Modelling Crude Oil Production In Nigerian National Petroleum Corporation

Adewoye Kunle Bayo, Salau Ganiyat Monishola, Olatinwo Motolani

Abstract— **In the last few decades, crude oil (petroleum) has claimed the topmost position in Nigerian export list, constituting a very fundamental change in the structure of Nigerian international trade. This paper work is focus on time series analysis on monthly crude oil production, the data used is secondary extracted from Nigerian National Petroleum Corporation (NNPC) record online and the statistical tools used for this research work are time plot to determine level of fluctuation of data, inferential statistics employed were Autocorrelation function, Autoregressive models, Partial Autocorrelation function and forecasting using autoregressive model. From the analysis it was discovered that fluctuation in production are mostly apparent in 2013 and 2015. This might be due to lack of adequate supply of stock to the depot and the forecasted values for 2016 quarters were increasing and decreasing in the same order.**

Index Terms— **Autocorrelation function, Autoregressive models, Partial Autocorrelation function and forecasting.**

I. Introduction

The Nigeria National Petroleum Corporation was established on April 1, 1997, under the statutory instrument. Decree no 33 of same year by a marger of Nigeria national oil corporation, NNOC, with its operational functions and the federal ministry of mines and power with regulatory responsibilities. This decree established NNPC, a public organization that would, on behalf of government, adequately manage all government interests in the Nigeria oil industry.

In addition to its exploration activities, the corporation was given powers and operational interests in refining petrochemicals and products transportations as well as marketing. Between 1978 and 1989, NNPC constructed refineries in Warri, Kaduna and Port Harcourt and took over the 35,000. Barrel shell refinery established in Port Harcourt in 1965.

Since its formation, NNPC has had various aims in the petroleum industry critical among to the regulation of foreign and local oil producing firms, advancing technology transfer, developing local content and indigenous participation in the industry. However, the performance of the company in terms of developing technical expertise in the exploration and production sector still lags other OPEC national oil companies and its partners while operational setbacks impedes the full potential of the Nigeria refineries making the oil producing nation also a fuel importing nation. This may be partially due to the government early stand favoring maximizing oil revenues from producers and improving Nigeria's standing in the international market whole delving little into the exploration and production aspect of the industry.

Over the years, the frequent review of prices of petroleum products has gain a space in the heart of Nigerians, and most of the time, the out of stock of petroleum products at depot for sales is also rampart. In view of that, this research work examines the monthly crude oil production in Nigerian National Petroleum Corporation (NNPC).

This paper aim and objectives are to construct an auto regressive model of a suitable order for the process and to forecast the series of crude oil production in 2016 quarterly.

II. Literature Review

In view of that fact that it is necessary to upgrade standard in other to meet the text of time and improved models on ground. The researcher is poised to consolidate on the work done by some researchers in the past on related topics. This research work therefore, reviews the works of past researchers and their reports as contained in textbooks, Newspapers, Bulletin and Journals on Crude oil in Nigeria.

The three words: 'petroleum; 'crude oil' and 'oil' are used interchangeably to mean the same thing. According to Robinson (1977); petroleum is the name usually given to the combination of gas, liquid and solid, which can be found in the oil field. As Nwoko (2005) would put it, 'Crude oil' otherwise known as 'petroleum' is derived from two Latin words "petrus" meaning rock and Oleum', which translates to oil. One could quickly, therefore, jump to say that 'crude oil' means rock oil. According to Baxter (1960), oil is found in many parts of the world of which some of the largest oil fields are in North America, South America, Russia and the Middle East. [6] Petroleum is extremely valuable. Not only do we use it as source of fuel, suitable for all forms of transport, but like coal, it can be used as a raw material to produce artificial rubber, plastics, synthetic textiles, pharmaceutical products, soaps, dyes, explosives, paints, insecticides, etc. Over 5000 different products can be produced from petroleum [Robinson; 1977]. [2]

Ette and Eberechi [11] studied the Nigerian Crude Oil Production using multiplicative SARIMA from January 2006 – August 2012. The time plot reveals a negative trend between 2006 and 2009 and a positive trend from 2009 to 2012. Twelve-month differencing yields a series with significant spikes of the autocorrelation function at lags 1and

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12 suggests an autocorrelation structure of a (0, 1, 1) x (0, 1, 1)12 SARIMA model which he used and found to be adequate. Other studies concentrated on modelling crude oil market volatility. For example Volume [3] proposed a hybrid model based on combination of Markov Switching (MS) model and stochastic volatility model (SV), called MSSV to predict volatility of crude oil short-term price. The author concluded that there is strong evidence to support regime switching in the oil market, and the MSSV model was superior to both SV and MS in forecasting the volatility of oil market for out-of-sample. It is noted that, in-sample forecasting, the MS model was superior to the SV and MSSV.

According to Johnson (1999) Africa produced 7.8 million barrel per day of crude oil in 1998 alone. The top oil producers in Africa in 1998 are as follows, in descending order of magnitude; Nigeria, Libya, Algeria, Egypt and Angola. In the same year, the top oil consumers in descending 34 Order of magnitude, in Africa are: Egypt, South Africa, Algeria and Libya. Total African oil consumption in 1998 is 2.5 million barrels per day. [7]

Dr. T.M John (1990) in his speech said that "there is too much waste in NNPC, the management style and habits are most wasteful". He emphasized that waste abounds in NNPC namely at the plants, in projects and in support services. He said in NNPC we replace rather than maintain and repair, we buy in excess of our requirement at prices higher than commercial average and from source capabilities lower than commercial standard. [8]

Yeldu and Mukhtar (2011) found that if the current trend continues, the production, export, and domestic consumption of Nigeria's crude oil will all be on the increase with 1006402, 838476 and 167926 thousand barrels expected by the year 2015 for production, export and domestic consumption respectively (Journal of Physical Science and Innovation Volume 5, No. 2, 2013)

Bachmeier and Griffin (2006) evaluated the degree of market integration both within and between crude oil, coal, and natural gas markets. Their approach yields parameters that can be readily tested against a priori conjectures. Using daily price data for five very different crude oils, they concluded that the world oil market is a single, highly integrated economic market. On the other hand, coal prices at five trading locations across the United States are cointegrated, but the degree of market integration is much weaker, particularly between Western and Eastern coals. Finally, they showed that crude oil, coal, and natural gas markets are only very weakly integrated. [1]

Asanya E. O (2005) in his research work declares that autocorrelation is the serial correlation of equally spaced time series between its members one or more lags one or more lags apart. [9]

Warren Gilchrist (1999) in his view asserts that forecasts are needed throughout an organization and they should certainly not be produced by an isolated group of forecasters neither is forecasting ever finished. Forecasts are needed continually and as time moves on, the impact of the forecast on actual performance is measured. [5]

Anderson O. D (2005) the selection and implementation of the proper forecast methodology has always been an important planning and control issues for organizations. Theodore and Emilie (2007) examined the relationship between UK wholesale gas prices and the Brent oil price over the period 1996–2003 in order to investigate whether oil and gas prices 'decoupled' during this period as orthodox gas market liberalisation theory had suggested. Tests for unit roots and cointegration were carried out and it was discovered that a long-run equilibrium relationship between UK gas and oil prices exists. It was found that the cointegrating relationship is present throughout the sample period. However, the long-run solutions seem to be more volatile. Evidence was provided that the short-run relationship is linear and impulse response functions are used to examine the effects that a shock in oil would have on gas. These findings do not support the assumption that gas prices and oil prices 'decouple' [4].

III. Methodology

The data used for this research were extracted from Annual Statistical Bulletin (Summarised) of Nigerian National Petroleum Corporation (NNPC) on monthly productions of crude oil (in barrels) in Nigeria from January 2006 to December 2015. Website (www.nnpcgroup.com)

The statistical tools used for the analysis are stated below:

Autocorrelation Functions, Partial Autocorrelation Function (P.A.C.F)

Forecasting: Using an Autoregressive Model

Autocorrelation function: is one of the tools used to find patterns in the data. Specifically, the autocorrelation function tells you the correlation between points separated by various time Lags.

Considering the fast that it is usually impossible to obtain a complete description of a stochastic process (i.e. actually specifying probability distribution).

The autocorrelation function provides a particular description of the process for modeling purpose. The autocorrelation function discusses how much interdependency there is between neighboring data point in the series y_t.

We define the autocorrelation with lag k as

$$\rho_k = \frac{E(y-y_t)(y_{t+k}-y_t)}{\sqrt{E(y-y_t)^2 E(y_{t+k}-y_t)^2}} = \frac{\operatorname{cov}(y+y_{t+k})}{\sigma_y \sigma_{y+k}}$$

For a station any process, the variance at time t is the same as the variance at time t+k hence, the denominator is just the variance of the stochastic process and the numerator is the covariance between Yt and Yttk, yk.

$$\rho_k = \frac{E(y-y_t)(y_{t+k}-y_t)}{\sigma_y \sigma_{y+k}}$$

Thus $\rho_k = \gamma_k = \rho_0 = \gamma_0 =$ for any stochastic process suppose that the stochastic process $Y_t = \sum t$

Where $\sum t$ is an independently distributed random variable with Zero mean.

The autocorrelation function for this process given is called a White Noise and there is no model that can provides a forecast any better that $Y_{t+1} = 0$ for al L. Where lag is sometime called serial correlation which refer co-efficient (95% significant) as a function.

$$\rho_k = \frac{\sum_{t-1} (y - y_t)(y_{t+k} - y_t)}{\sum_{t=1}^{t-k} (y - y_t)^2}$$

AUTOREGRESSIVE MODELS

Autoregressive is a stochastic process used in statistical calculations in which future value are estimated based on a weighted sum of past value. An autoregressive process operates under the premise that past values have an effect on current values.

Autoregressive process of order P in the current observation. It is generated by a weighted average of past observation going back P periods, together with a random in the current period denoted by AR (P) and with equation as

$$y_t = \phi_1 y_{t-1} + \phi y_{t-2} + \ldots + \phi y_{t-p} + \phi + \varepsilon_t$$

Where σ is a constant term which relates to the mean of the stochastic process.

NOTE:

If the autoregressive process is stationery, then its means is denoted by N which must be invariant with respect to time i.e.

$$\sum(y_t) = \sum(y_{t-1}) = \sum(y_{t-2}) = \ldots N$$

$$N = \phi_1 N + \phi_2 N + \ldots + \phi N_p + \sigma$$

The mean of the process also gives the stationery such that the process is stationery, the mean N must be finite and so

$$\phi_1 + \phi_2 + \ldots + \phi_p < 1$$

To examine the properties of a sample autoregressive process we must determine the mean, variance and covariance for the process i.e. first order autoregressive process AR (1)

$$y_t = \phi_1 y_{t-1} + \sigma + \varepsilon_t$$

This process has the mean

$$m = \frac{\sigma}{1 - \theta_1} \qquad \textit{stationary if } |\theta| < 1$$

The variance Y_o about its means, assuming stationery and setting $\sigma = 0$

$$\gamma_0 = \frac{\sigma \varepsilon^2}{1 - \theta_1^2}$$

The covariance of Y_t about the mean is

$$\gamma_k = \frac{\sum (y - y_t)(\theta y_{t+k} - y_t)}{\theta \gamma_0}$$

$$\gamma_1 = \frac{\sigma \varepsilon^2}{1 - \theta_1^2}$$

PARTIAL AUTOCORRELATION FUNCTION P.A.C.F.

The partial autocorrelation function is denoted by (Y_{Qkk}; 1,2,…) the set of partial autocorrelation at various lags K are denoted by

$$\phi_{kk} = \frac{(\rho_k)}{\rho_k}$$

Where:

P_k is the k x k autocorrelation matrix and P_k^x is P_k with the last column replaced by P.

$$\begin{bmatrix} \rho_k \\ \phi_{11} = \rho \\ \phi_{22} \end{bmatrix} = \frac{\begin{vmatrix} 1 & \rho_1 \\ \rho_1 & \rho_2 \end{vmatrix}}{\begin{vmatrix} 1 & \rho_1 \\ \rho_1 & 1 \end{vmatrix}} = \frac{\rho_2 - \rho_1^2}{1 - \rho_1^2}$$

And an estimate Qkk can be obtained by replacing the P. by Y. at lags large enough for the PACF to have died out Queenouile's formula gives.

$$\operatorname{var}(\phi_{kk}) = \frac{1}{N}$$

$$\phi_{33} = \frac{\begin{vmatrix} 1 & \rho_1 & 1 \\ \rho_1 & 1 & \rho_2 \\ \rho_2 & \rho_1 & \gamma_3 \end{vmatrix}}{\begin{vmatrix} 1 & \rho_1 & \rho_2 \\ \rho_1 & 1 & \rho_1 \\ \rho_2 & \rho_1 & 1 \end{vmatrix}}$$

Obtain the determinant of the matrix above.

Under the hypothesis of Y_{Qkk} = O, k = 1,2… Quenoullis formular for k>1 distribution with mean O and standard deviation $1/_{1}$ where (T = no observation in the series).

Bartlett's formular provides approximately standard errors for the autocorrelation, so that the order of the moving average process can be determined from significant test on the sample autocorrelations for the order of an autoregressive process, this can be obtained from the partial autoregressive function. To understand what the partial regressive function is and how it can be used let us consider the covariance and autocorrelation function for the autoregressive process of order P.

FORECASTING: USING AN AUTOREGRESSIVE MODEL

Having determined the model in which the chance element plays a dominant role in determining the structure of the model. Consider the simplest from Q_1 the Autoregressive model.

$$y_t = \phi_1 y_{t-1} + \sigma + \varepsilon_t$$

The general from of P^{th} order of the autoregressive. Process is defined by

$$y_t = \phi_1 y_{t-1} + \phi_2 y_{t-2} + \sigma + \varepsilon_t$$

When Q_1, Q_2…. Q_p are constants and the model is denoted as AR (P) generally the model may be written as

$$y_t = \phi_1 y_{t-1} + \sigma + \varepsilon_t$$

When O And $€_t$ are assume to be zero for a stationery time series.

Analysis

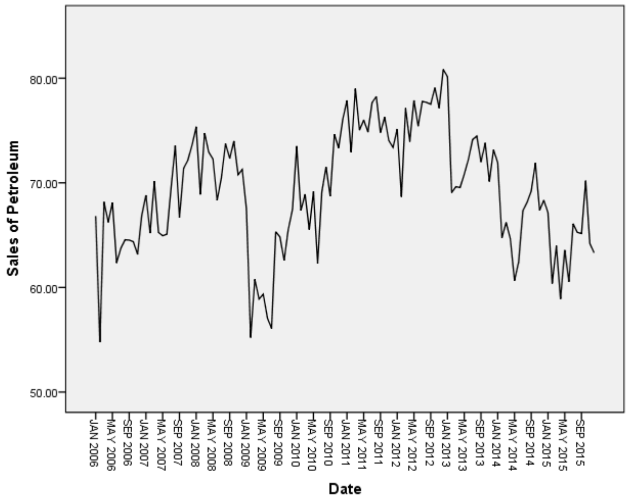

Fig 4.1: Time Series Plot on production of cruel oil

ESTIMATION OF AUTOCOVARIANCE AND AUTOCORROLEATION
FOR LAG K,0,1,2,3,4,5,

Auto covariance = $\sum \frac{(Y_t - y_t)(Y_{t+k} - y_t)}{T}$

Variance= $\sum_{t=1}^{T-k}(Y_t - y)^2$ Mean = $\sum \frac{y_t}{T}$ Computation

Let the variable be denoted by

$$\gamma_0 = \frac{10143.82}{40} = 253.60$$

The auto covariance of lag k is γ_k for k = 1, 2, 3, 4 and 5

$\gamma_0 = 1$ $\frac{8305.554}{40} = 207.64$

$\gamma_0 = 2$ $\frac{5127.1653}{40} = 128.18$

$\gamma_0 = 3$ $\frac{4683.89}{40} = 117.10$

$\gamma_0 = 4$ $\frac{4006.2521}{40} = 100.17$

$\gamma_0 = 5$ $\frac{1503.6124}{40}$ 37.59

Denote the autocorrelation by ρ_k and given by

$\rho_k = \frac{\gamma}{\gamma_0}$ for k=0,1,2,3,4 and 5

$\rho_0 = 0$ $\frac{253.60}{40} = 6.34$

$\rho_k = 1$ $\frac{207.64}{40} = 5.19$

$\rho_k = 2$ $\frac{128.18}{40} = 3.20$

$\rho_k = 3$ $\frac{117.10}{40} = 2.92$

$\rho_k = 4$ $\frac{100.17}{40} = 2.50$

$\rho_k = 5$ $\frac{37.59}{40} = 0.94$

Table 6: Arrangement of Auto-covariance and Autocorrelation

K	0	1	2	3	4	5
Auto covariance	253.60	207.64	128.18	117.10	100.17	37.59
Autocorrelation	6.34	5.19	3.20	2.92	2.50	0.94

ESTIMATING THE PARAMETER ϕ_1 AND ϕ_2 FOR THE AUTOCORRELATION PROCESS

$\rho_1 = 5.19,$ $\rho_2 = 3.20$

$\phi_1 + \phi_2 \rho_1 = \rho_1$

$\phi_1 \rho_1 + \phi_2 = \rho_2$

Substituting the values of p above into the equation the solve using substitution method

$\phi_1 + 5.19\phi_2 = 5.19$ …(1)

$5.19\rho_1 + \phi_2 = 3.20$ …(2)

From equation (1)

$\phi_1 + = 5.19 - 5.19\phi_2$ …(3)

Substitute ϕ_1 into equation (2)

$5.19(5.19 - 5.19\phi_2) + \phi_2 = 3.20$

$26.94 - 26.94\phi_2 + \phi_2 = 3.20$

ϕ_2 =0.92

For ϕ_1

Substitute the values of ϕ_2 into (3)

$\phi_1 + = 5.19 - 5.19(0.92)$

$\phi_1 = 0.42$

$\phi_1 = 0.42$ $\phi_2 = 0.92$

OBTAINING THE ORDER OF THE AUTO REGRESSIVES MODEL FROM THE PARTIAL AUTOCORRLEATION FUNCTION

$\rho_1 = 5.19$ $\rho_2 = 3.20$

$\phi_{11} = \rho_1 = 5.19$ $\phi_{22} = \frac{\rho_2 - \rho_1^2}{1 - \rho_1^2}$

$\phi_{22} = \frac{3.20 - (5.19)^2}{1 - (5.19)^2} = 0.92$ $\phi_{11} = 5.19$ $\phi_{22} = 0.92$

Hence ϕ_{22} is not significant i.e. $\phi_{22} = 0$ k>1

Therefore the auto regressive process is of order one i.e. AR (1) and the model is given as $y_t = \phi_1 y_{t-1} + \sigma + \varepsilon_t$

Assuming ε_t and σ to be zero since the series stationary as observed in the sample autocorrelation thus, the autoregressive model for this process can be as

$$y_{t+1} = \phi_1 y_t$$

$\phi_1 = 5.19$ $y_t = 197.72$

Forecasting the auto regressive process AR (1) for 2016 quarters

For first quarter

$y_{t+1} = \phi_1 y_t$ $y_{t+1} = 5.19 \times 197.72 = 102617$

For second quarters

$y_{t+1} = \phi_1 y_{t+1}$ $y_{t+2} = 5.19 \times 1026.17 = 5325.82$

For third quarter

$$y_{t+3} = \phi_1 y_{t+2} \qquad y_{t+3} = 5.19 \times 5325.82 = 27641$$

For fourth

$$y_{t+4} = \phi_1 y_{t+2} \qquad y_{t+4} = 5.19 \times 27641 = 14345679$$

Forecast figure for 2016 quarters

QTR1=1026.17 QTR2=5325.82
QTR3=27641 QTR4=143456.79

IV. Discussion of Results

Ten (10) years data were extracted from Annual Statistical Bulletin (Summarised) of Nigerian National Petroleum Corporation (NNPC) on monthly productions of crude oil (in barrels) in Nigeria from January 2006 to December 2015. The statistical tools used were time plot to determine level of fluctuation of data, inferential statistics employed were Autocorrelation function, Autoregressive models, Partial Autocorrelation function and forecasting using auto-regressive model. From the analysis it was discovered that fluctuation in production are mostly apparent in 2013 and 2015. This might be due to lack of adequate supply of stock to the depot and the forecasted values for 2016 quarters were increasing and decreasing in the same order.

V. Conclusion

1. Fluctuations in production are mostly apparent in 2013 and 2015. This might be due to lack of adequate supply of stock to the depot.
   Production at is part between 2010 and 2012. This might be due to sharp increase of prices of petroleum product. The series witness stationary for the years under study. This was as the sample auto correlation.
2. The forecast for the series is best obtained at auto regressive model of order one i.e. AR (1). Therefore casted values for 2016 quarters were free environment the company operation
3. More also, as the forecast for 2016 quarters were increasing in the same order, the forecasted values were decreasing. this simply explain the standpoint of the exorbitant prices and the mind of the consumers .this is to say, there might be general fall in production in future if the consumers have their way.

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