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# Dynamic Modeling and Volatility Analysis of Crude Oil Prices Using ARIMA–ARCH Framework

**ABDELHAFIDI Aissa**
DIQAPE Lab, University of Laghouat (Algeria), a.abdelhafidi@lagh-univ.dz

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**Abstract:**

This study presents a dynamic model of crude oil prices using a time series framework based on a large weekly dataset consisting of 1,958 observations. To capture the dynamics of crude oil prices, an ARMA model is employed, while an ARCH model is used to analyze and capture conditional volatility and volatility clustering, supported by a set of diagnostic tests to ensure statistical adequacy. The results indicate that the ARIMA(3,1,1)– ARCH(1) framework effectively describes and explains both the evolution and volatility behavior of crude oil prices, highlighting the robustness of dynamic and volatility-based approaches in energy market analysis..

**Keywords**: : Crude oil prices; ARMA–GARCH; Volatility; Time series; Energy markets.

**JEL Classification**: C22, C58, Q41.

## 1. Introduction:

Crude oil prices are one of the most important global economic variables due to their pivotal role in influencing economic growth, inflation, the trade balance, and the stability of financial markets, whether in energy-exporting or energy-importing countries. The crude oil market is characterized by a high degree of volatility and uncertainty, as a result of the overlap of multiple factors including global economic conditions, monetary policies, geopolitical tensions, decisions of the Organization of Petroleum Exporting Countries (OPEC), as well as unexpected shocks such as financial crises and global pandemics. These characteristics have made oil price forecasting both complex and important research issues.

Crude oil prices are one of the most volatile and influential economic variables in the global economy, due to their crucial role in determining production costs, guiding economic policies, and influencing international financial markets. These prices have known over time sharp changes resulting from multiple economic and geopolitical factors, making the analysis of their temporal behavior a matter of great scientific and applied importance. This study was characterized by the use of a large sample size that includes 1958 weekly observations, in addition to the adoption of recent data covering volatile periods, which enhances the accuracy of the results and the strength of the conclusions that can be drawn about the dynamics of oil prices.

In this context, the adoption of the time series methodology allows accurate price modeling, both at the level of average and conditional variance, with the ability to capture cyclical patterns and volatility clustering. Standard analysis also allows for an understanding of price response to past shocks and their persistence, providing a reliable scientific framework for the study of complex time series. By taking advantage of the large sample size and recent data, the study provides a comprehensive reading of the dynamics of oil prices, and enhances the credibility of the applied results that can be relied upon in economic analysis and investment decision-making.

### 1-1 Problematic:

Crude oil prices are characterized by significant fluctuations in the short and medium term, as a result of the interaction of a combination of economic, geopolitical, and global financial factors. These fluctuations make it difficult for researchers and decision-makers to accurately predict future prices, and increase the risks associated with investment and economic planning. Despite the multiplicity of studies on oil markets, many of them rely on short-term data or overlook the impact of divergence clusters and asymmetric shocks on price movements. Therefore, there is an urgent need to use standard time series models that can represent the full dynamics of prices, taking advantage of large sample size and recent data to ensure accurate and reliable results.

Accordingly, the problem of this study revolves around the following main question:

How can a standard time series model be constructed that accurately interprets oil price

movement, estimates changes in average and conditional volatility using recent and large weekly data?

**1-2 Study Hypotheses:**

Proceeding from the study problematic, this study assumes the following hypotheses:

- There is a temporal relationship between current and previous oil prices, so that they can be accurately represented using the Arma model, which allows to predict the future values of the average.
- Oil price fluctuations are affected by previous shocks, so they can be modeled using the arch/GARCH model, reflecting the presence of the Volatility Clustering property in the chain.
- The values estimated by the ARMA-GARCH model will be very close to the actual values of the series, reflecting the high explanatory power of the model and its ability to accurately represent the behavior of weekly oil prices.

**1-3 Objectives of the study:**

This study aims to achieve a set of scientific objectives consistent with the research hypotheses, all of which seek to understand and represent the dynamics of crude oil prices using appropriate standard models. These objectives include:

- Analyzing the dynamics of crude oil prices using large and recent data: Studying the behavior of weekly prices over a long period (1958 AD) to cover all the fluctuations of large rises and declines, while taking advantage of the freshness of the data to reflect the current reality of the market.
- Appropriate ARMA-ARCH/GARCH model estimation: Choosing a standard model capable of accurately representing mean and conditional variance, while ensuring that the coefficients are statistically valid and that the model is able to accommodate large dynamic changes.
- Evaluating the explanatory and predictive power of the model: Comparing the estimated values with the actual values to verify the model's ability to realistically represent the chain, and taking advantage of the large sample size to support the credibility of the predictive and analytical results.

**1-4 The Study Approach:**

This study is based on the analytical approach, as it combines an accurate description of the economic phenomenon of crude oil prices and an analysis of its statistical and dynamic characteristics, such as volatility and time dependence, with quantitative and predictive analysis using appropriate standard models, with the aim of estimating future price behavior and measuring the accuracy of forecasting , which allows combining an accurate theoretical understanding of the phenomenon and drawing practical results that can be used in making economic and investment decisions.

## 2. The theoretical framework of the study .

### 2.1 The importance of crude oil prices and their economic impact:

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Crude oil and its associated energy sector is one of the most important determinants of global economic growth, playing a central role as a key input into production, and forming a large part of the global energy mix that feeds into the industrial, transportation and manufacturing sectors of both developed and developing economies. Oil is seen in the economic literature as a major production factor contributing to increasing productivity and boosting economic activity, thanks to its role in providing energy for the operation of factories and the operation of transportation and critical infrastructure. The importance of oil and gas as an engine for economic growth has been emphasized in studies linking the energy sector and economic development at the global level, noting their impact on international trade and the GDP of energy-producing and importing countries. (Stevens P. , 2018, p. 72)

The economic impact of oil extends to currency markets and international trade, as oil is a commodity whose prices are closely linked to the balance of payments and trade flows between countries. Oil appears in the global economy as a unified commodity used by the whole world in production and consumption systems, making it a pivotal element in international economic integration. Research suggests that oil influences the structure of global trade through its role in shaping value chains, as trade patterns and global production overlaps are clearly correlated with oil price movements and the amount of oil consumed in different economies, reflecting the interdependence between energy and global economic growth (Paul, 2016, p. 3).

At the macro level, the price of oil is a factor influencing major economic variables such as inflation, economic growth, and financial stability. Recent benchmark studies have demonstrated that oil price fluctuations can be transmitted to economies in the form of shocks that affect price stability and aggregate production, making oil not just a consumer good but a key economic indicator that can contribute to forecasting future economic trends. This shows the importance of studying oil price behavior as part of economic time series analysis to understand global macroeconomic dynamics. (Francesco Picciolo, 2017, p. 762)

In addition to its role in driving economic growth, oil also plays an important role in the economic and strategic policies of producing countries, as oil revenues affect the budgets of countries, development programs and public investment. Oil industries may occupy a significant portion of government revenues in many energy-rich countries, making the oil sector a key component of economic planning and fiscal policies. Oil also forms a pivot in international economic relations, and significantly affects the economic effectiveness of countries within the global economic system, especially when it comes to

competing for markets and resources.

**2.2 The impact of price volatility on energy-exporting and energy-importing countries**:

Oil price fluctuations play a pivotal role in influencing growth rates and economic well-being in energy-exporting countries, especially those that rely heavily on oil as a major source of government revenue. Benchmark studies indicate that higher prices give a strong boost to government revenues, enabling increased public investments in infrastructure and social spending, which can support macroeconomic growth in the short and medium term. However, low or highly volatile prices can generate fiscal pressures on oil export-dependent governments, resulting in lower public revenues, reduced spending on development projects, and increased budget deficits, especially if income diversification mechanisms are absent in these economies.

Economic literature shows that oil price shocks affect economies differently depending on whether they are energy exporters or importers. Higher oil prices usually lead to higher GDP in exporting countries due to increased oil revenues and demand for their hydrocarbon exports, while these increases often lead to slower growth in importing countries because higher energy costs pressure domestic production and consumption, and increase operating costs. This is reflected in indicators such as GDP and inflation indicators, and the impact varies depending on the structure of the economy and the complexity of economic transmission channels of shocks. (Jin Shang, 2024 , , p. 940)

In the same context, research shows that oil price fluctuations can affect the structural balance of the economies of exporting countries through what is known as the “resource disease” (Dutch Disease), as higher prices lead to the flow of foreign currencies and an increase in the value of the local currency, which puts pressure on non-oil sectors such as industry and agriculture and reduces their competitiveness in global markets. When prices fall sharply, the economy becomes more fragile due to heavy reliance on the oil sector, which could affect employment and private investment if there are no effective policies to hedge against oil shocks.

Standard studies indicate that oil price fluctuations extend their effects to trade relations between countries, as countries that are linked to extensive trade networks are indirectly affected by oil price changes, whether through changes in demand for their imports or exports, or by adjusting monetary policies that affect the exchange rate and the cost of foreign goods. In the cases of exporting countries, higher prices can boost sources of hard currency and stimulate investment in other sectors, while in importing countries this rise can lead to higher import costs and erosion of the balance of payments. (FarhadTaghizadeh-Hesary, 2019,)

For energy-importing countries, lower oil prices are often a positive factor in the short term, reducing the cost of petroleum imports and easing pressure on the balance of payments and budgets of households and businesses, boosting purchasing power and spurring economic growth. However, price volatility can be associated with uncertainty in economic and investment policies, increasing exchange rate volatility and inflation in some

cases if there is no stability in monetary and fiscal policies.

Oil price fluctuations play an important role in the exchange rate dynamics of energy-exporting and energy-importing countries. National currency prices in exporting countries tend to correlate positively with higher oil prices due to increased demand for local currency through increased export revenues, while the currencies of importing countries can decline as prices rise as a result of increased cost of imports and trade balance pressures. These changes in exchange rates are also reflected in financial markets, where equity and credit indices interact, making the management of oil shocks a centerpiece of economic policies in both types of countries. (Arafet Hamida, 2024, p. 386)

Recent economic research indicates that * * oil price fluctuations not only affect the internal economic performance of energy-exporting and importing countries, but their effects extend to international economic relations through the so-called “volatility spillover” between oil prices and various economic indicators in global economies. Studies have found that oil price fluctuations can be transmitted to financial and exchange markets as well as to international production and trade indicators, leading to instability in growth indicators at the global level, especially in countries that rely heavily on energy in their production structure. These dynamic spreads of volatility reflect the close correlation between the global oil market and macroeconomic factors, as higher or lower prices can lead to changes in the level of investment, monetary policies, and exchange rates in multiple countries simultaneously, which in turn affects global trade flows and the balance of payments.

In addition to its effects on growth and trade, oil price fluctuations affect inflation and macroeconomic balances in both types of countries. In importing countries, sharp rises in oil prices often lead to increases in inflation due to higher energy costs that move to the prices of goods and services, while in exporting countries, higher prices can help support fiscal revenues, which may ease inflationary pressures internally and boost public investments, but in some cases it can lead to excessive inflation if monetary and fiscal policies are not balanced. (Jin Shang, 2024, p. 741)

### 2.3 Factors affecting oil prices (economic, geopolitical, financial) :

Economic factors are a key determinant of oil prices, as the price of crude oil is closely linked to the balance of supply and demand in the global market (Hamilton, 2009, p. 217). Oil demand is directly affected by levels of global economic growth, especially in major and emerging economies, as industrial expansion and rising economic activity increase energy consumption and thus upward pressure on prices (Kilian, 2008, p. 873). In contrast , the supply side is affected by the production capacities of producing countries and levels of investment in the exploration and development sector, in addition to extraction costs (Hamilton, 2009, p. 218). Economic literature has shown that shocks associated with global demand are often more impactful and sustainable on oil prices than short-term supply shocks.

Geopolitical factors play a pivotal role in explaining the sharp fluctuations in oil

prices, given the large geographical concentration of oil reserves in areas of political instability (Dario Caldara, 2022). Armed conflicts, economic sanctions, and internal unrest in producing countries can lead to supply disruptions or create concerns about security of supply, which is immediately reflected in prices through what is known as a geopolitical risk premium (Christiane Baumeister, 2013, p. 10). The effects of these factors are not limited to the actual decline in production, but extend to affect the expectations of dealers in global markets (Caldara & Iacoviello, 2022), which exacerbates price fluctuations.

Alongside real factors, financial factors are becoming increasingly influential on oil prices, especially as the role of futures markets expands and financial investors become more involved. The so-called "excessive financialization" of commodity markets has linked oil prices to global capital movements, interest rates, and stock market volatility (Tang K., 2012). Applied studies suggest that financial investment flows and speculation may amplify oil price fluctuations in the short term, even in the absence of fundamental changes in supply and demand fundamentals (Bassam Fattouh, 2013, p. 11).

Recent studies confirm that oil prices are determined not by a single factor, but by a complex interplay of economic, geopolitical, and financial factors. Geopolitical shocks often lead to higher risk premiums, which are reflected in financial behavior in oil markets , while global economic shocks contribute to price volatility through financial channels. This overlap highlights the importance of adopting dynamic analytical approaches to understanding the evolution of oil prices over time (Kilian Lutz, 2014, p. 460)

## 3. The applied framework of the study :

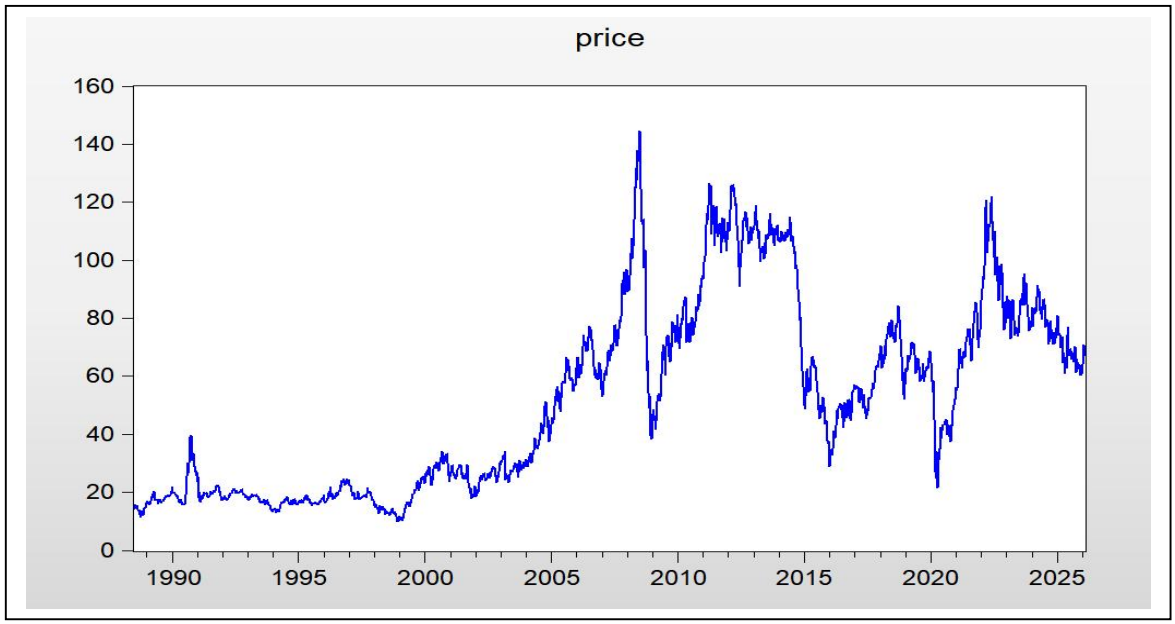
The applied framework of this study represents the practical stage in which the theoretical foundations of standard models are translated into quantitative analysis aimed at modeling the price of oil and predicting its behavior. In this section, the approved data, their statistical characteristics, stability tests will be presented, in addition to determining the most appropriate standard model for modeling oil prices, and testing its predictive efficiency. This will allow drawing practical conclusions that support the theoretical hypotheses of the study and contribute to understanding the dynamics of oil prices in the short and long term.

### 3.1 Descriptive analysis of the oil price chain:

In this study, the historical data of the price of Brent crude was relied upon. The weekly prices were taken from: 31/07/1988 to : 01/02/2026 . The size of the sample taken during this period was 1958 .

The main reason for choosing this period and the large size of the sample is to make the data include periods of oil crises and the large declines that accompanied them (1989 , 1997, 2008, 2014, 2020 ) , in addition to periods of large rises (1991 , 1998, 2008, 2013, 2022) , all of which will make the standard model more efficient in modeling oil prices.The following figure shows the development of Brent crude prices during the study period:

**Fig 01: Historical development of the oil price (31/07/1988 – 01/02/2026)**




**Source:** (Crude) https://sa.investing.com/commodities/brent-oil

From the figure, we find that oil prices witnessed noticeable fluctuations during the study period, where they witnessed significant declines during :

- **1988**: A sharp collapse in prices due to increased production, especially from OPEC, which led to a decline in price by more than 50%.
- **1998:** An Asian financial crisis affected global demand, especially after the Asian financial crisis, dropping prices to very low levels.
- **2008–2009:** After oil hit record levels in 2008, the price collapsed as the global financial crisis erupted, falling from around $147 to less than $40 per barrel.
- **2014–2016**: A major collapse due to the U.S. shale boom and oversupply, with OPEC deciding not to cut production initially.
- **2020**: Historical decline during the COVID-19 pandemic, as global demand collapsed and WTI even hit the record highs

In addition to the large declines, oil prices also witnessed large rises during :

- **1990–1991**: Sharp rise due to the Gulf War after Iraq's invasion of Kuwait.
- **2003–2008:** A strong rally driven by rising global demand, especially from China, as well as geopolitical tensions, culminating in a historic peak in 2008.
- **2011–2013**: Relatively high prices (above $100) as a result of turmoil in the Middle East, especially after the Arab Spring.
- **2021–2022:** A strong post-pandemic recovery, followed by a big jump following the outbreak of war between Russia and Ukraine, pushing prices to very high levels in 2022.

The following table shows the statistical characteristics of the study sample:

**Table (01): Descriptive characteristics of the time series**

| | P_OIL |
|---|---|
| | P_OIL |
| Mean | 52.21626 |
| Median | 49.13500 |
| Maximum | 144.4900 |
| Minimum | 9.820000 |
| Std. Dev. | 32.53708 |
| Skewness | 0.514911 |
| Kurtosis | 2.111763 |
| | |
| Jarque-Bera | 150.8884 |
| Probability | 0.000000 |
| | |
| Sum | 102239.4 |
| Sum Sq. Dev. | 2071801. |
| | |
| Observations | 1958 |

**Source:** Prepared by the researcher based on the outputs of EViews .12

From the statistical characteristics, we find that the average oil prices during the study period amounted to $49.13 per barrel , while the highest price reached $144.49 per barrel during 2008 , while the lowest price canceled $9.82 per barrel during 1988

### 3.2 Stability Study:

To study the stability of the time series, the developed Dickie Fuller ADF test was relied upon, and the result is shown in the following table:

**Table (02) : Descriptive characteristics of the oil price during the study period**

| | Calculated Value | 10 % | 5% | 1% | The Decision |
|---|---|---|---|---|---|
| **On the level.** | **- 0,65** | **-1,61** | **-1,94** | **-2,56** | **Unstable** |
| **Tier 1 Spreads** | **-45,56** | **-1,61** | **-1,94** | **- 2,56** | **Stable** |

**Source:** Prepared by the researcher based on Appendix 1

From Table 02 , we find that the time series of the oil price is unstable at the original level, as the test showed that the calculated value is less than the scheduled values (after taking the absolute value of the values) at all levels of significance, from which we accept the nihilistic hypothesis that states the existence of the unit root and thus the series is unstable , the first difference of the values was taken and the test was carried out again , to show that the series is stable, which is shown by the value of the selection ,where the calculated value is greater than the scheduled values (after taking the absolute values of the values ), from which we reject the nihilistic hypothesis and accept the alternative hypothesis that stated that there is no unit root and from which the time series is stable , so the series is integrated from the first degree.

### 3.3 Determine the appropriate model for the study .

In order to know the form of the appropriate model for the study , we resort to the form of the simple self-correlation function ,and the partial self-correlation function of the stable series, and the result is shown in the following figure:

**Fig (02) : Series D (P-oil) correlogram**

Correlogram of D(P_0IL)

Date: 02/13/26 Time: 18:43
Sample: 1 1958
Included observations: 1957

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| | | 1 | -0.031 | -0.031 | 1.8379 | 0.175 |
| | | 2 | -0.003 | -0.004 | 1.8600 | 0.395 |
| | | 3 | 0.064 | 0.064 | 9.9407 | 0.019 |
| | | 4 | 0.043 | 0.047 | 13.589 | 0.009 |
| | | 5 | 0.005 | 0.008 | 13.629 | 0.018 |
| | | 6 | 0.058 | 0.055 | 20.189 | 0.003 |
| | | 7 | 0.036 | 0.034 | 22.749 | 0.002 |
| | | 8 | 0.062 | 0.063 | 30.428 | 0.000 |
| | | 9 | -0.025 | -0.029 | 31.697 | 0.000 |
| | | 10 | -0.042 | -0.053 | 35.120 | 0.000 |
| | | 11 | 0.033 | 0.017 | 37.202 | 0.000 |
| | | 12 | -0.006 | -0.011 | 37.284 | 0.000 |
| | | 13 | -0.001 | 0.002 | 37.287 | 0.000 |
| | | 14 | -0.012 | -0.019 | 37.557 | 0.001 |
| | | 15 | 0.022 | 0.019 | 38.495 | 0.001 |

**Source:** Prepared by the researcher based on the outputs of EViews .12

From Figure No. (02), we note that there are several models of Arima, to choose the best model, a trade-off was made between them using the AIC and SC standards, as it was found that the optimal model is : Arima (3.1.1), based on the lowest value of the AIC and SC standards, and the result of estimating this model is shown in the following table:

**Table (3): ARIMA Estimate (3.1.1)**

Dependent Variable: D(P_0IL)
Method: ARMA Maximum Likelihood (OPG - BHHH)
Date: 02/13/26 Time: 23:19
Sample: 2 1958
Included observations: 1957
Convergence achieved after 32 iterations
Coefficient covariance computed using outer product of gradients

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| AR(3) | 0.065856 | 0.013608 | 4.839652 | 0.0000 |
| MA(1) | -0.033609 | 0.013901 | -2.417814 | 0.0157 |
| SIGMASQ | 7.021060 | 0.107181 | 65.50645 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.005158 | Mean dependent var | 0.026827 |
| Adjusted R-squared | 0.004140 | S.D. dependent var | 2.657268 |
| S.E. of regression | 2.651762 | Akaike info criterion | 4.789864 |
| Sum squared resid | 13740.21 | Schwarz criterion | 4.798417 |
| Log likelihood | -4683.882 | Hannan-Quinn criter. | 4.793008 |
| Durbin-Watson stat | 1.999020 | | |

**Source:** Prepared by the researcher based on the outputs of EViews .12

From the results of the estimation shown in Table No. **(3)**, it is clear that the model is statistically acceptable, as both parameters AR(3) and MA(1) have statistical significance, which is shown by the probabilistic value of the Student statistic, which is less than 0.05.

To ensure that there are fluctuations that usually characterize price chains, we test the stability of the variance arch, , the result is shown in the following table:

**Table (4): ARCH Heteroskedasticity Test.**

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 76.54340 | Prob. F(1,1954) | 0.0000 |
| Obs*R-squared | 73.73341 | Prob. Chi-Square(1) | 0.0000 |

**Source:** Prepared by the researcher based on the outputs of EViews .12

From Table No. (4), the result of the ARCH test shows that the variance of errors is not fixed, which is shown by the probability value of the test, which is less than 0.05 , that is, we accept the hypothesis H1, which states that the variance is not fixed,

### 3.4 ARIMA-GARCH model estimation.

After ensuring that the GARCH models could be integrated into the previous model, a trade-off was made between the possible models of GARCH based on the statistical trade-off criteria. The appropriate model was found to be: Arima (3.1.1) - GARCH(1 . 0) The result of the estimate is shown in the following table

**Table (5): Estimation of the study model.**

Dependent Variable: D(P_0IL)
Method: ML ARCH - Normal distribution (OPG - BHHH / Marquardt steps)
Date: 02/14/26 Time: 10:30
Sample (adjusted): 2 1958
Included observations: 1957 after adjustments
Convergence achieved after 98 iterations
Coefficient covariance computed using outer product of gradients
Presample variance: backcast (parameter = 0.7)
GARCH = C(3) + C(4)*RESID(-1)^2

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| AR(3) | 0.018495 | 0.008050 | 2.297585 | 0.0216 |
| MA(1) | -0.037660 | 0.013616 | -2.765813 | 0.0057 |
| Variance Equation | | | | |
| C | 3.742809 | 0.082843 | 45.17953 | 0.0000 |
| RESID(-1)^2 | 0.699354 | 0.039129 | 17.87305 | 0.0000 |

| | | | |
|---|---|---|---|
| R-squared | 0.002880 | Mean dependent var | 0.026827 |
| Adjusted R-squared | 0.002370 | S.D. dependent var | 2.657268 |
| S.E. of regression | 2.654118 | Akaike info criterion | 4.642824 |
| Sum squared resid | 13771.69 | Schwarz criterion | 4.654228 |
| Log likelihood | -4539.003 | Hannan-Quinn criter. | 4.647016 |
| Durbin-Watson stat | 1.986687 | | |

**Source:** Prepared by the researcher based on the outputs of EViews .12

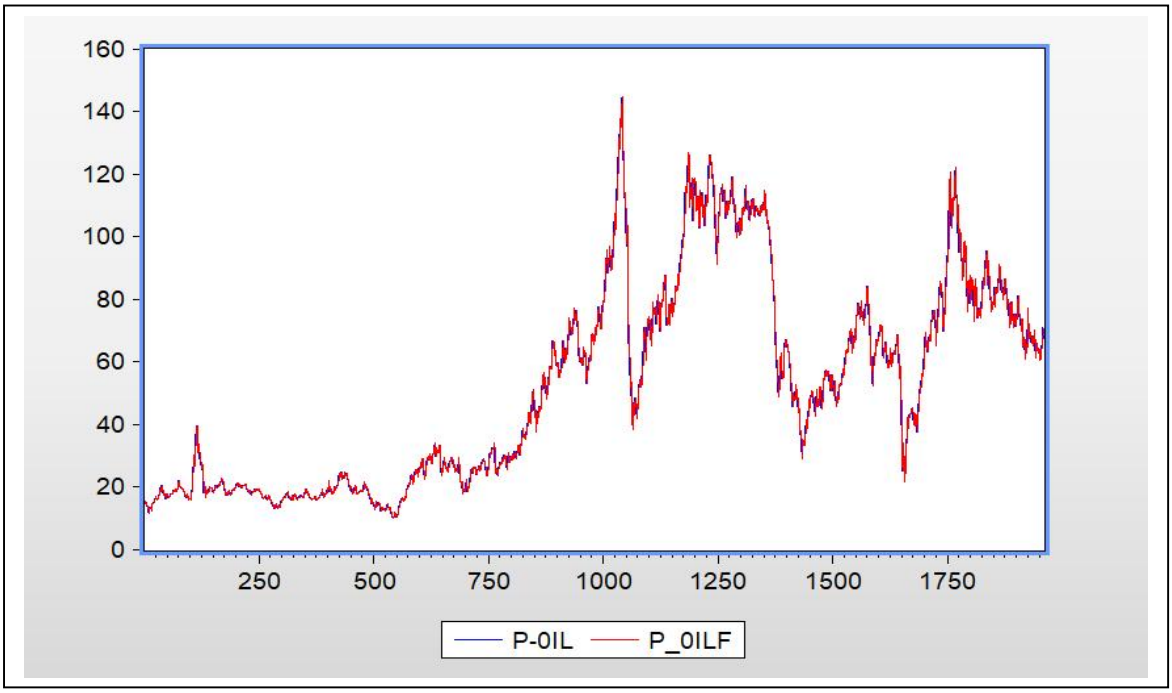
The model estimation results shown in Table (5) indicate that the average equation is able to adequately represent the dynamics of weekly changes in crude oil prices, as the self-regression coefficients and the moving average reflect the existence of a short-term time dependence between the current and previous values of the time series. At the level of conditional variation, the arch(1) model showed that previous shocks in oil prices directly

affect the volatility of the current period, which indicates the presence of the Volatility Clustering feature in the chain. The stability of the coefficient of variation also reflects the model's ability to represent volatility behavior without exaggerating its continuity, making it appropriate for the nature of the weekly data adopted. In general, the results show that fluctuations in oil prices are mainly affected by recent shocks, while the bulk of price changes are explained by the dynamics of the average, which enhances the efficiency of the model in analysis and forecasting in the short term.

To verify the integrity of the ARMA-GARCH type estimated model, a set of diagnostic tests was performed on the residues. Initially, the residual autocorrelation examination was completed through a correlograme analysis, where the results showed that all correlation coefficients fall within the limits of statistical confidence, and the probability values of the Q statistic were greater than the approved significance level, indicating the absence of autocorrelation in the residues. The results also showed the disappearance of the self-correlation of the remainder squares, and the lack of statistical significance of arch LM, which indicates that the model succeeded in capturing the dynamic of conditional variation and eliminating the phenomenon of clustering of fluctuations. Accordingly, it can be said that the estimated ARMA-GARCH model has good statistical integrity, both at the level of the mean equation and the variance equation, which makes it suitable for analyzing the studied time series and predicting its future behavior.( Appendix 2)

To assess the strength of the estimated model in predicting the price of oil , we compare the estimated values from the model with the actual values. The result is shown in the following figure:

**Figure(3) : Comparing the estimated values with the actual values**




**Source:** Prepared by the researcher based on the outputs of EViews .12

From Figure No. (3), we find that the values estimated by the Arma model (8 .1 . 3) –

GARCH(0. 1) Significantly aligned with actual values, which shows the strength of the study model in estimating oil prices

**4. Conclusion:**

This study concluded with an in-depth standard analysis of the series of crude oil prices, starting from highlighting the economic and strategic importance of oil, and then moving on to modeling its temporal behavior using historical data of weekly prices extending from 1988 to the beginning of 2026 , where the sample included 1958 views. In order to contain as much information as possible and important fluctuations to explain price behavior based on historical data, the initial statistical treatment showed the need to convert the chain to its first differences to ensure stability, and the self-correlation analysis showed the appropriateness of the average representation of the ARMA model (3 ; 1). Conditional variation tests revealed the existence of variable fluctuations over time, reflecting the property of the variation conglomerate that distinguishes oil prices.

The ARMA model (3 ;1) was paired with the GARCH model (1,0) to describe conditional variation, as the estimation results showed a high continuity of volatility, reflecting the sensitivity of oil prices to previous shocks. Diagnostic tests also confirmed the validity of the model in terms of the absence of self-correlation in the residuals and the fading of the residual arch effect, which demonstrates the model's ability to adequately represent the temporal dynamics of oil prices, and highlights the importance of time series standard models in analyzing oil markets and understanding their volatile behavior.

The results of the internal evaluation of the model showed a high explanatory power, by comparing the estimated values with the actual values of the oil price chain. This comparison showed significant convergence and even remarkable congruence in a number of periods, reflecting the model's ability to track the temporal behavior of the series with high accuracy. This convergence indicates that the model was able to accommodate the basic dynamic characteristics of oil prices, both at the level of the average chain and at the level of its volatility, which enhances its representational efficiency and supports its analytical validity within the studied sample. However, this performance mainly reflects the quality of fit within the sample, which necessitates careful handling when interpreting predictive out-of-sample results.

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## 7. Appendices :

## 7.1 Appendix 1:

**Augmented Dickey-Fuller Unit Root Test on P_0IL**

Null Hypothesis: P_0IL has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=25)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -0.658311 | 0.4322 |
| Test critical values: | 1% level | -2.566144 | |
| | 5% level | -1.940986 | |
| | 10% level | -1.616591 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(P_0IL)
Method: Least Squares
Date: 02/15/26 Time: 21:08
Sample (adjusted): 2 1958
Included observations: 1957 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| P_0IL(-1) | -0.000643 | 0.000976 | -0.658311 | 0.5104 |

**Augmented Dickey-Fuller Unit Root Test on D(P_0IL)**

Null Hypothesis: D(P_0IL) has a unit root
Exogenous: None
Lag Length: 0 (Automatic - based on SIC, maxlag=25)

| | | t-Statistic | Prob.* |
|---|---|---|---|
| Augmented Dickey-Fuller test statistic | | -45.56654 | 0.0001 |
| Test critical values: | 1% level | -2.566145 | |
| | 5% level | -1.940986 | |
| | 10% level | -1.616591 | |

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(P_0IL,2)
Method: Least Squares
Date: 02/15/26 Time: 21:07
Sample (adjusted): 3 1958
Included observations: 1956 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(P_0IL(-1)) | -1.030539 | 0.022616 | -45.56654 | 0.0000 |

## 7.2 Appendix 2:

**Correlogram of Standardized Residuals**

Date: 02/15/26 Time: 21:21
Sample: 1 1958
Included observations: 1957
Q-statistic probabilities adjusted for 2 ARMA terms

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob* |
|---|---|---|---|---|---|---|
| | | 1 | 0.001 | 0.001 | 0.0005 | |
| | | 2 | -0.005 | -0.005 | 0.0403 | |
| | | 3 | -0.008 | -0.008 | 0.1783 | 0.673 |
| | | 4 | 0.021 | 0.021 | 1.0080 | 0.604 |
| | | 5 | -0.009 | -0.010 | 1.1840 | 0.757 |
| | | 6 | -0.018 | -0.018 | 1.7953 | 0.773 |
| | | 7 | 0.020 | 0.020 | 2.5628 | 0.767 |
| | | 8 | -0.020 | -0.021 | 3.3787 | 0.760 |
| | | 9 | -0.002 | -0.001 | 3.3845 | 0.847 |
| | | 10 | 0.005 | 0.005 | 3.4259 | 0.905 |

Heteroskedasticity Test: ARCH

| | | | |
|---|---|---|---|
| F-statistic | 0.084508 | Prob. F(1,1954) | 0.7713 |
| Obs*R-squared | 0.084591 | Prob. Chi-Square(1) | 0.7712 |