

Impact Assessment of Gap on Nigerian Crude Oil Production: A Box-Tiao Intervention Approach

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Authors' contributions

Both authors contributed equally in this work, except the analyses which was carried out by author EJI. Both authors proof-read and approved the final manuscript.

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Abstract

The Nigerian disarmament, demobilization and reintegration programme known as the Amnesty Programme have become common practice in countries facing violent conflict. A time-series model for monthly crude oil production was developed to examine the effect of Government's Amnesty Programme (GAP) introduced in August 2009. The data used in this study are the monthly crude oil production spanning from January 1999 to December 2020. From results of model estimation, we found that the intervention due to the Amnesty programme had no impact on crude oil production since the null hypothesis that ω is 0 was retained. Factors suggested to account for this development includes: Crack in deal, as Nigerian Government found it difficult to fund the programme due to incessant fall in oil price and emergence of new groups of militant. The renewed instability and violent attacks on oil facilities have resulted in a serious reduction of crude oil production. Thus, government should consider tackling wider socio-economic grievances in the country's oil production region in other to bring stability, which will lead to increase in oil production.

Keywords: GAP; Nigeria; crude oil; impact assessment; Box-Tiao.

1 Introduction

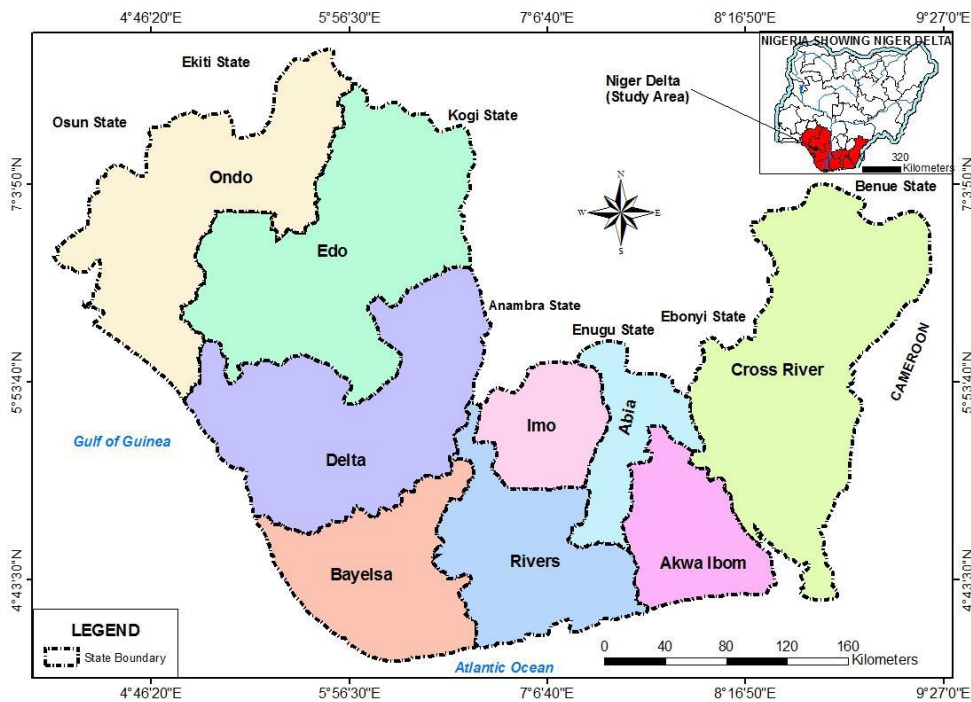
Crude oil plays an increasingly significant role in the world economy, where nearly two-thirds of the world's energy consumption comes from it. The search of crude oil in Nigeria started as early as 1937, but the discovery

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was not until 1956. Nigeria have been over dependent on crude oil Since its discovery, since crude oil has been Nigeria’s major revenue driver. Except through OPEC, Nigeria does not have any effective hold on global oil price and so is essentially a price taker and vulnerable to global oil price shocks and its politics. Nigeria has witnessed continuous decrease in crude oil production which has strong effect on the country’s economy and this reduction in oil production stem from incessant violent attacks by the Niger Delta Militant group.

Oil siphoning rackets, sabotage and kidnappings by the Militants who say they are fighting to gain the local population a greater share of the country’s oil wealth had always hit the country’s economy hard. Government in the past had been responding with aggression such as the use of military to launched a major ground, air and sea offensive to flush militants out of their camps in the Niger Delta but this attempts by the Nigerian government to use force against the militants have proved unsuccessful as the militants continue to evade direct confrontation with the military.

Late President Umaru Musa Yar’Adua then announced the 2009 amnesty deal. The amnesty programme was set up to put an end to the violence and instability in region which causes reduction in oil production and export. Its main objective was to disarm, demobilize and reintegrate armed militants back into communities. The programme involved offering benefits such as opportunities in education, employment and as well as money to militants who gave up their weapons. A digital geographical profile of the studied area is given below, see Map 1.



Map 1. Map of the Niger Delta Region Showing States

2 Review of Literature

Box Jenkins ARIMA methodology has been a widely used technique for modeling and forecasting in time series [1]. However, when the patterns of the time series under study are affected by some external event (called 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 Box and Tiao [2]. In this study the data on monthly crude oil production is analyzed 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. [3], used Arima-intervention Analysis in modelling Nigerian Automotive Gas Oil Distribution. Etuk and Amadi [4], modelled Nigerian Monthly Crude Oil Prices using Arima-intervention model. Shittu and Inyang [5], 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 [6], Modelled the Nigeria Crude Oil Prices Using ARIMA, Pre-intervention and Post-intervention Model. Mrinmoy et al. [7], used time series Intervention Modelling for Modelling and Forecasting Cotton Yield in India. Jarrett and Kyper [8], used ARIMA Modeling with Intervention to Forecast and Analyze Chinese Stock Prices. Roy et al. [9], used ARIMA – Intervention Analysis in Modeling the Financial Crisis in China’s Manufacturing Industry.

This paper attempts to investigate the impact of Government’s amnesty programme (GAP) on crude oil production in Nigeria under the studied period.

3 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:

$$Y_t = G(B)I_t + Z_t \tag{1}$$

Let,

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

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

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

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

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

Then,

$$\delta(B) = 1 - \delta_1 B - \dots - \delta_r B^r, \omega(B) = \omega_0 - \omega_1 B - \dots - \omega_s B^s \tag{6}$$

$$\phi(B) = 1 - \phi_1 B - \dots - \phi_p B^p, \theta(B) = 1 - \theta_1 B - \dots - \theta_q B^q \tag{7}$$

$$\Phi(B) = 1 - \Phi_{s,1} B^s - \dots - \Phi_{s,p} B^{ps}, \Theta(B) = 1 + \Theta_{s,1} B^s + \dots + \Theta_{s,q} B^{qs} \tag{8}$$

Where:

Y_t = Observed crude oil production, b = Delay parameter, ω = Impact parameter, δ = Slope parameter, ϕ = Autoregressive parameter, θ = Moving average parameter, B = Backshift operator, 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, ε_t = White noise, I_t = Indicator variable defined as;

The intervention type of “step function” starts from a given time till the last time period. Mathematically it is written as

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

T is the time of intervention when it first occurred (T = August 2009).

4 Data Description

The data used for this study are the monthly crude oil production (COP) spanning from January 1999 - December 2020, the secondary data were collected from The Nigerian National Petroleum Corporation (NNPC) Statistical Bulletin [10]. The dataset was divided into observations belonging to pre-intervention (January 1999 - July 2009) and post-intervention periods (August 2009 – December 2020). The statistical package used for the analysis of this work is the R language (R-4.1.2-win).

5 Results and Discussion

The dataset considered in this study were divided into observations belonging to pre-intervention and post-intervention periods. Intervention analysis [2] is employed to measure the effect of the external intervention being the 2009 Government Amnesty Programme (GAP) on crude oil production for period under study. In June 2009, the President of Nigeria, late President Umaru Yar'Adua signed an offer of unconditional amnesty for militants operating in the Niger Delta but this offer was effective on August 2009 and this point were labelled by indicator function as:

$$I_t = \begin{cases} 0, & t < \text{August, 2009} \\ 1, & t \geq \text{August, 2009} \end{cases}$$

The time plot showing the monthly crude oil Production under the studied period is given in Fig. 1 of Appendix I. 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. From the plot, we observed a significant drop in crude oil Production in April 2009 before the intervention.

The dataset on monthly crude oil production was divided into pre-intervention and post-intervention periods. Data from January 1999 to July 2009 is used for pre – intervention ARIMA model fitting while data from August 2009 to December 2020 is used in determining the intervention component form. Pre – intervention plots shown in Fig. 2 (1st graph) and Fig. 3 shows that the series is non-stationary (see Appendix I), confirmed by ADF test in Table 1 of Appendix II. Following the 3 iterative steps of model building by [1], ARIMA(0,1,1)(2,1,0)₁₂ appeared to be statistically adequate, confirmed by the Ljung-Box test in Table 4 of Appendix II.

From the impulse response function, though the intervention occurred August 2009 but its effect was felt after a delay of 2 periods, Fig. 5 in Appendix I. The parameter ω with value 0.0483 is non-significant with p-value

(0.0549 > 0.05). The intervention effect is relatively persistent since the value of \mathcal{D} is near 1. The full intervention model was found to be adequate (see Table 4 of Appendix II) and is presented mathematically as:

$$Y_t^* = \frac{0.0483}{1-0.8339B} B^2 I_t + \frac{(1+0.262B)}{(1+0.6668B+0.3914B^2)} \varepsilon_t \quad (10)$$

Where: $Y_t^* = \nabla_{12} \nabla Y_t = \nabla_{12} (Y_t - Y_{t-1}) = Y_{t-1} + Y_{t-12} + Y_{t-13}$

6 Conclusion

Results of the estimated model revealed that there is not any statistically significant evidence which show the amnesty programme had no impact on crude oil production. Factors suggested to account for this development includes: (i) Crack in the deal started as the Nigerian Government found it difficult to fund the programme due to sharp fall in oil price. For instance, monthly allowance of enrolled ex-militants was suspended in May 2015. (ii) Emergence of new groups of militant. Youths who weren't part of any armed militant group, started to mobilise into new groups in order to benefit from the amnesty programme. The renewed instability and violent attacks on oil facilities have resulted in a serious reduction of the crude oil production.

7 Recommendations

From the framework of this study the following recommendations are made:

- (i) Amnesty Programme was short term option. Thus, Nigerian government should consider tackling wider socio-economic grievances such as lack of social development in local oil communities, environmental pollution (oil spillage, etc) and the exclusion of the local communities from the governance of oil production in the Niger Delta region.
- (ii) There have been outcries calling for diversification of the Nigerian economy in the past. Therefore, Government should diversify its economy to avoid distress economy.

Competing Interests

Authors have declared that no competing interests exist.

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Appendix I

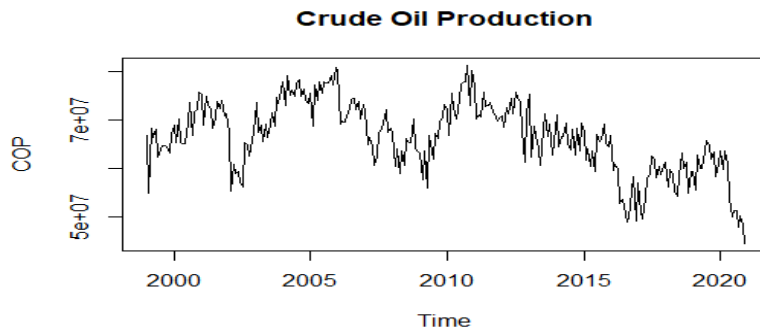


Fig. 1. Time Plot of Crude Oil Production (COP)

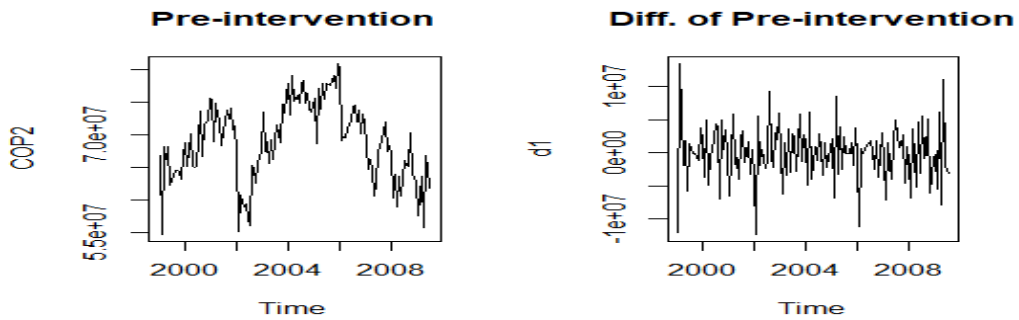


Fig. 2. Time plot of pre-intervention series before and after first difference

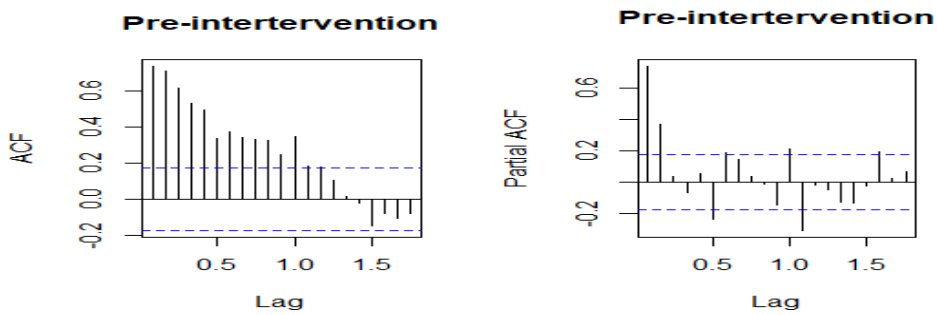


Fig. 3. ACF and PACF Plots of Pre-intervention

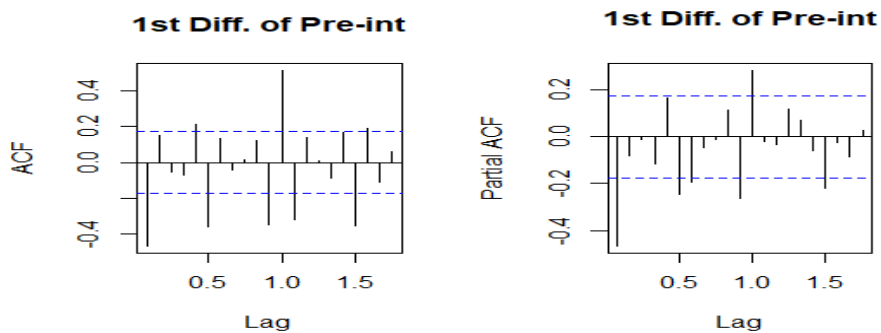


Fig. 4. ACF and PACF Plots of First Difference of Pre-intervention

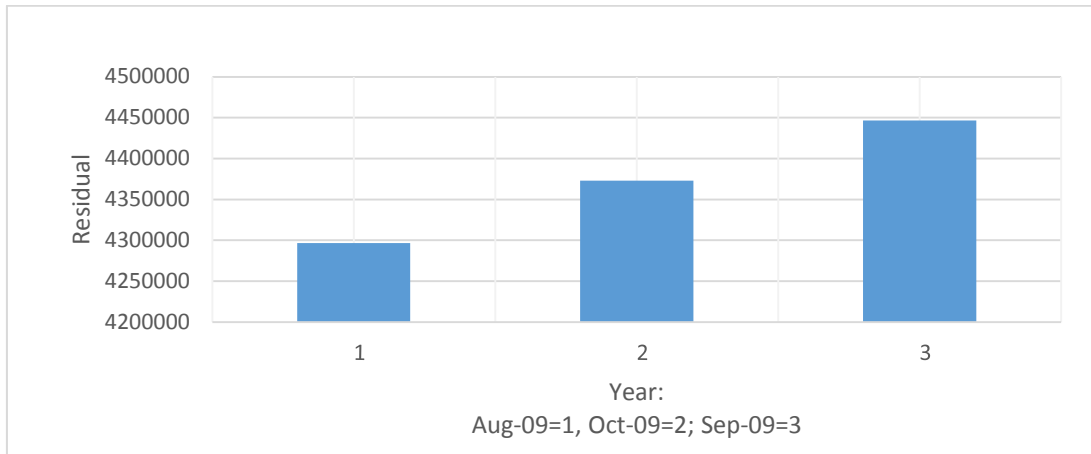


Fig. 5. Impulse response function

Appendix II

Table 1. Unit root test

ADF TEST Before 1st Differencing	ADF TEST After 1st Differencing
Data: Pre-intervention Series	Data: 1 st Diff. Pre-intervention Series
Dickey-Fuller = -2.8455,	Dickey-Fuller = -4.7292,
Lag order = 5, p-value = 0.2251	Lag order = 4, p-value = 0.01
Alternative hypothesis: stationary	Alternative hypothesis: stationary

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

Parameter	Estamte	Std.Error	Z-value	P-value
MA(1)	-0.1854	0.0969	-1.9137	0.05566
SAR(1)	-0.5603	0.0989	-5.8434	5.115e-09***
mSAR(2)	-0.4707	0.0920	-5.1187	3.076e-07***
BIC	3747.345			
AIC	3736.401			

Table 3. Parameter estimation for the full intervention model

Parameter	Estamte	Std.Error	Z-value	P-value
MA(1)	-0.2620	0.0663	-3.9481	7.878e-05***
SAR(1)	-0.6668	0.0608	-10.9481	<2.2e-16***
SAR(2)	-0.3914	0.0606	-6.4622	1.032e-10***
Impact(ω)	0.0483	0.02519	1.9193	0.0549
Slope(δ)	0.8339	0.1142	7.3031	2.812e-13***
Deley(b)	2			

Table 4. Ljung-Box Test for ARIMA and ARIMA-INTERVENTION Models

ARIMA(0,1,1)(2,1,0)[12]	ARIMA-INTERVENTION(0,1,1)(2,1,0)[12]
Q* = 11.294, df = 21, p-value = 0.9567	Q* = 23.635, df = 19, p-value = 0.2105
Model df: 3. Total lags used: 24	Model df: 5. Total lags used: 24

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