7956 euro, we also noted that during the period 2003-2008 the direction of the dollar exchange rate against the euro was descending, The year 2008 recorded the lowest value of the dollar against the euro due to the effects of the mortgage crisis, as investors believed that the high risks will be mostly in the USA[4], while in the period 2008-2018 we noticed an upward trend ranging between 0.68 and 0.77 euro during the period 2008-2014 Then it increased to between 0,85 and 0,90 euro in the period 2015-2018, this increase after 2008 due to the European sovereign debt crisis and its implications for the euro[5].

It is worth noting that there are three main factors affecting the exchange rate of the dollar against the euro, which is the interest rate of the European Central Bank. European country debt and the strength of the European economy.[6]

3 OIL PRICE FLUCTUATIONS DURING 2000-2018

Oil prices are characterized by fluctuation as a result of being affected by a variety of factors, as these prices respond to the decisions of production made by OPEC, which includes oil-exporting countries, and supply and demand laws also affect oil prices, along with the impact of natural disasters that can lead to disruption of production In addition to the political turmoil in the oil producing countries that also have an impact on prices, and like any other product, production costs affect oil prices, and interest rate trends may also affect these prices[7].

[3] https://www.ig.com/ar-ae/forex/markets-forex/eur-usd/euro-to-dollar-history
[4] https://www.ig.com/ar-ae/forex/markets-forex/eur-usd/euro-to-dollar-history
[5] Will Kenton, European Sovereign Debt Crisis, available on: https://www.investopedia.com/terms/e/european-sovereign-debt-crisis.asp
[6] Kimberly Amadeo, Euro to Dollar Conversion and Its History, available on:
https://www.thebalance.com/what-is-the-euro-to-dollar-conversion-its-history-3306091
[7] Nick Lioudis
Updated Oct 3, 2019 What Causes Oil Prices to Fluctuate?
https://www.investopedia.com/ask/answers/012715/what-causes-oil-prices-fluctuate.asp

The following figure shows the development of oil prices in international markets during the period 2000-2018.

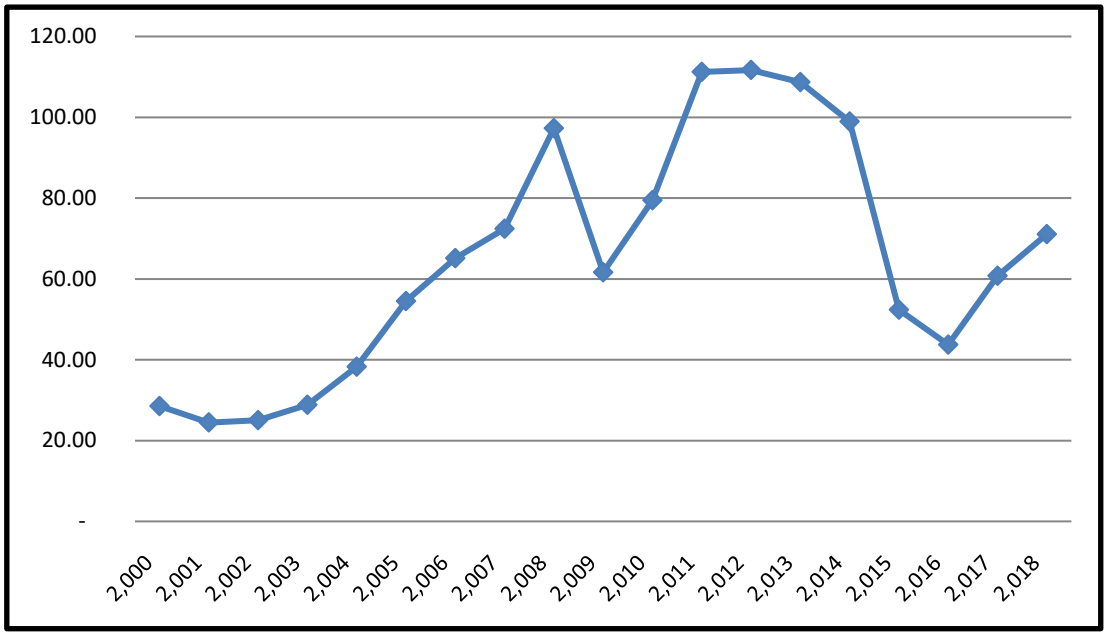

Fig. 2. Evolution of oil prices on international markets during 2000-2018

Source: prepared by researchers using EIA data.

Through the figure, we note that in the years between 2000 and 2008 a continuous rise in oil prices due to the increase in demand for oil in the world very significantly after the growth and demand in India and the three active countries, which are the United States of America, China and the European Union, However, the growth in demand was surprising for OPEC, as the International Monetary Fund data in 2006 indicated that the rate of international economic growth increased from 2.7% in 2001 to 3.1% in 2002 and then to 4.1% in 2003, Then to 5.3% in 2004, the highest level in thirty years, and it continued at a level of 4.8% in 2005 as a result of this rise and economic growth, oil demand increased from 76.6 million barrels per day in 2001 to 84 million barrels per day in 2006, this caused the price increase due to the limited supply growth of oil to the growth of demand for it, because OPEC is not ready for this volume of growth in international demand.

In 2008, speculation intensified on oil prices and OPEC contributed to the rise in prices and reached $ 147 a barrel in that year, which is the highest level in history, but prices Decreased a lot in late that year, after speculation decreased and oil demand decreased due to the global financial crisis that arose as a result of the bankruptcy of the major American banks and the collapse of mortgage companies, prices decreased by the end of 2008 to below $ 40 a barrel, as OPEC decided to make the largest collective reduction in the history of the organization and the result of this decision was to withdraw 4.2 million barrels per day from the market, which resulted in stability in the international oil market.

Whereas, in 2009, there was an upward trend in OPEC basket prices to reach $ 78.2 a barrel (Al-Hanbali and Hussein, 2011, page 10), in spite of this prices have risen steadily over the mentioned period, which confirms the great role of speculators and oil companies in raising prices, and they take advantage of any political or economic events in the oil producing and exporting countries to raise concern, which leads to higher oil futures prices that are determined based on Expectations, which are greatly influenced by future expectations (Ahmed and Nivin 2009 p 14), And some economists believe that the reason for the high prices is due to the increase in demand with the stability of supply (Bernard & Annie, 2005, p 116), Others believe that financial speculators are the main responsible for the rise in prices because of the effects of speculation on price stability (Cabinet of the United Kingdom, 2008, p 51), then it decreased slightly to less than $ 70 a barrel in mid-August 2009, after which it reached significant levels of decline at the end of October, bringing the price of oil in 2010 to about $ 77 a barrel and continuing to rise in 2011 to reach $ 107, $ 112 in 2012, and $ 110 in 2013, but in 2014, international oil prices fell by more than half compared to the price recorded in the summer of 2014 to reach unprecedented levels, the price of oil per barrel of Brent mix decreased from $ 115 to $ 52.4 in 2015, and reached $ 43.73 in 2016.

As for 2017, oil prices increased to $ 60 a barrel, thanks to the confirmation of oil producing countries its commitment to the agreement to reduce production, which came into effect January 01, 2017, when OPEC countries agreed to reduce

production to 1.2 million barrels per day, Russia and other non-OPEC producers also decide to cut production by up to half of the amount produced, with the implementation of this agreement, the price trend has gone back up to $ 60 in the second quarter of 2017, and OPEC crude oil prices increased in 2018, reaching $ 79.4 a barrel, an increase of about $ 23.9 since 2014.

4 THE IMPACT OF DOLLAR EXCHANGE RATE CHANGES ON OIL PRICES IN INTERNATIONAL MARKETS (EMPIRICAL STUDY)

4.1 METHODOLOGY AND RESULTS

For the purpose of studying the relationship between the dollar exchange rate and oil prices in international markets, we used annual data during the period 2000-2018, and in line with recent trends in time series analysis we used the ARDL auto-regression model with distributed time gaps, the study is based on oil price data obtained from the EIA website, and we relied on the website (www.x-rates.com) for the dollar exchange rate series.

TIME SERIES DATA STABILITY TEST

The unit root test aims to examine the properties of the time series of all economic and social variables, to ensure its range, and to determine the rank of the integration of each variable separately. To test the silence of the time series of the model variables under study, we will use the Dickey and Fuller (ADF) test. This test is based on Test the following hypothesis (Obben, 1998, pp. 109-121):

H0: The unit root in the chain, meaning that the time series is unstable.

H1: There is no unit root in the chain which means that the time series is stable.

This test for the original time series is performed first at the level, if it does not stabilize at the level, we take the first and then the second differences, and we continue like this until it stabilizes, then we reject the null hypothesis that the unit root problem exists If the calculated absolute value of the ADF test is greater than the absolute values of the critical value at the significance level of 0.05, and if the probability value is less than 0.05 (Gujarati, 2003, p 19).

The ADF test for the regression equation is done in three formulas (fixed border or fixed limit and direction or without fixed limit and direction (Lafi El Naif and Elhanti, 2018, p 26), as shown in the following table:

Table 1. Stability tests using ADF test at 5% level of significance:

Variable	The model	The original series Level		1st difference	
		ADF	t-Statistic	ADF	t-Statistic
EX	III/None	0.162720	-1.691409	-3.663274	-1.964418
	II/trend and intercept	1.837822	-3.690814	-4.782974	-3.733200
	I/ intercept	-2.148632	3.040391-	-3.526789	-3.065585
PP	III/None	-0.298366	1.962813	-4.489850	-1.968430
	II/trend and intercept	-1.260743	-3.710482	-4.040816	-3.791172
	I/ intercept	-1.602212	-3.052169	-4.287859	-3.098896

Source: Prepared by researchers based on EViews.10.

After testing by using EViews.10 program, we found that the time series of dollar exchange rates and oil prices were inherently unstable because the ADF test statistic was insignificant, in this case we enter the difference of the one degree, After treating the original chains using the first-order difference method, we found that the first difference chains (DEX and DPP) are stable due to its stability condition, which is that the absolute values of the test statistics are greater than the critical values corresponding to them in the three models of extended Dickey Fuller test, this proves that the US dollar and oil price chains are integrated from the first degree, which means that they have the same degree of integration, so there is a long-run relationship.

Test Bound: In this case there are two hypotheses:

- The null hypothesis H0 which indicates that there is no long-run relationship going from the explained variable to the dependent variable if the calculated F is less than I1Bound.
- The hypothesis of variant H1 indicates a long-run relationship going from the interpreted variable to the dependent variable if the calculated F is greater than I1Bound and we compare the calculated F-statistic with I1Bound.

Table 2. Test Bound results

ARDL Bounds Test Date: 11/15/19 Time: 18:51 Sample: 2004 2018 Included observations: 15 Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	k
F-statistic	9.703114	1
Critical Value Bounds		
Significance	I0 Bound	I1Bound
10%	4.04	4.78
5%	4.94	5.73
2.5%	5.77	6.68
1%	6.84	7.84

Source: Prepared by researchers using EViews.10.

Through the table 2, we note that the computed is greater than the F-statistic= 9.703114 is greater than F Bound = 5.73 at the level of significance 5% in this case we reject the null hypothesis H0 and accept the alternative hypothesis H1, it mean there is a long-run relationship going from the explained variable (the exchange rate of US dollar) to the variable (oil prices) at the 1% significance level.

COMMON INTEGRATION SLOPE ACCORDING TO ARDL MODEL

We test co-integration to investigate a balanced relationship in the long run between variables, and the nature of the relationship of balance in the long run considering that the relationship between them is complementary, for co-integration to be present there must be one integral vector between the variables in the ARDL test, and Autoregressive Distributed Lag Model, ARDL appeared as the best alternative because it does not require that the estimated variables have the same integral rank, since co-integration is tested using ARDL.

Joint integration testing using ARDL is done through the "Bound Test" method developed by Pesaran and Shin in 2001 where Autoregressive Model, AR (p) and Distributed Lag Models were combined, In this methodology, the time series is a function of slowing down its values and the values of the current explanatory variables by one or more period (Pesaran, Smith, & Shin, 2001, pp. 289-326), the ARDL method differs from other traditional methods used to test joint integration with multiple advantages (Narayan, 2005, p. 258), these differences are as follows:

This method can be applied if the variables under study are integrated from the rank I (0) or integrated from the rank of one true I (1) or integrated from different degrees, which means that it can be applied when the degree of integration is unknown or not uniform for all study variables;

Also, the results of the study in practice are efficient in the event that the sample size (number of observations) is small unlike most traditional joint integration tests that require that the sample size be large in order for the results to be more efficient, and that its use helps to estimate the components of (long and short term relationships) Together at the same time in one equation instead of two separate equations as shown in the following table:

Table 3. ARDL Model Estimation Results

Dependent Variable: PP
Method: ARDL
Date: 11/15/19 Time: 19:55
Sample (adjusted): 2004 2018
Included observations: 15 after adjustments
Maximum dependent lags: 4 (Automatic selection)
Model selection method: Akaike info criterion (AIC)
Dynamic regressors (4 lags, automatic): EX
Fixed regressors: C
Number of models evalulated: 20
Selected Model: ARDL(4, 4)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
PP(-1)	0.590186	0.288246	2.047507	0.0959
PP(-2)	-0.371633	0.330571	-1.124216	0.3120
PP(-3)	-0.359660	0.361936	-0.993712	0.3660
PP(-4)	-0.392057	0.305109	-1.284974	0.2551
EX	-120.4302	65.73814	-1.831968	0.1264
EX(-1)	73.13531	57.42445	1.273592	0.2588
EX(-2)	-17.98718	68.23267	-0.263615	0.8026
EX(-3)	9.210312	62.59148	0.147150	0.8888
EX(-4)	170.9302	58.85447	2.904285	0.0336
C	-33.90398	92.90799	-0.364920	0.7301

R-squared	0.896995	Mean dependent var	74.72635
Adjusted R-squared	0.711587	S.D. dependent var	25.16488
S.E. of regression	13.51457	Akaike info criterion	8.280135
Sum squared resid	913.2184	Schwarz criterion	8.752169
Log likelihood	-52.10101	Hannan-Quinn criter.	8.275107
F-statistic	4.837943	Durbin-Watson stat	1.647932
Prob(F-statistic)	0.008659		

**Note: p-values and any subsequent tests do not account for model selection*

Source: Prepared by researchers using EViews.10.

The results of the statistical tests for the regression equation in the table indicate that the quality of the (F-statistic) parameter at the significance level is less than 5%.

4.2 ERROR CORRECTION MODEL

Now we estimate the error correction factor using ARDL Cointegrating And Long Run Form.

The results are shown in the following table:

Table 4. Results of estimating the error correction factor methodology

ARDL Cointegrating And Long Run Form
Dependent Variable: PP
Selected Model: ARDL(4, 4)
Date: 11/15/19 Time: 19:48
Sample: 2000 2018
Included observations: 15

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(PP(-1))	1.123350	0.406261	2.765094	0.0396
D(PP(-2))	0.751717	0.408868	1.838534	0.1254
D(PP(-3))	0.392057	0.305109	1.284974	0.2551
D(EX)	-120.430166	65.738138	-1.831968	0.1264
D(EX(-1))	-17.987182	68.232673	0.263615	0.8026
D(EX(-2))	-9.210312	62.591480	-0.147150	0.8888
D(EX(-3))	-170.930153	58.854467	-2.904285	0.0336
CointEq(-1)	-1.533164	0.365050	-4.199876	0.0085

Cointeq = PP + (15.9159*EX -22.1137)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
EX	-15.915940	48.939102	1.530799	0.1864
C	22.113734	61.953542	-0.356941	0.7357

Source: Prepared by researchers using EViews 10.

In this test, two conditions must be satisfied that the value of CointEq (-1) is negative and significant, from the results of Table 04, we notice that CointEq (-1) = -1.533164 with a negative and significant value because prob = 0.0085 is less than 0.05, it means that they do not get far apart so that they exhibit similar behavior, in the error correction model, the estimated and correct (-1.533164) error correction test indicates that this relationship is out of balance in the long-run, and it is corrected every day by 1.53%, also the causal relationship is moving from the dollar exchange rate to the international oil prices in the short and long run.

The long-run common integration equation is written as follows:

G=22.11 -15.91-PP.....02

US dollar exchange rates are negative and they are consistent with previous studies, which mean that if the dollar exchange rate against the euro decreased, the demand for oil will increase, and as a result oil prices rise on global, this reflects the correctness of the hypothesis.

So there is a long-term counter-balance relationship between the dollar exchange rate and oil prices, that is, whenever the dollar price falls by one unit, oil prices in global will rise by 15.91 dollars, and this explains the correctness of the hypothesis, It is also noticed that the value of the determining coefficient R^2 = 0.896995, and this indicates that the independent variable, the dollar exchange rate (EX), is explained by 98% of the changes that occur in the dependent variable, oil prices (PP), and the value of 2% is the amount of error or other variables not included in the model or Inaccuracy of statistical data.

AUTO CORRELATION BETWEEN ERRORS BY USING THE LAGRANGE MULTIPLIER (LM) TEST

Table 5. Results of estimating the auto-correlation between errors using (LM Test)

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.078761	Prob. F(2,3)	0.9261
Obs*R-squared	0.748316	Prob. Chi-Square(2)	0.6879

Source: Prepared by researchers using EViews.10

Since Prob.F (2,3 (=0.9261 greater than 5%, we accept the null hypothesis and reject the alternative hypothesis, i.e. there is no serial self-correlation between the errors, so the errors are independent between them.

5 HETEROGENEITY OF ERROR VARIANCE BY USING BREUSCH-PAGAN-GODFREY TEST

Table 6. Results of estimating the heterogeneity test for error variations

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	0.186298	Prob. F(9,5)	0.9854
Obs*R-squared	3.766875	Prob. Chi-Square(9)	0.9261
Scaled explained SS	0.213318	Prob. Chi-Square(9)	1.0000

Source: Prepared by researchers using EViews.10

From the above table it is clear that the probability of testing for heterogeneity of error variations F Prob (9,5) = 0.9854 F (9,5) It is greater than 5%, therefore, we reject the alternative hypothesis H1, we accept the null hypothesis H0, this means that there is no problem of heterogeneity in the estimated model, that is, that the residues have a homogeneous contrast and the differences between its variations are not significant.

5.1 THE NORMAL DISTRIBUTION TEST FOR THE REMAINING ESTIMATED MODEL -JARQUE-BERA-

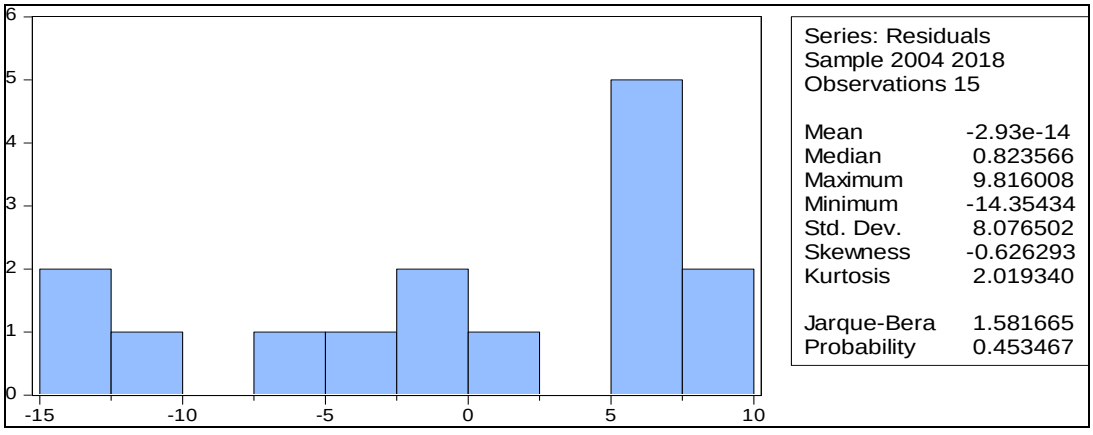

Fig. 3. Test for normal distribution of residues of the estimated model

Source: Prepared by researchers using EViews.10

From Figure 3 we notice that the probability value of the Jarque-Bera statistic (Prob = 0.654858) is greater than 05%, so the the rest follows the normal distribution. And since the rest of the estimated model are similar (have the same variance and are independent between them) and follow the normal distribution, we can accept this model in explaining the effect of the dollar exchange rate on oil prices in international markets, this means that the estimated model in our study is valid for explanation, after its performance In both two tests, the statistical tests (first degree tests) and the standard tests for the rest (second degree tests).

6 CONCLUSION

Through this research paper, we studied the effect of changes in the exchange rate of US dollar against the euro on oil prices in international markets during 2000-2018 by using the ARDL model of auto-regression of the distributed time gaps, and at the conclusion of this analytical and empirical study we reached the following results:

- The oil market is characterized by fluctuation and volatility, especially in recent years, oil prices experienced two strong shocks, the first was in 2009 and the second was in 2014, when oil prices decreased, by losing more than two-thirds of its values.
- By analyzing the movements of oil prices in international markets, we noticed that these prices are characterized by fluctuations with a lot of highs and lows during the period 2000-2018.
- The results of the applied study also showed that there is a long-run balance relationship between the dollar exchange rate and oil prices, which means that the US dollar exchange rate has a long-run impact on oil prices in international markets, that is, in the long term oil prices move directly to changes in the US dollar exchange rate against euro
- In the long term, the US dollar exchange rate changes adversely affect oil prices, which means that the decrease in the US dollar exchange rate against the euro leads to an increase in the volume of oil demand in European countries and other countries except the United States of America, This leads to higher oil prices, and vice versa if the US dollar exchange rate rises.
- Finally, the results of this study seem more realistic, especially as it is compatible with the results of most previous studies that dealt with the subject in previous periods, as oil prices in international markets are adversely affected by changes in the US dollar exchange rate.

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