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Modelling Monthly Sales of Crude Oil Production in Nigeria

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ABSTRACT

Changes in the price of crude oil around the world have always been the main topic of economic and financial news. Changes in the price of oil on the world market have a direct effect on the prices of retail oil products and consequently on all and sundry. This present research aims at developing a time series model that could observe and predict sales of crude oil production. The secondary data used in this study was the monthly sales of crude oil production for eleven years, which resulted in a usable sample of size 132. The plot of the raw data over time shows a non-stationary series with a downward trend. With non-stationarity observed, the series was differenced twice before obtaining stationarity. The ARIMA model with optimum p, d and q was found to be (0, 1, 1) (0, 0, 2), and the ARIMA model was used to predict sales of crude oil between 2021 and 2025. The study revealed that the forecast for the series shows that will keep going down until 2025 before it becomes stable. The study recommends that government should pay attention to variables affecting crude oil production and circulation in other to aid increase in the volume produced and amount sold.

Keywords: Modelling, Sales, Crude oil, Forecasting

1. INTRODUCTION

Changes in the price of crude oil around the world have always been the main topic of economic and financial news (Onyeka-Ubaka et al., 2018). Changes in the price of oil on the world market have a direct effect on the prices of retail oil products in both the upstream and downstream sectors (Olayungbo and Ojeyinka, 2021). Researchers have looked at whether the effects are the same on both sides or not (Valadkhani et al., 2015; Rahman, 2016; Apergis and Vouzacalis, 2018; Eleftheriou et al., 2018; Kang et al., 2018; Bragoudakis et al., 2020). All oil-producing countries around the world are either helped or hurt by how volatile crude prices are (Akinlo and Apanisile, 2015). In particular, the drop in the price of crude oil from 2013 to the present has hurt Nigeria's government income, since crude oil exports are the country's main source of income (Odupitan, 2017; Adedokun, 2018). The oil market has changed in ways that have a big impact on the growth of the world economy, national strategic security, and investor confidence (Kilian, 2017).

Both the inside and outside of the oil market are changing, and the factors that affect it have

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become more diverse and complicated (Kilian, 2017). As the things that affect the price of oil on the international market get more complicated, it gets harder to predict oil prices based on real-world factors (Quanying et al. 2021). Many pieces of past literatures predicting the price of crude oil show that the results depend on how the modelling sample data frequency and data intervals are chosen (Yu et al., 2019; Zhang et al., 2015). From 1970 to 2020, the number of poor people in Nigeria went from 36% to 70%, and the unemployment rate in 2020 is 30.7% [16]. Based on this, it suggests that oil money did not raise the standard of living or create jobs, but instead caused social and economic problems for the people of Nigeria (Taiwo et al., 2021).

To add to the burden, the COVID-19 epidemic, since 2019, has paralysed the international economy (Otache, 2020). This has led to a crash in oil prices around the world and the worst recession in Nigeria in 40 years. Even though oil revenues are falling, unemployment, poverty, insurgency, and bad management make it harder for the government to get the economy back on track (Raji et al., 2020; OECD, 2020). Volatility of oil market price leads to market uncertainty, which makes companies put off investments (Festus et al., 2019). Nigeria's economy is more vulnerable to sudden changes in oil prices because it depends on oil exports for all of its income (Ogundipe et al., 2014).

With this in mind, this study will be used to model and predict the historical monthly crude oil prices in Nigeria from January 2010 to December 2020. This is done so that we can predict the future price of crude oil, which is important for Nigeria's growth and development in the future. Autoregressive Integrated Moving Average (ARIMA) was used to model and predict the volatility of Nigerian crude oil prices. This is a univariate time series model.

The Box-Jenkins' Autoregressive integrated moving average (ARIMA) model is the one that is mostly used to model time-series data (Usoro et al., 2020). Aside from influencing factors, researchers are also very interested in how to improve the accuracy of forecasts. Oil price modeling and forecasting use the four main types of forecasting methods: time series models, econometric models, qualitative methods, and artificial intelligence techniques (Charles and Darne, 2017; Yu et al., 2019; Sun et al., 2019; Suganthi and Samuel, 2012; Zhang et al., 2008; Valgaev et al., 2020). The most popular time series forecasting models are the autoregressive integrated moving average (ARIMA) and the exponential smoothing (ETS). These models are often used as the benchmark models (Kang et al., 2018; Chai et al., 2018; Zhu et al., 2017). A lot of people also use econometric models and qualitative methods like the generalized autoregressive conditional heteroskedastic model (GARCH), the vector auto-regression model (VAR), the state-space models, and the threshold models [31]. Orlu (2017) looked into how the price of premium motor spirit (PMS) affects the growth of the economy in Nigeria. The result of this study shows that the rise in PMS price has had a big and bad effect on the Nigerian economy. A used three different kinds of oil price data to

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study how changes in oil prices affect inflation in four OPEC countries in Africa: Algeria, Angola, Libya, and Nigeria. In general, it was found that both up and down changes in the price of oil have a positive effect on inflation (Umar and Lee, 2018).

In addition, Anthony (2019) used a state-space model with oil price as a latent variable to figure out how oil price changes affect Nigeria's CPI. He did this by looking at monthly data sets for the two variables between 1986 and 2015. The results show that the state space model did a very good job of tracking how the two variables changed over time. This suggests that changes in the price of crude oil on the international market have an indirect effect on prices in the United States.

The study of Chinanuife et al. (2021) used macroeconomic variables in Nigeria to model the volatility of oil prices. In their paper, all of the macroeconomic variables studied (real GDP, interest rate, exchange rate, and oil price) are very unstable. It was found that oil price is a major cause of macroeconomic instability in Nigeria. Because of this, the Nigerian economy is vulnerable to shocks from both inside and outside the country. Studies have also found that ARIMA models are suitable for modelling and predicting the price crude oil (Suleiman et al., 2017; Omekara et al., 2015). Based on these evidences, the adoption of ARIMA model is therefore justifiable in modelling sales of crude oil price.

2. METHODS

2.1. Source of Data

The secondary data utilized in this study was taken from the Nigerian National Petroleum Corporation's (NNPC) 2020 First Edition Annual Statistical Bulletin (ASB) publication.

2.2. Statistical Tool Used

Time series is the statistical method that was used in this study. For predicting future sales, the Auto Regressive Integrated Moving Average (ARIMA) model is used to figure out how much crude oil was sold each month. A time series is a set of observations that have been made over time. Time series analysis uses methods or processes that break a series into parts that can be understood. This makes it possible to find trends, make estimates, and make predictions. There are two main goals of time series analysis: figuring out the nature of the event shown by the sequence of observations and making predictions about what will happen next.

2.2.1. Autoregressive Moving Average Model (ARIMA)

The ARIMA model is usually denoted with the notation ARIMA (p, d, q). The p, d and q are the others of the Autoregressive part, difference and the Moving Average part.

2.2.2. How to Fit an ARIMA Model

In fitting an ARIMA model, the steps include: model specification; parameter estimation; and diagnostics and potential improvement. Model specification requires finding the three numbers p, d, and q that define the autoregressive integrated moving average model (ARIMA). At first, data stationarity is examined. If it is, d = 0, otherwise the series is differenced until stationarity is obtained.

After figuring out d, we can use sample partial

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autocorrelation (PACF) to find the order of AR (p). If the PACF stops after a certain number of lags, that number is the order of AR, or p. The sample autocorrelation (ACF) plot of the differenced data can also be used to figure out the order q of the moving average (MA). If the autocorrelation stops after a certain number of lags, that number is the MA's order.

Once we have the orders (p and q), we need to find the parameters, which is our main goal. Methods like least square, maximum likelihood, and method of moments are often used. Method of maximum likelihood is used for this project. Once the model is made, the assumptions are checked to see if the model is correct. We mostly look at the residual's normality and autocorrelation and look for ways to make it better. If the model has been set up correctly, the autocorrelation or partial autocorrelation of the residuals should not show any big spikes, especially in the first few lags.

3. RESULTS

3.1. Data Visualization

The Figure 1 above shows the trend of how much crude oil is sold each month. The chart is made in R using the ggplot2 toolkits, and the code is in the appendix. From the line plot, it is clear that the sales of crude oil production change every month over the time period considered. The line plot also shows that the sales of crude oil production are not steady. This means that there is a big difference between the cases and that they don't stay stable around the mean.. Please keep your affiliations as succinct as possible (for example, do not differentiate among departments of the same organization). This template was designed for two affiliations.

3.1.1. Time Series Analysis

I. Stationarity test

Time plot in Figure 2 shows that the series is

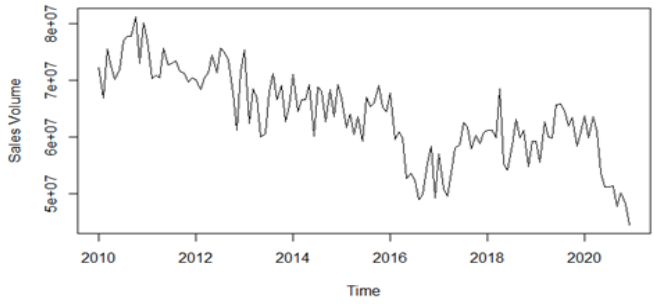

Figure 1. Line plot of monthly sales of crude oil production

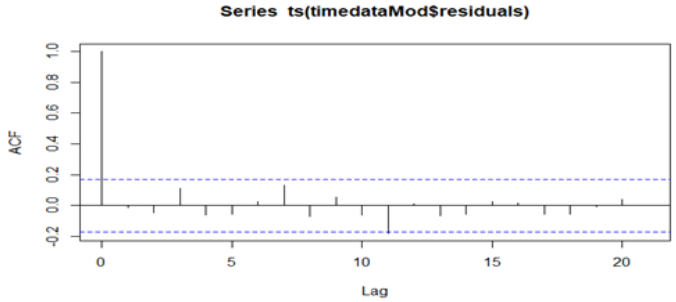

Figure 2. Plot shows the stationary test series is trendy

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trendy. This is a clear sign that the series are not stationary. But besides the time plot, the Augmented Dickey-Fuller test is used to find out if the series is stationary. The autocorrelation plot is also useful for this purpose. Augmented Dickey-Fuller test is used to investigate the stationarity of the series and the result is presented below:

Augmented Dickey-Fuller Test data: timedata

Dickey-Fuller = -4.0117, Lag order = 1, p-value = 0.01088

The computation (the ADF test) shows that the series is not stationary because the p-value < 0.05. To make the series stay still, you need to do some differentiating. The difference between the two methods and the results are shown below.

II. Differencing and Stationarity

As observed, the monthly sales of crude oil production are not stationary, it is therefore necessary to use differencing to make the series stationary. By taking the difference between the lags of two observations, the differencing method is used to reduce stationarity. Differentiating can be done as many times as needed until the series stays the same. In this study, the monthly sales of crude oil production only became stable after the second difference (i.e., when d = 2). Below is the automatic plot of the second difference (Figure 3).

The Augmented Dickey-Fuller test is performed again to confirm the stationarity of the series as portrayed above in the auto-plot. The ADF test as shown below revealed that the series is now stationary.

Augmented Dickey-Fuller Test

data: timedata

Dickey-Fuller = -19.312, Lag order = 1, p-value = 0.01

alternative hypothesis: stationary

III. Auto and Partial Auto Correlation Plots

To make accurate predictions with the ARIMA model, one must find the best ARIMA order (where p is the number of time lags in the autoregressive model, d is the degree of difference, and q is the order of moving average). The best value for p can be found in the ACF, and the best value for q can be found in the PACF. The ARIMA model with optimum p, d, and q are shown in Figure 3 and Figure 4.

IV. Forecasting

As observed, the best ARIMA model for predicting monthly sales of crude oil in the future is shown to be (0, 1, 1). (0, 0, 2). Forecasts are made for the next 60 days about how much crude oil will be sold each month, and the results of fitting the ARIMA model is shown in Figure 5.

V. Result Validation

To further validate the prediction from the ARIMA model, the presence of auto-correlation in the predicted series is tested using Box-Ljung test. The result as shown below reveals the absence of auto-correlation because the p-value < 0.05.

Box-Ljung Test

data: timedataF$residuals

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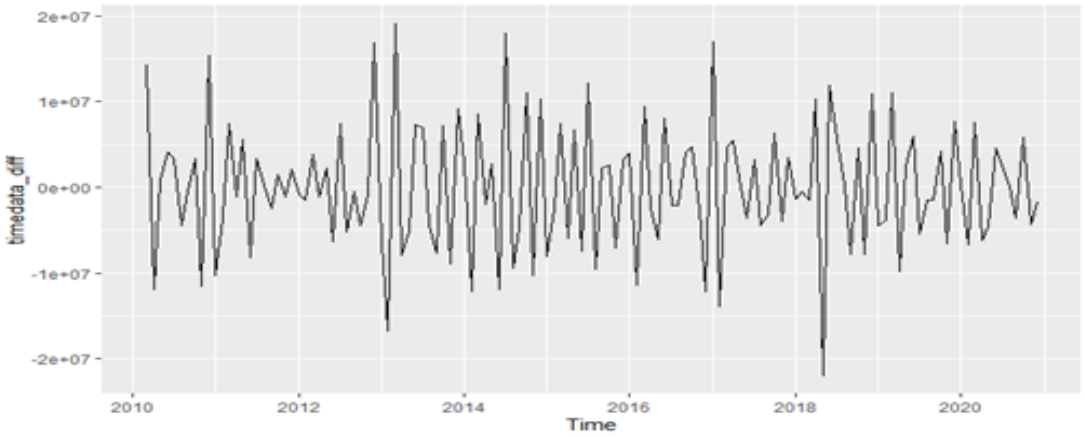

Figure 3 . Auto plot of the second differenced of series

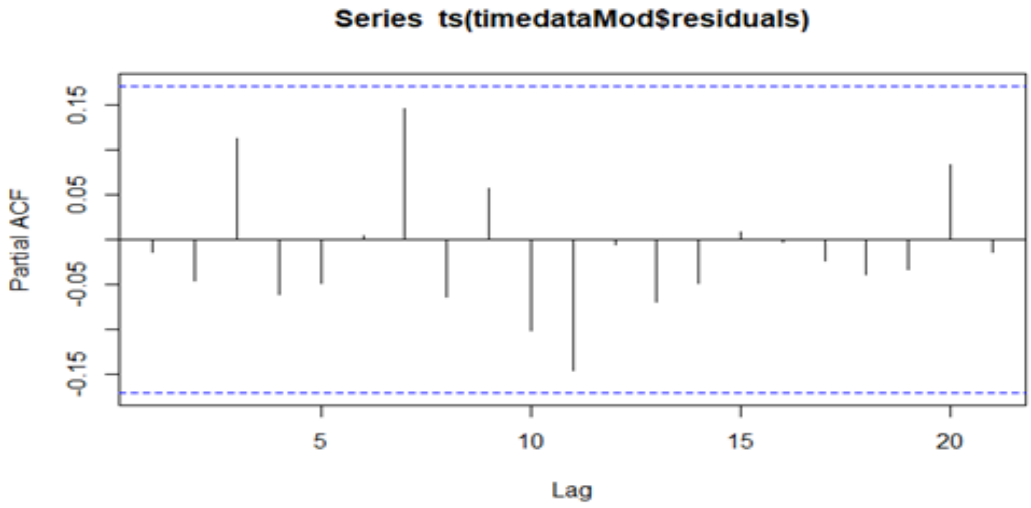

Figure 4. PACF plot of the differenced of series

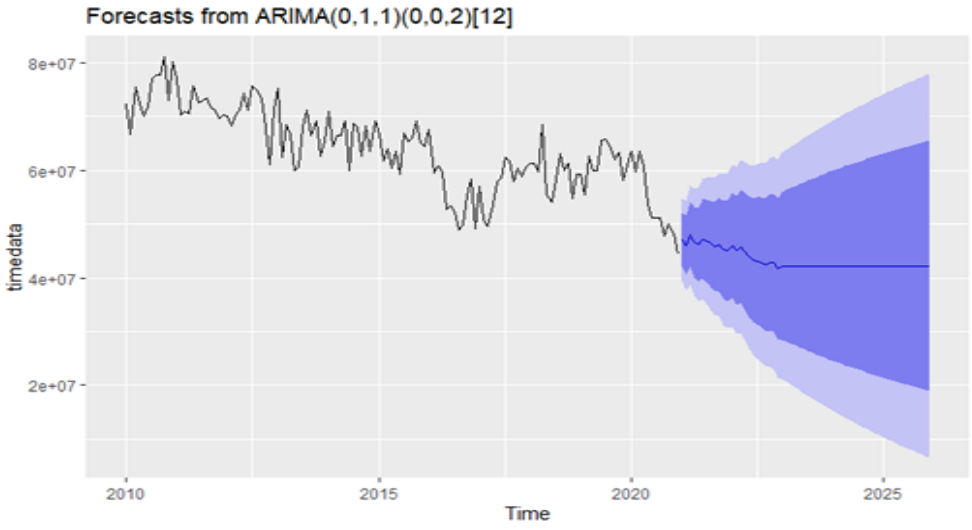

Figure 5. Forecast of monthly sales of crude oil production

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4. DISCUSSIONS

The plot of the raw data over time shows that the series is non-stationary with a downward trend. With these actions, the series had to be differenced twice before it became stationary (a series with constant mean, variance and auto covariance). The best order for the ARIMA model for the series was adopted to predict future monthly sales of crude oil production. As observed from the prediction from the ARIMA model, the sales of crude show a steady decrease in the amount of crude oil sold each month until 2025. In consonance with the present study, [38] found that future sales of crude oil production will not increase all things been equal.

5. CONCLUSIONS

The aim of this study is predict the future price of crude oil using ARIMA model. Autoregressive Integrated Moving Average (ARIMA) was used to model and predict the volatility of Nigerian crude oil prices. The result revealed that sales of crude oil production vary and slowly go down on monthly basis. However, the forecast for the series shows that it will keep going down until 2025, when it will become stable. Therefore, the study recommends the following: as suggestion in handling the increase in the oil price.

(i) The Nigerian National Petroleum Corporation (NNPC) should increase the amount of refined petroleum it exports by making more products in the downstream sector.

(ii) The government should try to get more private businesses to take part. So that refineries can be built with better tools and the cost of refining crude oil will go down.

(iii) On the high sea, where crude oil products are being smuggled, there needs to be more security. This will help cut down on the money that is lost when crude oil products are illegally exported.

(iv) The government should help the people who live in the area where crude oil is being taken out right away. This will make that area less troubled.

(v) The government should set up an organization to make sure that big oil companies are socially responsible to the communities where they work.

(vi) The government should fight corruption by setting up a system that will find corrupt public officials and put them in jail.

Therefore, sinking fund should be set up from which money would be taken to do maintenance and repairs on the country's refineries. This would ensure a steady supply of oil products throughout the year and keep the country ahead in crude oil production.

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