Analysis of Crude Oil Price in Nigeria using Autoregressive Model Approach

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ABSTRACT

This research conducts a time series analysis of crude oil prices in Nigeria from 2013 to 2022, with a focus on trend examination, stationarity tests, integrated moving average model development, and future price forecasting. Utilizing data from the Central Bank of Nigeria Statistical Bulletin, the study employs statistical methods such as Autocorrelation Function (ACF), Partial Autocorrelation Function (PACF), and Bayesian Information Criterion (BIC) to identify and assess the most suitable ARIMA model. The findings reveal a downward trend in crude oil prices based on Ordinary Least Square (OLS) analysis, with a stationary original series. The best-fitted model is identified as an Autoregressive (AR) model of order 1, indicating a significant lag effect. Forecasting using this AR(1) model predicts fluctuations in crude oil prices from 2022 to 2031.

In conclusion, the research emphasizes the need for investors to diversify portfolios amid volatile crude oil prices and encourages policymakers to promote renewable energy initiatives. The study also suggests avenues for further research, exploring advanced statistical models and collaborative efforts to bridge the gap between research findings and practical applications in the energy sector.

(Keywords: crude oil prices, time-series analysis, Autoregressive Integrated Moving Average, ARIMA, Bayesian Information Criterion, BIC, forecasting)

INTRODUCTION

Crude oil is a major source of energy in Nigeria and the world in general. Known as 'black gold', crude oil accounts for a large part of global energy demand and it has been an indispensable energy source to the world economy. Furthermore, it is inevitably one of the main components of a wide range of daily life products, taking all these into consideration, in spite of alternative energy sources, crude oil remains the primary energy source for the world in the days to come (Zhao, *et al*., 2018).

Crude oil prices have been experiencing large fluctuations at the global scene. The first major global oil price shock occurred from 1973 to 1974 due to the Arabian embargo when oil prices increased from US$3 to US$12. The recent global oil price shock with an oil price below US$30 was a result of the Corona-virus pandemic which is currently ravaging the world. Indeed, the fluctuations in the global oil price have direct impacts on the retail petroleum product prices either in the upstream or downstream sector. The impacts have been studied to be either symmetric or asymmetric (Valadkhani, *et al*., 2015; Rahman, 2016; Apergis, *et al*., 2018; Eleftheriou, *et al*., 2018; Kang, *et al*., 2018; Bragoudakis, *et al*., 2020).

No doubt, crude oil prices have many social and economic determinants. Crude oil prices are usually driven by exporting countries' supply and industrialized countries demand (Alvarez-Ramirez, *et al*., 2013; Uddin and Bekiros, 2018). In addition, crude oil prices are remarkably affected by gross domestic product, political events, weather conditions, speculative behaviors by financial investors, stock markets, financial uncertainty, trader positions at community markets, and economic policy uncertainty (Karasu, *et al*., 2020). Crude oil prices are also affected by economic crises and political events.

Concerning some significant events affecting the oil prices in the past fifty years, some political turmoil and wars between countries, such as Iran-Iraq War, Gulf War, and Iranian Revolution, gave rise to significant increases in oil prices causing huge economic and social consequences for the whole world. On the other hand, with the Asian financial crisis of 1997 and global economic crisis of 2008, oil prices witnessed sharp declines (Baumeister, 2016).

On the other hand, the path of oil prices is crucial for macroeconomic projections of investors and central banks (Safari and Davallou, 2018). The fluctuations in crude oil prices have naturally important effects on a variety of macroeconomic indicators such as inflation, investments and economic growth rate, current account deficit, exchange rates, international trade terms, etc. leading to business cycles. Of course, the effect of fluctuations in oil prices varies from country to country. It is generally determined by the extent to what an economy depends on oil importing or exporting to sustain its economic activities. (Li, *et al.*, 2016).

Nigeria Oil Industry

The oil industry is highly structured and serves as the backbone of foreign exchange revenue for the government. Crude oil was first discovered by Shell-BP in the year 1956, at Oloibiri in the Niger Delta region of Nigeria. In the year 1958, Nigeria joined the ranks of other oil producers when it produced 5,100 bpd from its first oil field. The exploration rights in offshore and onshore areas that were adjoined to the Niger Delta were extended to foreign oil companies. The EA field was also discovered by Shell in the southeast shallow water of Warri, in the year 1965.

After the Biafra war, there was an increase in global oil price. Nigeria benefitted from this increase and focused on oil production. In the year 1971, Nigeria became a member of the Organization of Petroleum Exporting Countries (OPEC), the country then created the Nigerian National Petroleum Company (NNPC) in the year 1977 which is a key player in both the downstream and upstream sector of the Nigerian oil industry. After the discovery of crude oil, pioneer production of oil commenced in Shell D‟Arcy Petroleum‟s oil field in Oloibiri, the eastern part of Niger Delta. During the late 60s and the early 70s, the country had achieved an oil production level of more than 2 million barrels in each day. However, these figures declined due to a change in economic activity in the 80s.

The production and export of petroleum plays a key role in the Nigerian economy. This commodity accounts for more than 90% of the country's earnings. The dominant role played petroleum production has channeled focus from agriculture. The agricultural sector was the mainstay of the Nigerian economy in the early 50s and 60s.

Nigeria is a known exporter of oil to different parts of the world. It is the 8th largest oil exporter in the world. The country's oil export goes to the United States of America, India, Europe, Canada and Brazil. The earnings from oil export are of major benefit to the country's economy provided that the country and its citizens enjoy the benefits from tangible development, export earnings and foreign direct investment. The Niger Delta region is the most prolific producer of oil in Nigeria. Besides the abundance of natural gas and crude oil resources, the states in the Niger Delta region have enormous deposits of solid minerals which could be a potential source of income for the country. From the earnings generated from the export of crude oil, oil producing regions receive 13% as allocation to these regions. The federation account also distributes allocation from crude oil earnings to all tiers of government in the different states in Nigeria. Another source of fund to the Niger Delta region is NDDC which receives 3% of the total budget of the year from all the oil companies in the region. These funds are basically used for the development of the Niger Delta region.

LITERATURE REVIEW

Many research studies have been conducted in areas related to the research topic. However, a major part of the research conducted were on crude oil price and economic growth nexus or on exchange rate economic growth nexus. Akpan (2012) analyzed the dynamic relationship between oil price shocks and major macroeconomic variables in Nigeria by applying a Vector Auto-Regression (VAR) approach. The findings of the study showed a strong positive relationship between positive oil price changes and real government expenditures. Unexpectedly, the result identifies a marginal impact of oil price fluctuations on industrial output growth.

Aremo, *et al.* (2012) examined the effect of oil price shock on fiscal policy in Nigeria by using structural vector auto-regression (SVAR) method within the study period of 1980:1 to 2009:4. The study also revealed that oil price shock affects GDP first before reflecting on fiscal expenditure. The study suggests strongly that diversification of the economy is necessary in order to minimize the consequences of oil price fluctuations on government revenue, by implication government expenditure planning in the country.

Ismail and Adegbemi (2013) explored the impact of oil price movements on real output growth in Nigeria during the period 1970-2011. Using dynamic VAR analytical framework, the findings indicate that the oil price shocks are therefore not found to directly contribute to output, exchange rate or inflation in the short run. They however, manifest significant and positive relationship with output growth in the long run. The generalized impulse responses reaffirm the direct link between the oil price shock and growth, as well as the indirect linkages.

Oriakhi and Osaze (2013) examined the consequences of oil prices volatility on the growth of the Nigerian economy within the period 1970 to 2010 using quarterly data and employing the VAR methodology. It was discovered that oil prices volatility impacted directly real government expenditure, real exchange rate and real import, while real government expenditure impacted real GDP, real money supply and inflation, hence, oil prices changes have the capacity to determine government expenditure level, which in turn determine the growth of the economy thereby reflecting the dominant role of government in Nigeria.

Awujola, Adam, and Alumbugu (2015) in their study conducted, examines the economic impact of oil production on Nigerian economy covering a period of 1970 to 2012. Vector error correction model was analysis the data. The result obtained from our empirical analysis shows that there exists a long run relationship between the crude oil exports and the economic.

Usman, Madu, and Abdullahi (2015) carried out a study titled Evidence of Petroleum Resources on Nigerian Economic Development (2000-2009). The main objective of the study was to examine the impact of petroleum on Nigeria’s economic development.

Suleiman, *et al*. (2015) looked at the most effective GARCH and ARIMA models for accurately forecasting the price of crude oil in Nigeria. The 189 monthly crude oil price observations used in this analysis covered the period from January 1998 to September 2013. Based on factors like AIC, HQC, and SIC, their study evaluated fifteen (15) models and chose the top ARIMA and GARCH models. The model with the least values of the criteria was deemed to be the best model. According to their findings, the best models for predicting the crude oil price data series were ARIMA (3, 1, 1) and GARCH (2, 1). Models AR 1, AR 3, and MA 1 were significant at the 0.05 significance level. Their projection, which was developed for a period of six months, indicates a sharp increase in the price of crude oil when compared to historical averages.

Abraham (2016) examines the effects of crude oil price movement and exchange rate policy on the Nigerian stock market over the period spanning 2012 to 2015. After applying ARDL the results shows that oil prices are positively and significantly related to the performance of the Nigerian stock market and exchange rate is found to be effective in cushioning the effect of crude oil price decline on the stock market. The result from the granger causality test suggested that the policy measure may not be potent as expected.

Zied, *et al*. (2016) studied the degree of interdependence between oil price and economic growth activity for four major countries (United Arab Emirate, Kuwait, Saudi Arabia, and Venezuela) in OPEC over the periods of 2000 to 2010. Using frequency approach of Priestley and Ton, and Engle Granger test for co-integration. The results show that oil price shocks in the periods during period of fluctuations in the global financial turmoil affect the relationship between oil and economic growth in the OPEC countries.

Apere and Eniekezimene (2016) examines the relationship between crude oil price and economic growth of Nigeria over the 1981 to 2013 periods. Using VAR model and ordinary least square (OLS), the results from the VAR model showed that the oil price changes in oil price has a significant impact on the economic growth of Nigeria. While the result from OLS method showed oil prices have positive relationship with GDP, decrease in oil prices have a negative impact on GDP and fluctuation in exchange rate has both negative and positive impact on crude oil price and the GDP. They recommended the need for the diversification of the economy to strengthen the economy even without oil.

Chikwe, Ujah, and Uzoma (2016) analyzed the effect of oil price on the macroeconomic variables from 1990-2015 in Nigeria. Using multiple regression technique, the results showed that unemployment rate contribute positively and significantly to crude oil price. While interest rate impacted negatively and significantly on crude oil price. The result further revealed that inflation rate, exchange rate and real gross domestic product do not have any effect on crude oil price.

Roland (2017) investigated the impact of premium motor spirit, gross domestic investment, labor employment and lending interest rate on economic growth over the period of 1970-2013 in Nigeria. Using error correction model the result showed that premium motor spirit and the lags of interest rate indicated negative and significant impact on economic growth, while gross domestic investment and the lags of labor employment indicate positive and significant impact on economic growth. They recommend that government should reduce the premium motor spirit pump price by deregulation and allowing private sector participation.

Al-Zanganee (2017) investigates the impact of crude oil price volatility on the levels of economic activity in Iraq over the periods of 2003 to 2015. Using VAR model, the results revealed a highly significant impact of volatility of crude oil price on the level of gross domestic product in Iraq.

Bala and Chin (2018) estimate the asymmetric impacts of oil price shocks on inflation in four African oil producing countries - Algeria, Angola, Libya and Nigeria using the ARDL dynamic panels framework. The study discovered that both positive and negative oil price shocks positively influence inflation in these countries during the period, but the impact was more pronounced in periods of oil price declines.

Angela, *et al.* (2018) examines the macroeconomic effects of exogenous oil price shock in Nigeria, using generalized autoregressive conditional heteroscedasticity (GARCH), component generalized autoregressive conditional heteroscedasticity (CGARCH) and exponential generalized autoregressive conditional heteroscedasticity (EGARCH). Results showed that oil price volatility has significant positive effect on exchange rate, foreign external reserves, government revenue, capital importation and, symmetric and persistent of oil price shock in Nigeria.

Sunday, (2019) investigated the nexus between oil price volatility and infrastructural growth in Nigeria using co-integration and error correction modeling approach for the periods 1981-2016. The results suggest that both the oil price volatility and inflation rate tend to exert negative impact on infrastructural growth, while the appreciation of real exchange rate tends to trigger investment in infrastructure. They recommended the need for the design and implement effective diversification of policies with a view to raising nation's revenue trajectory.

Conclusively, all the relevant literature on Nigeria in this area generally focused on relating crude oil price volatility or shocks with economic growth or exchange rate and economic growth or GDP. In line with this, the study seeks to fill this gap by testing the impact of crude oil price and exchange rate on economic growth of Nigeria. Omolade, *et al*. (2019) adopted SVAR to examine the monetary transmission channel of oil price shock in Nigeria. Their findings showed that crude oil price shocks lead to exchange rate appreciation in the long run. The consumer price index response to the shock was negative and insignificant. This implies shock on crude oil prices is not inflationary.

Shah and Kiruthiga (2020) also applied ARIMA in crude oil price forecasting. They managed to examine the time series and nonlinear feature of the oil prices. According to their results, ARIMA (0,1,4) was the most appropriate model for prediction of the oil prices. To make predictions, (Selvi, *et al*., 2018) also used the ARIMA model; it was concluded from their times series analysis observations that the ARIMA model they had established was sufficient. Their projections for the years 2017 through 2021 were produced using the model. Crude oil prices will rise throughout the course of the following year. They suggested that prices should be stabilized, and that extra attention should be paid to monitoring oil prices because a steady increase in oil costs could be a significant problem for a country's economy in the future.

METHODOLOGY

<u>Research Design</u>

A time series design was used in this study. Time series consists of numerical data recorded at equal interval of time. This design was chosen since crude oil prices tend to fluctuate over time. Using monthly crude oil prices from January 2013 to December 2022 as a suitable time series, the ARIMA model was fitted to produce predictions that can be used to predict crude oil prices in the future using historical data.

Time Plot

This is the graph of time series observation against time. Time plot helps in understanding the past behaviors of a variable and also helps to determine the rate of growth extent and direction of periodic fluctuation.

Model Specification

Utilizing a stationary time series is one of the prerequisites for the Box-Jenkins approach. The series must go through a logarithmic transformation if it is not stationary in order to lower the level of variability before being differenced in order to make it stationary.

The stationarity test is carried out by analyzing the correlogram using the autocorrelation function (ACF) and partial autocorrelation function. If the ACF value is 0 for each lag, the data is stationary (Agustin, 2019). After checking for stationarity, finding the ARIMA model is the following step. The Autocorrelation Function (ACF) and the Partial Autocorrelation Function (ACF) are the two commonly used techniques for choosing the ARIMA model.

Model Selection

This study employed the Bayesian Information Criteria, to determine which model was the best. Bayesian Information Criteria (AIC), a penalized-likelihood criterion, is a relative measure of the distance between the fitted likelihood function of the model and the real likelihood function of the data. If BIC of the model is lower, it is considered to be more accurate.

Diagnostic Check

This technique is used by the Box Jenkins-Methodology to determine whether residuals are white noise. To do this, the serial correlation is observed if it exists in the plots of Auto Correlation Function (ACF) and Partial Auto Correlation Function (PACF) of the residuals. Additionally, the residuals are assumed to follow a normal distribution with a mean of zero and a constant variance.

Model Prediction

This stage involves getting the accurate forecasts from the chosen ARIMA model in the model selection stage. These estimates are obtained by fitting the time series data to the ARIMA model. This stage also provides some cautions regarding the suitability of the model; if the model does not adhere to the standards for suitability, it is ignored.

ANALYSIS AND RESULT

Time Plot

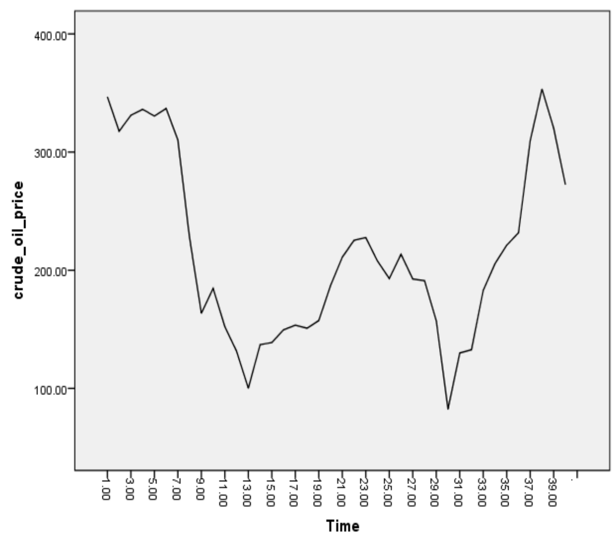

Figure 1: The Time Plot of Crude Oil Price.

Looking at the graph in Figure 1, it is clear that the curve swings or fluctuates around the mean. A fluctuating trend indicates that the values of the data are not following a steady or consistent pattern, but rather showing periodic increases and decreases.

Estimation of Trend Using Least Square Method

Table 1: Model Summary and Parameter Estimates for Linear Trend.

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	237.643	24.714		9.616	.000
	Time	-1.099	1.050	-.167	-1.046	.302

Dependent Variable: Crude oil price.

The linear equation is given as Y_t = 237.943 – 1.099t

Figure 2: Trend (Graphical).

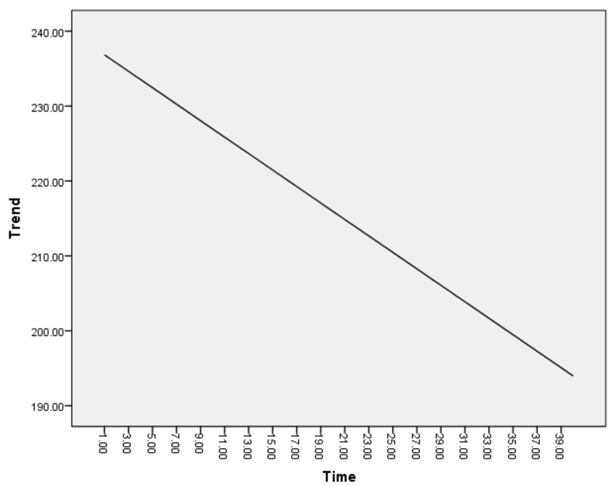

Table 2: Estimation of Trend Line.

Crude Oil Price	t	Y_t = 237.943 – 1.099t
346.84	1	236.84
317.61	2	235.75
331.21	3	234.65
336.18	4	233.55
330.49	5	232.45
336.91	6	231.35
310.23	7	230.25
227.2	8	229.15
163.59	9	228.05
184.59	10	226.95
152.18	11	225.85
131.48	12	224.76
100.12	13	223.66
137.06	14	222.56
138.83	15	221.46
149.67	16	220.36
153.53	17	219.26
150.93	18	218.16
157.44	19	217.06
187.13	20	215.96
211.07	21	214.86
225.39	22	213.77
227.66	23	212.67
207.77	24	211.57
192.95	25	210.47
213.47	26	209.37
192.56	27	208.27
191.22	28	207.17
157.42	29	206.07
82.48	30	204.97
130.01	31	203.87
132.77	32	202.78
182.97	33	201.68
205.59	34	200.58
221.2	35	199.48
231.68	36	198.38
309.58	37	197.28
353.33	38	196.18
320.13	39	195.08
272.43	40	193.98

Seasonal Decomposition

Table 3: Seasonal Decomposition.

Series Name: crude_oil_price							
DATE_	Original Series	Moving Average Series	Ratio of Original Series to Moving Average Series (%)	Seasonal Factor (%)	Seasonally Adjusted Series	Smoothed Trend-Cycle Series	Irregular (Error) Component
Q1 2013	346.840	.	.	97.8	354.777	329.746	1.076
Q2 2013	317.610	.	.	103.7	306.231	330.198	.927
Q3 2013	331.210	332.9600	99.5	100.5	329.587	331.104	.995
Q4 2013	336.180	328.8725	102.2	98.0	342.939	332.797	1.030
Q1 2014	330.490	333.6975	99.0	97.8	338.053	332.002	1.018
Q2 2014	336.910	328.4525	102.6	103.7	324.840	315.861	1.028
Q3 2014	310.230	301.2075	103.0	100.5	308.710	282.748	1.092
Q4 2014	227.200	259.4825	87.6	98.0	231.768	238.912	.970
Q1 2015	163.590	221.4025	73.9	97.8	167.334	197.959	.845
Q2 2015	184.590	181.8900	101.5	103.7	177.977	170.818	1.042
Q3 2015	152.180	157.9600	96.3	100.5	151.434	149.805	1.011
Q4 2015	131.480	142.0925	92.5	98.0	134.124	135.576	.989
Q1 2016	100.120	130.2100	76.9	97.8	102.411	125.485	.816
Q2 2016	137.060	126.8725	108.0	103.7	132.150	129.375	1.021
Q3 2016	138.830	131.4200	105.6	100.5	138.150	138.174	1.000
Q4 2016	149.670	144.7725	103.4	98.0	152.679	147.344	1.036
Q1 2017	153.530	148.2400	103.6	97.8	157.043	151.372	1.037
Q2 2017	150.930	152.8925	98.7	103.7	145.523	156.396	.930
Q3 2017	157.440	162.2575	97.0	100.5	156.669	168.420	.930
Q4 2017	187.130	176.6425	105.9	98.0	190.892	186.739	1.022
Q1 2018	211.070	195.2575	108.1	97.8	215.900	205.259	1.052
Q2 2018	225.390	212.8125	105.9	103.7	217.315	215.519	1.008
Q3 2018	227.660	217.9725	104.4	100.5	226.545	216.825	1.045
Q4 2018	207.770	213.4425	97.3	98.0	211.947	211.867	1.000
Q1 2019	192.950	210.4625	91.7	97.8	197.365	205.088	.962
Q2 2019	213.470	201.6875	105.8	103.7	205.822	200.271	1.028
Q3 2019	192.560	197.5500	97.5	100.5	191.616	192.779	.994
Q4 2019	191.220	188.6675	101.4	98.0	195.065	175.091	1.114
Q1 2020	157.420	155.9200	101.0	97.8	161.022	150.360	1.071
Q2 2020	82.480	140.2825	58.8	103.7	79.525	127.763	.622
Q3 2020	130.010	125.6700	103.5	100.5	129.373	129.581	.998
Q4 2020	132.770	132.0575	100.5	98.0	135.439	146.348	.925
Q1 2021	182.970	162.8350	112.4	97.8	187.157	175.365	1.067
Q2 2021	205.590	185.6325	110.8	103.7	198.224	197.889	1.002
Q3 2021	221.200	210.3600	105.2	100.5	220.116	225.922	.974
Q4 2021	231.680	242.0125	95.7	98.0	236.338	257.941	.916
Q1 2022	309.580	278.9475	111.0	97.8	316.664	293.632	1.078
Q2 2022	353.330	303.6800	116.3	103.7	340.672	311.857	1.092
Q3 2022	320.130	313.8675	102.0	100.5	318.561	312.380	1.020
Q4 2022	272.430	.	.	98.0	277.907	312.642	.889

Test for Stationary of the Data

Table 4: Autocorrelation Function of Original Series.

Series: crude_oil_price					
Lag	Autocorrelation	Std. Error[a]	Box-Ljung Statistic		
			Value	df	Sig.[b]
1	.859	.152	31.795	1	.000
2	.674	.150	51.878	2	.000
3	.468	.148	61.807	3	.000
4	.275	.146	65.347	4	.000
5	.091	.144	65.747	5	.000
6	-.102	.142	66.259	6	.000
7	-.276	.140	70.145	7	.000
8	-.362	.138	77.029	8	.000
9	-.340	.136	83.289	9	.000
10	-.300	.134	88.337	10	.000
11	-.232	.131	91.452	11	.000
12	-.182	.129	93.433	12	.000
13	-.117	.127	94.289	13	.000
14	-.056	.124	94.489	14	.000
15	.009	.122	94.495	15	.000
16	.062	.120	94.766	16	.000
a. The underlying process assumed is independence (white noise).					
b. Based on the asymptotic chi-square approximation.					

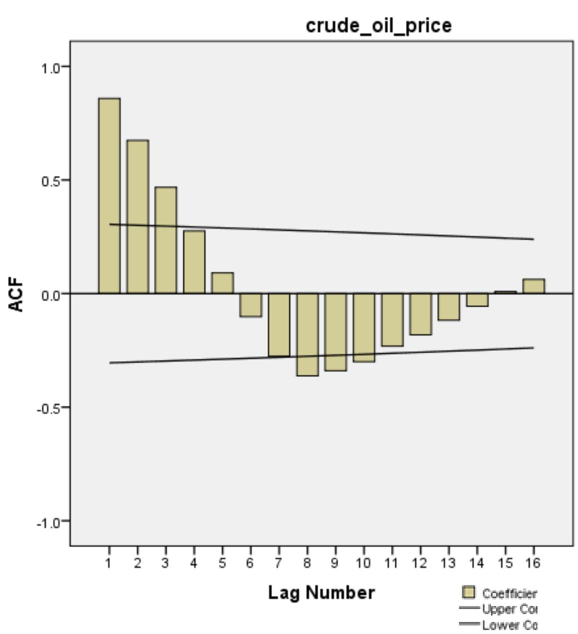

Figure 3: Correllogram of the Original Series.

Table 6: Partial Autocorrelations.

Series: crude_oil_price		
Lag	Partial Autocorrelation	Std. Error
1	.859	.158
2	-.245	.158
3	-.174	.158
4	-.066	.158
5	-.130	.158
6	-.223	.158
7	-.125	.158
8	.153	.158
9	.229	.158
10	-.138	.158
11	.029	.158
12	-.103	.158
13	-.026	.158
14	-.101	.158
15	.076	.158
16	.135	.158

Model Identification

The original series ACF and PACF plot in Figure 3 highly resemble the simulated ARIMA ACF and PACF plot. This is indicating that the model is Autoregressive and Moving Average Model. Applying Box Jenkins Methodology, the original series was stationary, thus the series is integrated of order 0 i.e d=0.

Thus, ARIMA (p,d, q) model is used since the model is autoregressive model. We vary values of p and q then judge the model suitability based on their Bayesian Information Criterion (BIC). The model with the lowest BIC will be regard as the best model.

Table 7: Summary of Bayesian Information Criterion (BIC) for Each Model.

Model Description	BIC	R-Squared
AR (p)		
(1)	**7.415**	**0.797**
(2)	7.464	0.811
(3)	7.589	0.810
(4)	7.719	0.809
(5)	7.845	0.808
MA (q)		
(1)	8.146	0.579
(2)	7.833	0.727
(3)	7.789	0.768
(4)	7.786	0.795
(5)	7.890	0.799
ARIMA (p.q)		
(1,1)	7.469	0.810
(1,2)	7.579	0.812
(1,3)	7.700	0.812
(1,4)	7.818	0.813
(1,5)	7.990	0.804
(2,1)	7.667	0.795
(2,2)	7.714	0.810

Since, AR (1) has the lowest Bayesian Information Criterion (BIC) = 7.415.

Estimation of the Parameters of the Model

The value of parameters of the model with respect to their standard error and significant.

Table 8: Model Parameters.

ARIMA Model Parameters					Estimate	SE	t	Sig.
crude_oil_price-Model_1	crude_oil_price	No Transformation	Constant		281.205	76.303	3.685	.001
			AR	Lag 1	.907	.070	12.983	.000
	Time	No Transformation	Numerator	Lag 0	-1.695	3.035	-.558	.580

$$Y_t = 281.205 + 0.907e_{t-1} - 1.695e_{t-2}$$

Diagnostic Checking

Table 9: Showing Stationary R squared, R-squared and Ljung-Box Q Statistic.

Model Statistics								
Model	Number of Predictors	Model Fit statistics			Ljung-Box Q(18)			Number of Outliers
		Stationary R-squared	R-squared	Normalized BIC	Statistics	DF	Sig.	
crude_oil_price-Model_1	1	.797	.797	7.415	19.629	17	.294	0

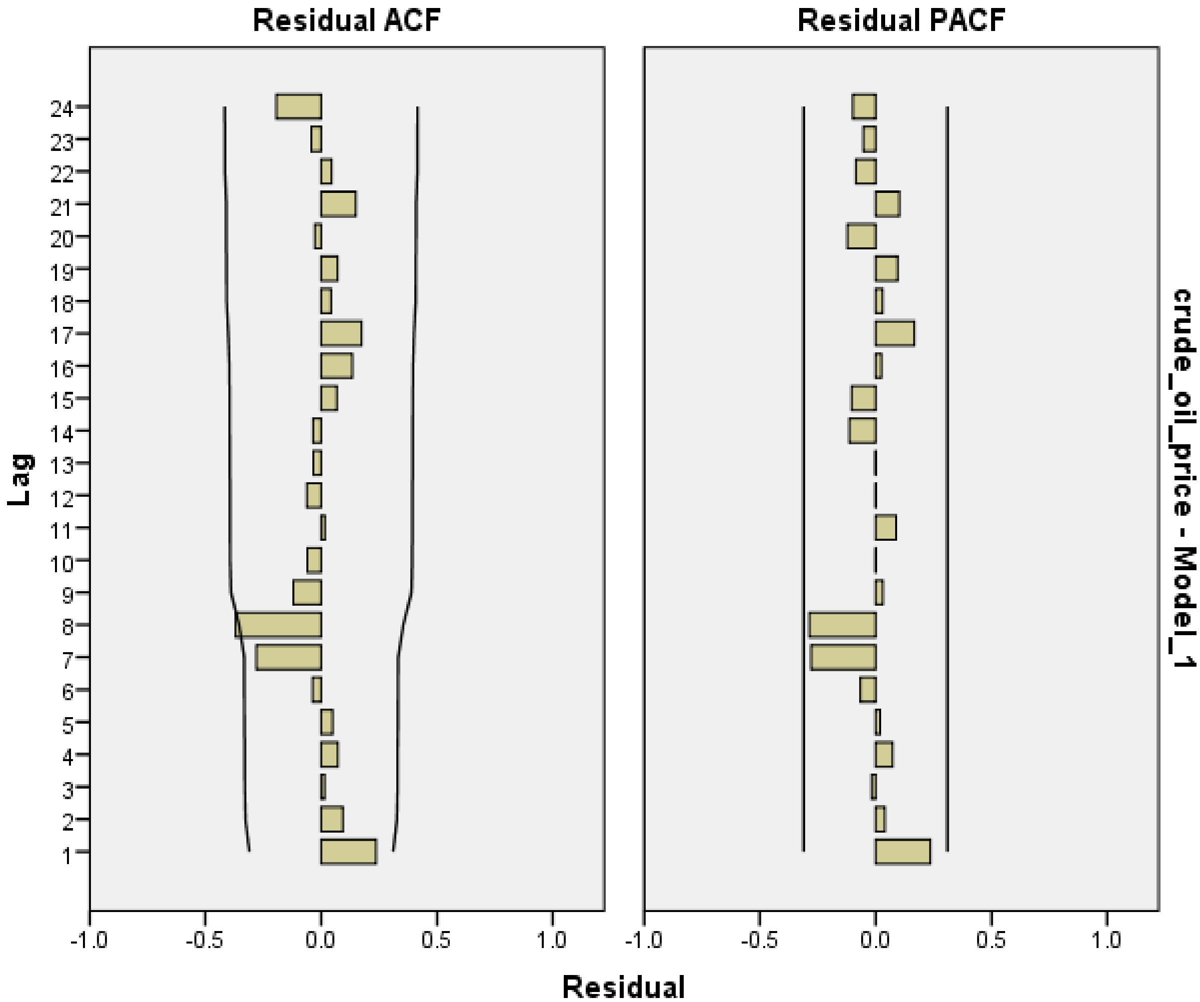

Figure 4: Correlogram of Residual ACF and Residual PACF respectively, for AR (1) Model

The corelograms show that all the autocorrelation functions at lag 1 to lag 24 are significant at 95% confidence interval. This is another condition that verified the model is a good one. The model AR(1) which is most suitable for the series is given by the equation:

$$Y_t = 281.205 + 0.907e_{t-1} - 1.695e_{t-2}$$

Model Forecast

The table below shows the forecast for the next ten years using the model AR (1).

Table 10: Ten Year Forecast Values.

Years	Forecast Values	LCL	UCL
Q1 2023	279.51	115.56	443.46
Q2 2023	338.90	269.92	407.87
Q3 2023	312.22	243.24	381.20
Q4 2023	324.40	255.42	393.38
Q1 2024	328.75	259.77	397.73
Q2 2024	323.43	254.45	392.41
Q3 2024	329.10	260.12	398.08
Q4 2024	304.74	235.76	373.72
Q1 2025	229.26	160.28	298.24
Q2 2025	171.40	102.42	240.38
Q3 2025	190.29	121.31	259.27
Q4 2025	160.73	91.75	229.71
Q1 2026	141.79	72.81	210.77
Q2 2026	113.19	44.21	182.17
Q3 2026	146.54	77.56	215.52
Q4 2026	147.99	79.01	216.97
Q1 2027	157.67	88.69	226.65
Q2 2027	161.01	92.03	229.99
Q3 2027	158.49	89.51	227.47
Q4 2027	164.24	95.26	233.22
Q1 2028	191.02	122.04	260.00
Q2 2028	212.58	143.60	281.56
Q3 2028	225.41	156.43	294.39
Q4 2028	227.32	158.34	296.30
Q1 2029	209.11	140.13	278.09
Q2 2029	195.51	126.53	264.49
Q3 2029	213.97	144.99	282.95
Q4 2029	194.84	125.86	263.82
Q1 2030	193.47	124.49	262.45
Q2 2030	162.65	93.67	231.63
Q3 2030	94.51	25.53	163.49
Q4 2030	137.47	68.49	206.45
Q1 2031	139.82	70.84	208.80
Q2 2031	185.20	116.22	254.18
Q3 2031	205.56	136.58	274.54
Q4 2031	219.57	150.59	288.55
Q1 2032	228.92	159.94	297.90
Q2 2032	299.43	230.45	368.41
Q3 2032	338.96	269.98	407.94
Q4 2032	308.68	239.71	377.66

SUMMARY OF FINDINGS, CONCLUSION, AND RECOMMENDATION

Summary of Findings

The linear trend using the Ordinary Least Square (OLS) approach shows a downward trend with fitted model:

Y_t = 237.943 – 1.099t

The correlogram of the original series using Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF), the p–values shows that the autocorrelation are significant for all lags with $p < 0.05$. We conclude that the series is stationary and transformation is not needed.

The model identification, stimulated model ACF and PACF are compared with the original series ACF and PACF to determine the appropriate model and order for the data. The original series of ACF and PACF plot highly resemble the stimulated ARIMA with ACF and PACF plot. This is indicating that the model is Autoregressive and Moving average model and the order is 0, since the original data was stationary (i.e., (d=0)), thus ARIMA (p,d,q) = ARIMA (p,0,q) model.

Since the model is Autoregressive and Moving Average model. We vary values of p and q then judge the model suitability based on their Bayesian Information Criterion (BIC). The model with the lowesr BIC will be the best mode. AR (1) has the lowest Bayesian Information Criterion (BIC) with a value of 7.415 and the fitted model is:

$$Y_t = 281.205 + 0.907e_{t-1} - 1.695e_{t-2}$$

The model which is the best for prediction AR(1) is used to forecast the future price of crude oil from 2022-2031. The values show that there will be fluctuation in the price of crude oil.

Conclusion

The quarterly data on crude oil price from 2013-2022 analyzed in chapter four of this project reveals that the linear trend using the Ordinary Least Square (OLS) approach predicted a downward movement of the trend. The time series was stationary at the original series. The original series ACF and PACF plots identified ARIMA (p,d,q) model with both ACF and PACF (Significant spikes) but in varying the value of p and q order of the model, it was concluded that the model of best is Autoregressive (AR) model of the order (1).

Recommendations

After carrying out the analysis, the following recommendations were made to the following category of users:

Investors

i. Diversify investment portfolios to mitigate risks associated with volatile crude oil prices.
ii. Stay updated on geopolitical events and global economic indicators, as they significantly impact oil prices.

Policymakers

i. Implement policies that promote renewable energy initiatives to reduce dependency on fossil fuels.
ii. Establish mechanisms to monitor and stabilize fuel prices, protecting consumers from sudden fluctuations.
iii. Encourage research and development in alternative energy technologies to decrease reliance on crude oil.

Oil Companies

i. Invest in research and development of cost-effective extraction technologies to enhance efficiency and reduce production costs.
ii. Diversify energy portfolios by investing in renewable energy sources and technologies.
iii. Collaborate with governments and environmental organizations to adopt sustainable practices in oil exploration and production.

Consumers

i. Practice energy conservation methods to reduce overall consumption and dependence on fossil fuels.
ii. Stay informed about energy-efficient alternatives for transportation and home

appliances to minimize reliance on crude oil-based products.

Researchers and Academia

i. Explore advanced statistical models and machine learning algorithms for more accurate predictions of crude oil price trends.
ii. Collaborate with industry experts to bridge the gap between research findings and practical applications in the energy sector.

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