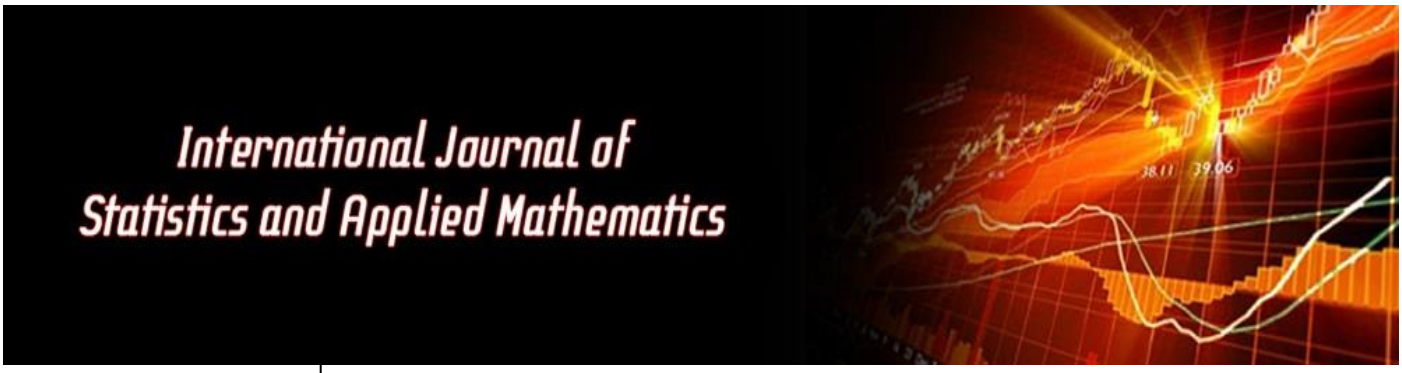

ISSN: 2456-1452
Maths 2022; 7(2): 165-169

www.mathsjournal.com
Received: 14-01-2022
Accepted: 19-02-2022

Ette H Etuk
Department of Mathematics, Rivers State University of Science and Technology, Port Harcourt, Nigeria

Elisha J Inyang
Department of Statistics, University of Uyo, Uyo, Nigeria

Unyime P Udoudo
Department of Statistics, Akwa Ibom State Polytechnic, Ikot Osurua, Ikot Ekpene, Nigeria

Corresponding Author:
Elisha J Inyang
Department of Statistics, University of Uyo, Uyo, Nigeria

Impact of declaration of cooperation on the Nigerian crude oil production

Ette H Etuk, Elisha J Inyang and Unyime P Udoudo

DOI: https://doi.org/10.22271/maths.2022.v7.i2b.812

Abstract
The Nigerian economy has consistently suffered from global price shocks and its politics. And this shocks at many occasion has not been friendly with the Nigeria economy, since her over dependent on oil as the major source of revenue. A time-series model for the Nigerian monthly crude oil production is developed to examine the impact of Declaration of Cooperation (DoC). The data for this study are the monthly crude oil production spanning from January 1999 - December 2020. From the result, the impact parameter indicates that the DoC had a negative impact on the Nigerian crude oil production. That is, there's about 35% level production reduction in Nigerian crude oil production after the introduction of DoC. The negative impact can further be seen in an all-time lowest drop in crude oil production (44,452,090 barrels) recorded in December 2020 after the introduction of DoC against a maximum crude oil production of 81,196,554 barrels recorded in October 2010 before the emergence of DoC. The intervention effect is described as immediate and gradual.

Keywords: OPEC, DoC, crude oil, Nigeria, statistical assessment

Introduction
Crude oil and its importance in powering the world economy can't be overemphasized. Sustainable access to crude oil has remained a key aspect of international politics and relations by both importing and exporting countries. Import-dependent countries are interested on how to maintain sustainable, secure access to oil at low prices, whereas oil exporting countries, are interested in balancing their desire to uphold prices and revenues while maintaining market share. Between 1920 and 1973 the seven sisters were firmly in control of world oil. They had substantial influence on decisions concerning where and when to drill for oil, how much to produce, and what price would be charged for the oil. These eventually raised concerns among the Petroleum Exporting Countries who wanted to obtain more benefits from their crude oil deposits and wanted to have greater control. It was these countries namely Iraq, Iran, Kuwait, Saudi Arabia and Venezuela that decided to form the Organization of Petroleum Exporting Countries (OPEC) in September 1960 and more other countries were added like Nigeria (1971) and recently Gabon re-joined (2016), Equatorial Guinea (2017), Congo (2018).
OPEC's clear objective is to co-ordinate and unify petroleum policies among members countries, in order to secure fair and stable prices for petroleum producers; an efficient, economic and regular supply of petroleum to consuming nations; and a fair return on capital to those investing in the industry. One of OPEC's recent intervention is the Declaration of Cooperation (DoC) which constitutes an unprecedented milestone in the history of OPEC.
Market conditions led to the emergence of the unprecedented Declaration of Cooperation (DoC) in December 2016, with OPEC members and 10 non-OPEC oil-producing countries coming together to help rebalance the market, bring down inventory levels and support oil market stability.

Review of Literature
Box Jenkins ARIMA methodology has been a widely used technique for modelling and forecasting in time series [1]. However, when the patterns of the time series are interrupted by some external event (known as intervention), then the forecasting performance of ARIMA model may be affected.

However, it can be improved by employing appropriate techniques such as ARIMA-Intervention model developed by [2]. In this study the data on monthly crude oil production is analysed using the ARIMA-Intervention model [2]. Intervention analysis measures the effect of an external or exogenous intervention on a time series data of interest.

This technique has been successfully applied by scholars like: Etuk *et al.* (2021) [3] used Arima-intervention Analysis in modelling Nigerian Automotive Gas Oil Distribution. Etuk and Amadi (2021) [4] modelled Nigerian Monthly Crude Oil Prices using Arima-intervention model. Shittu and Inyang (2019) [9] modelled Nigerian monthly crude oil prices using the ARIMA Intervention model with a view to comparing the result with that of the intervention model using lag operator. Wiri and Tuaneh (2019) [10] modelled the Nigerian Crude Oil Prices Using ARIMA, Pre-intervention and Post-intervention Model. Mrinmoy *et al.* (2014) [6] used time series Intervention Modelling for Modelling and Forecasting Cotton Yield in India. Jarrett and Kyper (2011) [5], used ARIMA Modelling with Intervention to Forecast and Analysed Chinese Stock Prices. Roy *et al.* (2009) [8] used ARIMA – Intervention Analysis in Modelling the Financial Crisis in China's Manufacturing Industry.

Therefore, this paper attempts to investigate the impact of OPEC's DoC on the Nigerian crude oil production.

Model Specification

Let $\{Z_t\}$ be a time series. Suppose there is an event occurring which changes the trend in the series. This event is referred to as an intervention. If it occurs at time t=T, [2] proposed that the pre-intervention observation of $\{Z_t\}$ be modelled as [1]. Intervention model is of the general form:

$$X_t = H(B)I_t + Z_t \quad (1)$$

Let,

$$H(B) = \frac{\omega(B)}{\delta(B)}B^b, \text{ Transfer function component} \quad (2)$$

$$Z_t = \frac{\theta(B)}{\phi(B)}\varepsilon_t, \text{ Noise component} \quad (3)$$

Accordingly, intervention models with non-seasonal and seasonal ARIMA process can be written respectively as

$$X_t = \frac{\omega(B)}{\delta(B)}B^b I_t + \frac{\theta(B)}{\phi(B)}\varepsilon_t \quad (4)$$

$$X_t = \frac{\omega(B)}{\delta(B)}B^b I_t + \frac{\theta(B)\Theta(B)}{\phi(B)\Phi(B)}\varepsilon_t \quad (5)$$

$$\delta(B) = 1 - \delta_1 B - \ldots - \delta_r B^r, \omega(B) = \omega_0 - \omega_1 B - \ldots - \omega_s B^s \quad (6)$$

$$\phi(B) = 1 - \phi_1 B - \ldots - \phi_p B^p, \theta(B) = 1 + \theta_1 B + \ldots + \theta_q B^q \quad (7)$$

$$\Phi(B) = 1 - \Phi_{S,1}B^s - \ldots - \Phi_{S,P}B^{PS}, \Theta(B) = 1 + \Theta_{S,1}B^s + \ldots + \Theta_{S,Q}B^{QS} \quad (8)$$

Where:

X_t= Observed crude oil production, b= Delay parameter, ω = Impact parameter, δ = Slope parameter, ϕ = Autoregressive parameter, θ = Moving average parameter, B = Backshift operator, ε_t= White noise, p= order of Autoregressive process, q= order of Moving Average process, S= the seasonal period, Φ = seasonal Autoregressive parameter, Θ = seasonal Moving average parameter, P= seasonal order of Autoregressive process, Q= seasonal order of Moving Average, I_t= Indicator variable defined as;

The intervention type of "step function" starts from a given time till the last time period.

In this study the indicator function was labelled as:

$$I_t = \begin{cases} 0, t < December, 2016 \\ 1, t \geq December, 2016 \end{cases} \quad (9)$$

Data Description

The data used for this study are the monthly crude oil production (COP) spanning from January 1999 - December 2020, were collected from The Nigerian National Petroleum Corporation (NNPC) Statistical Bulletin [7]. The dataset was divided into observations belonging to pre-intervention period (January 1999 - November 2016) named as Series-1 and post-intervention period (December 2016 - December 2020) named Series-2. The statistical package used for the analysis of this work is the R language (R-4.1.2-win).

Results and Discussions

The data were divided into observations belonging to pre-intervention period named Series-1 and post-intervention period named Series-2. Intervention analysis [2] is employed to measure the effect of the external event being the DoC on the Nigerian crude oil production for period under study. The DoC was introduced in December 2016 and this point were labelled by indicator function in (9).

In view of making sense from the dataset, basic summary statistics were obtained. The monthly crude oil production from January 1999 to December 2020 had a total of 264 observations, Series-1 (Jan. 1999 – Nov. 2016) had a total 215 observations while Series-2 (Dec. 2016 – Dec. 2020) had total of 49 observations. The lowest crude oil Production occurred in December 2020 with the sum of 44,452,090 barrels, maximum production was recorded in October 2010 with 81,196,554 barrels and total sum of production under this study was 17,527,420,000 barrels.

The time plot in Fig. 1 which is the monthly COP under the studied period. The graph of the series does not show any unique pattern as it rises and falls at random; perhaps dues to the mechanism that generated the data set. The dataset on monthly COP was divided into Series-1 and Series-2 defined above. Series-1 was used for model fitting while Series-2 was used in determining the intervention component form. Pre – intervention plots shown in Fig. 2 (1st graph) and Fig. 3 shows that the series was non-stationary. The series was transformed to attain stationarity, Fig. 2 (2nd graph) & Table 1 (ADF test). Following the 3 iterative stages by [1], ARIMA$(0,1,1)(0,1,1)_{12}$ was found to be statistically significant and adequate, Fig. 5 and Table 4.

From the impulse response function, it can be inferred that b=0, implying that effect of the intervention was felt at the point of the intervention itself, Fig. 6. The impact parameter with value -0.1838 was significant with p-value (0.0001). The negative sign of the intervention parameter (-0.1838) indicates that crude oil production were reduced after the introduction of DoC by OPEC. In percentage terms, this indicates that a-level production is reduced to 65% of their pre-intervention mean or by about 35% after introduction of DoC. The full model is represented mathematically as

$$X_t^* = \frac{-0.1838}{1.3922}I_t + (1 - .2067B)(1 - .9238B)\varepsilon_t \quad (10)$$

Where,

$$\nabla_{12}\nabla X_t = \nabla_{12}(X_t - X_{t-1}), X_t^* = X_{t-1} + X_{t-12} - X_{t-13}$$

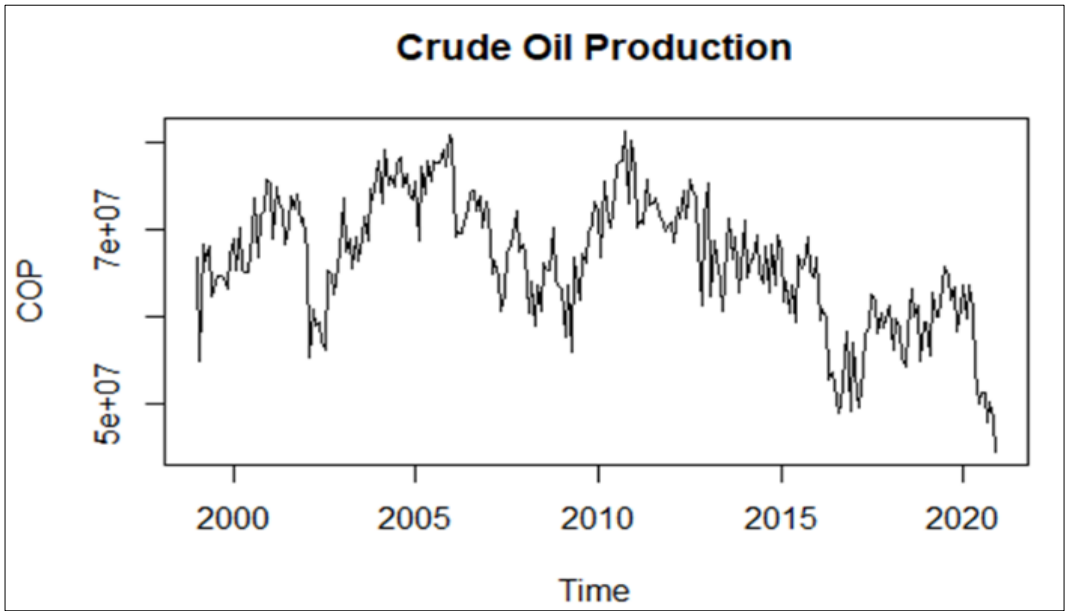

Fig 1: Time Plot of Crude Oil Production (COP)

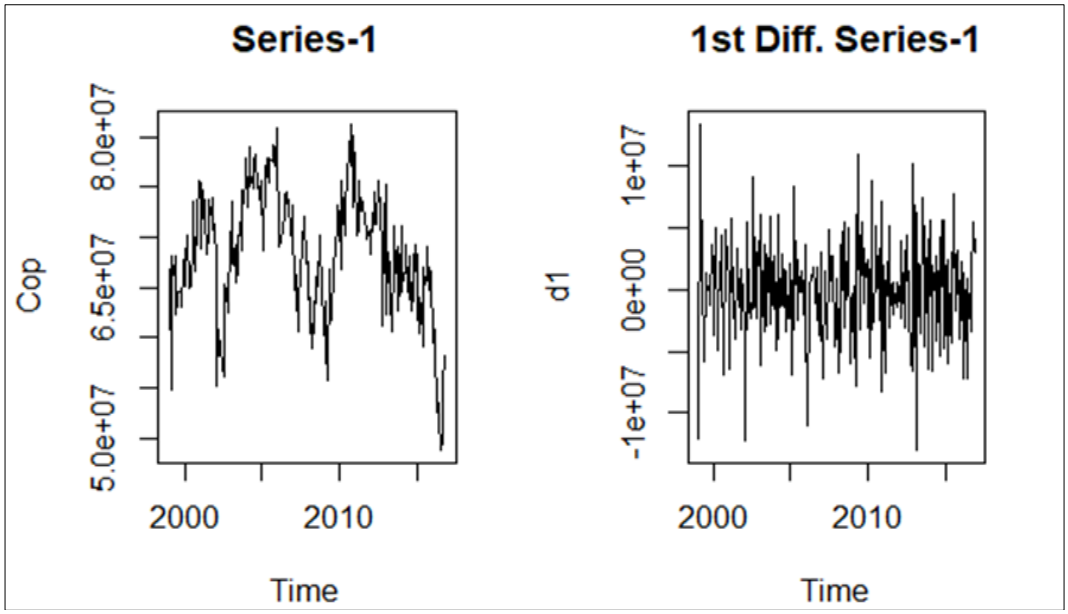

Fig 2: Time Plot of Series-1 before and after First Difference

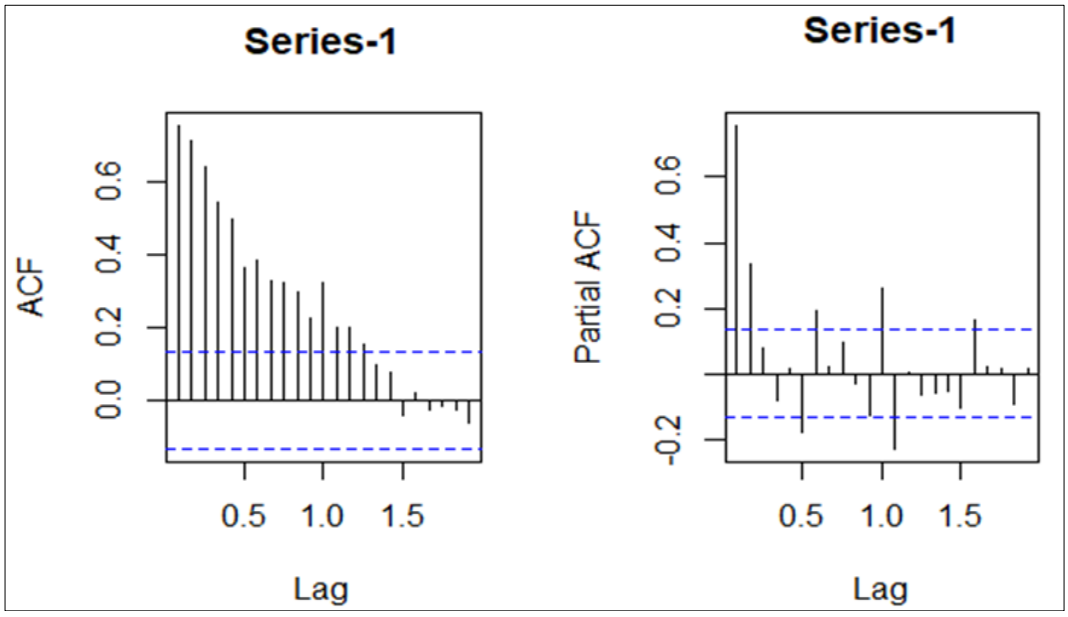

Fig 3: ACF and PACF Plots of Series-1

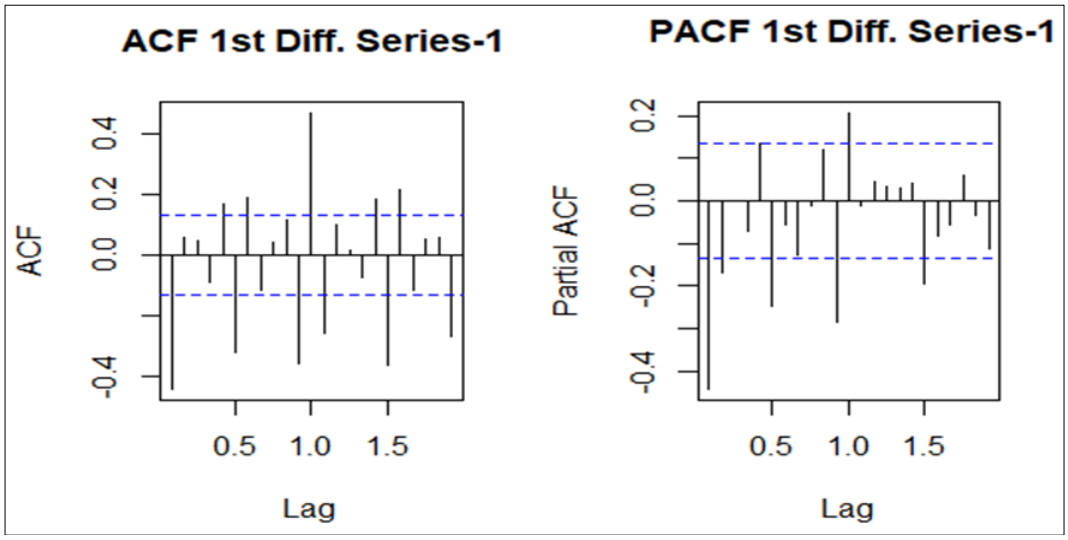

Fig 4: ACF and PACF Plots of First Difference of Series-1

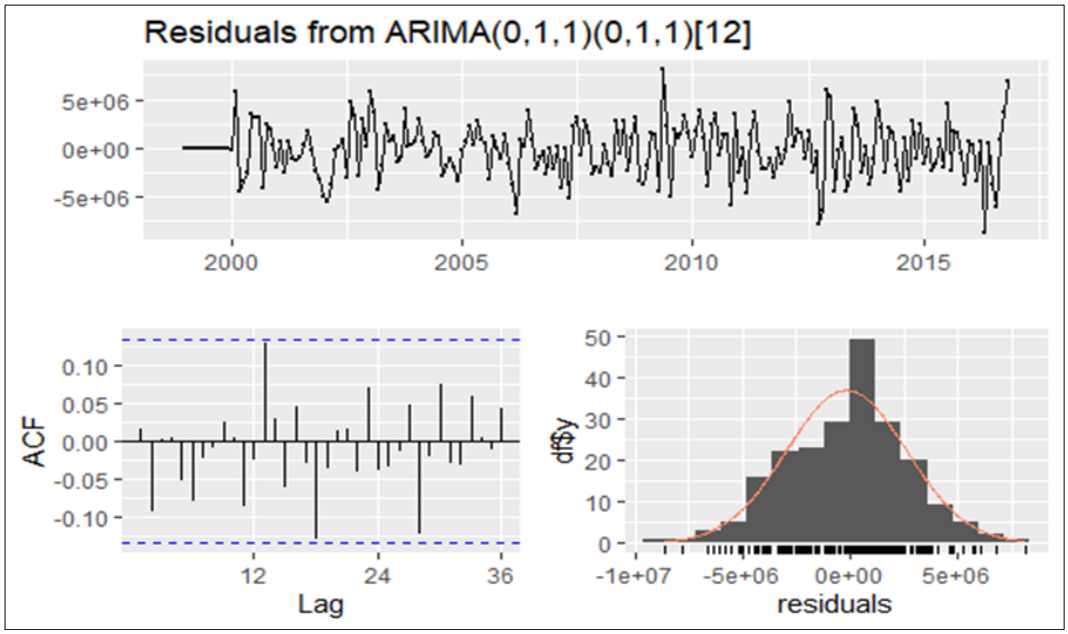

Fig 5: Residual from ARIMA $(0,1,1)(0,1,1)_{12}$

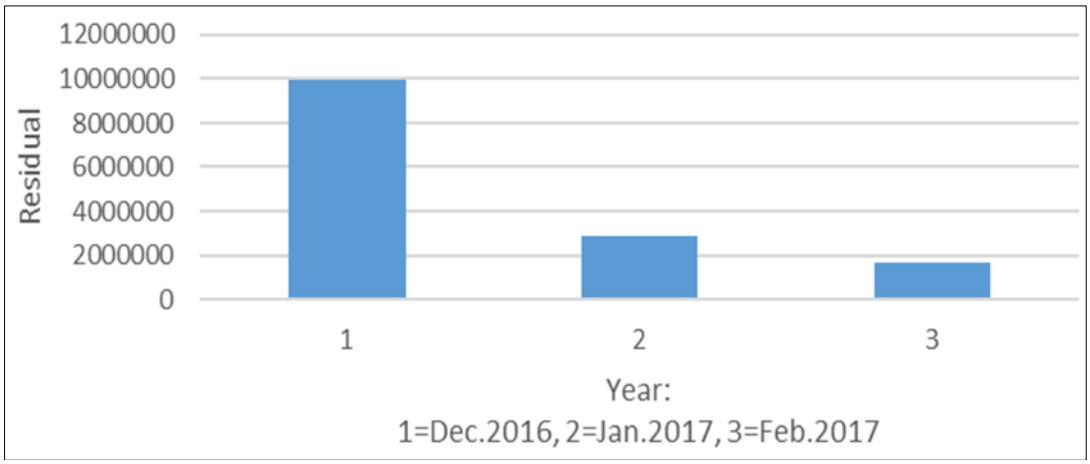

Fig 6: Impulse Response Function

Table 1: Unit Root Test

Augmented Dickey-Fuller Test data: 1st Diff. Series-1 Dickey-Fuller = -7.687, Lag order = 5, p-value = 0.01 alternative hypothesis: stationary

Table 2: Parameter Estimation for ARIMA (0,1,1) (0,1,1) [12]

Parameter	Estimate	Std. Error	Z-value	p-value
MA (1)	-0.2721	0.0758	-3.5883	0.0003***
SMA (1)	-0.999	0.1183	-8.453	<2.2e-16***
BIC =6631.595			AIC=6621.671	

Table 3: Parameter Estimation for the Full Intervention Model

Parameter	Estimate	Std. Error	Z-value	p-value
MA (1)	-0.2067	0.0700	-2.9537	0.0031***
SMA (1)	-0.9238	0.06349	-14.5512	<2.2e-16***
Impact (ω)	-0.1838	0.0477	-3.8552	0.0001
Slope (δ)	-0.3922	0.1419	-2.7640	0.0057
Deley (b)	0			

Table 4: Ljung-Box Test for ARIMA and ARIMA-Intervention Models

ARIMA (0,1,1) (0,1,1) [12]	ARIMA-Intervention (0,1,1) (0,1,1) [12]
Q* = 18.013, df = 22, p-value = 0.7052 Model df: 2. Total lags used: 24	Q* = 17.191, df = 20, p-value = 0.6405 Model df: 4., Total lags used: 24

Conclusion

The full model in (10) was found to be statistically significant and adequate. The significance of the impact parameter indicates that the DoC has a negative impact on Nigerian crude oil production. That is, there's about 35% level production reduction in Nigerian crude oil production after the introduction of DoC by OPEC and the effect of the intervention is immediate and gradual. Visually the negative impact of DoC can further be seen in the lowest drop of crude oil production (44,452,090 barrels) recorded in December 2020 after the introduction of DoC against a maximum crude oil production of 81,196,554 barrels recorded in October 2010 before the emergence of DoC.

References

1. Box GEP, Jenkins GM. Time Series Analysis, Forecasting and Control, Revised Edition, Holden – day, San Francisco; c1976.
2. Box GEP, Tiao GC. Intervention Analysis with Application to Economic and Environmental Problems. Journal of American Statistical Association. 1975;70(349):70-79.
3. Etuk EH, Moffat IU, Agbam AS. Intervention Analysis of Nigerian Automotive Gas Oil Distribution. Nigerian Journal of Oil and Gas Technology. 2021;3:2.
4. Etuk EH, Amadi EH. Arima Intervention Analysis of Nigerian Monthly Crude Oil Prices. Nigerian Journal of Oil and Gas Technology. 2021;3(1)107-115.
5. Jarrett JE, Kyper E. ARIMA Modelling with Intervention to Forecast and Analyze Chinese Stock Prices. Int. J Eng. bus. Manag. 2011;3(3):53-58.
6. Mrinmoy R, Ramasubramanian V, Amrender K, Anil R. Application of Time Series Intervention Modelling for Modelling and Forecasting Cotton Yield. Statistics and Applications. 2014;12(1-2):61-70.
7. Nigerian National Petroleum Corporation. Oil and Gas Statistical Bulletin | Monthly Performance; c2022. www.nnpcgroup.com
8. Roy CPC, Ip WH, Chan SL. An ARIMA - Intervention Analysis Model for the Financial Crisis in China's Manufacturing Industry. Intervention Journal of Engineering Business Management. 2009;1(1):15-18.
9. Shittu OI, Inyang EJ. Statistical Assessment of Government's Interventions on Nigerian Crude Oil Prices. A Publication of Professional Statisticians Society of Nigeria, Proceedings of 3rd International Conference. 2019;3:519-524.
10. Wiri L, Tuaneh GL. Modelling the Nigeria Crude Oil Prices Using ARIMA, Pre-intervention and Post-intervention Model. Asian Journal of Probability and Statistics. 2019;3(1):1-12. Article No. AJPAS.46900