

# Modeling and Forecasting Crude Oil Price: Implications for the Nigeria's 2013 Budget Proposal

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**Abstract:** *This work is an attempt to forecast crude oil price for 2013 using Box and Jenkins Methodology. It is to advise Nigeria on the oil price benchmark for her budget using the Auto-regressive [AR (2)] model which is found to be most appropriate. The diagnostics tests show that the model is good. Based on the model, a forecast is conducted for year 2013, and it shows that the price level will be stable around \$100. A benchmark of \$80 per barrel is recommended given the nature and structure of the Nigerian economy (being solely oil-dependent) as well as given the expected vagaries in the international price of crude oil.*

**Keywords:** Nigeria, Crude Oil Price, Box and Jenkins Methodology

## 1. The Problem

An economy will be better-off with respect to the utilization of scarce resources if the government of that economy is able to situate its budget within an optimal benchmark in the face of various instabilities surrounding the source of its revenue. In Nigeria, it is a known fact that the economy is oil-driven. The economy depends on the revenue from the exportation of crude oil. Major fluctuations in the international price of crude oil have implications for government budgeting and spending. The Nigerian economy has over the years been experiencing difficulties in terms of an accurate forecast of revenue accruals for the implementation of the budget for the given fiscal year. It has always set budget that either overshoots or undershoots the level that is consistent with the expected revenue for that fiscal year; thereby making the economy to incur debt in order to fully implement the budget in the event of an overshoot of the budget for that fiscal year or under-utilized the revenue in the event of an undershoot of the budget for that fiscal year. Since the economy depends on revenue from crude oil and the international price of crude oil is exogenously determined, an accurate forecast of this crude oil price will be of upmost significance for the Nigerian government to be able to situate and benchmark its budget and utilize available resources optimally. The focus of this paper is the application of a widely-used method of forecast popularly known as the Box-Jenkins Methodology<sup>1</sup> in order to model and forecast the behavior of crude oil price and to examine its implication for the Nigerian government budgeting for 2013.

## 2. Approaches to Economic Forecasting

How do we forecast economic variables such as GDP, inflation, exchange rate, unemployment rate etc? Forecasting is an important part of research, in fact, for some researchers; it is probably the most important. The topic of economic forecasting is vast. Five approaches to economic forecasting based on time series data are discussed below:

- a. Exponential Smoothing method
- b. Single-equation regression models

c. Simultaneous –equation regression

d. Autoregressive integrated moving average models (ARIMA)-Box-Jenkins (BJ) Methodology

e. Vector auto regression

### a. Exponential Smoothing Method

This is a simple method of adaptive forecasting. It is an effective way of forecasting when you have only few observations on which your forecast is based. Unlike forecast from regression models which uses fixed coefficients, forecasts from exponential smoothing method is based upon past forecast errors. The smoothing equation is based on averaging (smoothing) past values of a series in a decreasing (exponential) manner. The observations are weighted with more weight given to the most recent observation.

### b. Single equation Regression models

In this case, a variable under study is explained by a single function (linear or nonlinear) of explanatory variables. The equation will often be time-dependent so that one can easily predict the response over time of the variables under study to changes in one or more explanatory variables.

### c. Simultaneous –Equation Regression Models

In this case, variables to be studied may be a function of several explanatory variables, which are related to one another as well as to the variable under study through a set of equations. The construction of multi-equation model begins with the specification of a set of individual relationships, each of which is fitted to evaluate the data. An example of this is a complete model of Nigerian Liquefied Gas (NLG) industry that contains equation explaining variables such as gas demand, gas production output, employment of production workers, investment in the industry, and gas price. These variables will be related to one another as well as to other variables. Such variables may include national income, consumer price index, interest rates etc through a set of linear or nonlinear equations.

### d. VAR Models:

In a VAR model, all the variables in the system are endogenous; with each written as a linear function of its own lagged values as well as those of all the other variables in the

<sup>1</sup>G.P.E BOX and G.M Jenkins, Time Series Analysis: Forecasting and Control, 1976

system. If all the variables are gathered into a single vector, this can be viewed as a vector auto regression-this vector expressed as linear function of its own lagged values (with several lags) plus an error vector. Estimation is undertaken by running a regression containing separate equations for each of the variables in the entire system.

**e. ARIMA Models (Box and Jenkins Methodology)**

The terminology ‘time series analysis’ at one time referred to the BJ approach to modeling time series. It was developed by Box and Jenkins (1970) in the context of forecasting. This method abandoned the econometric modeling approach of using explanatory variables suggested by economic theory to explain or forecast. Instead, it chooses to rely on past behavior of the variable being modeled. It simply says “let the data speak for itself”.

Suppose Y is the variable to be modeled or forecasted, the BJ approach begins by transforming Y to ensure that it is stationary. This is checked in a rather casual way by visual inspection of the estimated correlogram. A correlogram is a graph that plots the estimated kth-order autocorrelation coefficient,  $\rho_k$ , as a function of k ( $\rho_k$  is the covariance between  $Y_t$  and  $Y_{t-k}$ , normalized by dividing it by the variance. For a stationary variable, the correlogram should show autocorrelations that die out fairly quickly as k becomes large. If any variable is non stationary, it can be made stationary by differencing; and usually only one or two differencing operations are required. This creates a new data series,  $Y^*$ , which becomes the input for the BJ analysis. The general model expresses  $Y^*$  in terms of its own past values along with current and past errors. There are no explanatory variables as there would be in a traditional econometric model. The model is denoted as ARIMA (p, d, q) for Y stands for autoregressive integrated moving average. Where P is the number of lagged values of  $Y^*$ , representing the order of the autoregressive (AR) dimension of the model. AR captures the past values of the variable; d is the number of times Y is differenced to produce  $Y^*$ ; q is the number of lagged values of the error term, representing the order of the moving average (MA) dimension of the model.

There are three basic steps to the development of an ARIMA model.

- i. Identification/Model selection: The values of p, d, and q must be determined. The principle of parsimony is adopted: most stationary time series can be modeled using very low values of p and q.
- ii. Estimation: The parameters must be estimated, usually by employing a least squares approximation to the maximum likelihood estimator.
- iii. Diagnostic Checking: The estimated model must be checked for its adequacy and revised if necessary, implying that this entire process may have to be repeated until a satisfactory model is found; and then forecasting can be made.

As mentioned earlier, Nigeria is a country that depends almost entirely on oil to finance her budget. The volatility in oil prices has always made budget implementation a difficult thing in the country. Therefore, the essence of this work is to forecast what the oil price might be for the 2013 as the knowledge of this will help the policy makers make

informed decision. This study will utilize the Box-Jenkins approach as this approach is one of the mostly applied methodologies for the analysis of time-series data. For the purpose of modeling and forecasting economics relationships, it is suitable for any type of series; whether the series is stationary or not, with or without seasonal elements.

**3. Methodology**

Building an ARIMA model requires a suitable sample size. Box and Jenkins suggested that about 50 observations is the minimum required number. Some analysts may rarely use a smaller sample size, interpreting the results with caution. A large sample size is especially attractive when working with seasonal data.

The most common ARIMA model included three parameters: p, d, and q where p is the number of autoregressive parameters, d is the number of differencing parameters and q is the number of moving average parameters.

We can use the graph of the sample autocorrelation function (ACF) and the sample partial autocorrelation function (PACF) to determine the model. There are two phases to the identification of an appropriate Box-Jenkins model: changing the data if necessary into a stationary time series and determining the tentative model by observing the behavior of the autocorrelation and partial autocorrelation function. Box and Jenkins suggest that the number of lags should not be more than (n/4). The autocorrelation coefficient measures the correlation between a set of observations and a lagged set of observation in a time series. Once a stationary time series has been selected (the ACF cuts off or dies down quickly), we can identify a tentative model by examining the behavior of the ACF and PACF as summarized below:

| Model       | AC Function             | PAC Function            |
|-------------|-------------------------|-------------------------|
| MA(q)       | Cuts off after lag q    | Dies down exponentially |
| AR(p)       | Dies down exponentially | Cuts off after lag p    |
| ARMA (p, q) | Dies down exponentially | Dies down exponentially |

However, because of the ambiguous nature of interpretation of the correlogram, it is often necessary to identify several tentative models, and then perform diagnostic checks to determine the most appropriate.

**4. Building the ARIMA Model and Forecasting**

**4.1 Data Source**

In this study, data for monthly crude oil prices (in US dollar) for the period 1993 January –2012 October, giving about 252 observations is used. The data was gotten from Oil Price Net.

**4.2 Unit Root Test**

The first step in this work is to establish the stationarity of the series. To do this, the graphical test is first conducted by plotting the graph of the series. This is shown below:

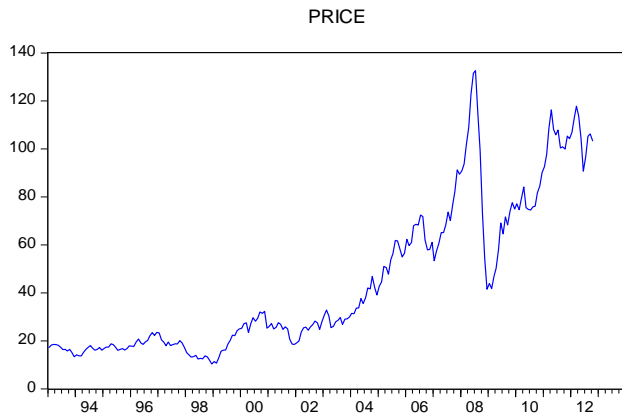


Figure 1: Stationarity test

As shown in the graph above, the series drifts away from the mean, suggesting that it is not stationary. This was also confirmed by the plots of the correlogram as shown in table 1 below.

Furthermore, this was confirmed using one of the most famous tests, the augmented Dickey- Fuller (ADF) test. This test used the existence of a unit root as the null hypothesis. The result shows that the series is not stationary at level, but it is so at first difference. This are presented in Table 1.

Table 1: Unit root test

| Unit Root Test (stationary test) variable (Oil price) |             |                                   |   |         |
|---|-------------|-----------------------------------|---|---------|
| Test critical values:                                 | -1.343318   | 1% level<br>5% level<br>10% level | -<br>3.457984<br>-<br>2.873596<br>-<br>2.573270 |         |
| Variable  | Coefficient | Std. Error<br>t                   | t-test  | P-value |
| Price   | -0.011338   | 0.008440                          | -<br>1.343318                                   | 0.1805  |
| D(PRICE(-1))  | -0.578354   | 0.059357                          | -<br>9.743649                                   | 0.0000  |

Source: Authors' calculations

4.3. Model Identification

Various models were estimated, but going by the rule of identification stated above, AR (2) model showed a good fit of the data. The model parameters are stated below:

Table 2: Model parameter

| Types | Coefficient | Stand Error | Prob   |
|-------|-------------|-------------|--------|
| AR(2) | 0.217774    | 0.064018    | 0.0008 |

4.4 Diagnostic Checking

The next stage is the diagnostic checking. From the result estimated, convergence was achieved after 3 interactions, and the AR root shows that invertibility was achieved.

Residual Normality

The residual is also normally distributed as shown by the plots of the Histogram. A look at the statistics shows that it is negatively skewed. The Jarque-Bera also shows that it is normally distributed. This is shown below:

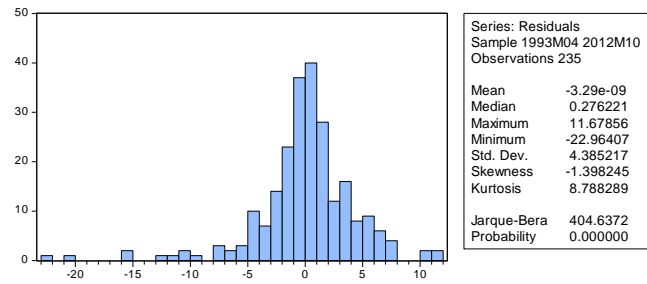


Figure 2: Normality test

Significance of the Parameters

The parameter is also significant as indicated by the p-value of the coefficient.

5. Making the Forecast

Once the model has been identified and the diagnostics established, the next thing is to make the forecast. The out-of-sample forecast was done from 2012 November to 2013 December.

5.1. The Result

Figure 3 below gives a vivid picture of the forecast of the crude oil prices using the Box-Jenkins methodology as explained above. From the result of the forecast, it can be observed that oil price will be stable around \$100 through the period of the forecast ceteris paribus.

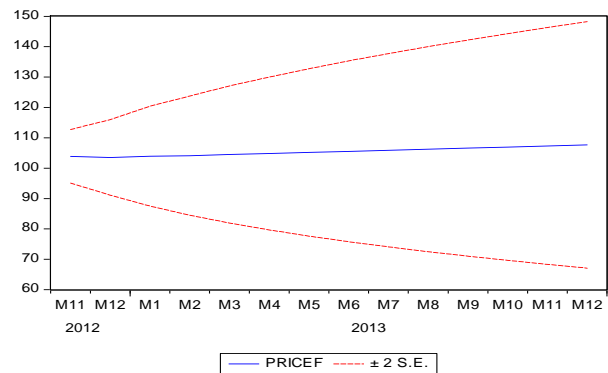


Figure 3: Forecast of the crude oil prices

5.2. Implications of the Result

The result of the forecast carried out above has implications for government budgeting in the Nigerian economy especially if the budget is not appropriately benchmarked. In the light of the foregoing analysis and the result of the forecast, fixing a benchmark for the budget at \$80 per barrel is optimal and therefore recommended for the federal authorities of the country. Even though this appears to be \$20 per barrel less than the forecasted value, it is considered appropriate as it leaves a considerable margin for unforeseen contingencies in the international frontiers. Also this is appropriate because the forecast is done based on historical

data and this may not predict future events and trends with 100% degree of accuracy. A benchmark higher than this (say \$90 or \$100 per barrel) may end up affecting the economy adversely in the event that actual crude oil price end up being less than this as this situation would force the government into borrowing to finance its budgeted expenditures. On the other hand, a benchmark lower than this (say \$60 or \$70 per barrel) would be sub-optimal in the event that actual crude oil prices end up being higher than the forecasted price of \$100 per barrel as idle resources would be left unutilized even in the face of rising poverty, unemployment, inadequate infrastructures and various economic hardships experienced in the country that the government would have otherwise deploy resources to ameliorate.

## 6. Conclusion

In this paper, a model for crude oil price was developed and it is found to be AR (2). The diagnostics show that the model is good. Based on the model, a forecast was conducted for year 2013, and it shows the price level will be stable around \$100. A benchmark of \$80 per barrel is recommended given the nature and structure of the Nigerian economy (being solely oil-dependent) as well as given the expected vagaries in the international price of crude oil.

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