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Autoregressive Integrated Moving Average with Exogenous Variable (ARIMAX) Model for Nigerian Non Oil Export

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Abstract
This study specifically fitted an appropriate ARIMAX model for the Nigerian non-oil export using exchange rate (in dollars) as the exogenous variable by adopting the Box-Jenkins iterative three-stage modelling approach – identification, estimation and diagnostic checking. The time plot of the two series at level showed that the mean and variance are not constant but variant with time. The Augumented Dickey-Fuller (ADF) tests confirmed both series are non stationarity hence the two series were differenced once. Results of the unit roots tests in the first difference rejected the null hypotheses at 5% level of significance of non stationarity after first difference. The Autocorrelation function (ACF) and Partial autocorrelation function (PACF) combined patterns suggested AR(2) and MA(6) respectively. By comparing their various Akaike information criteria (AIC), the parsimonious model was estimated as ARIMAX (2,1,5). The goodness of fit test confirmed the adequacy of the estimated model. All the roots of the estimated ARIMAX process lie inside the unit circle. The plots of the residuals are mostly uncorrelated, the actual and the fitted agreed very closely. In addition, Q-statistics and LM test both indicate serial non-correlation. Result from the estimated model implies that exchange rate has no impact on Nigerian non-oil as exchange rate failed to be significant.
Keywords: Non-oil export, ARIMAX model, exogenous variable.

Introduction

There are lot of methods and techniques used to analyze time series. One of the most used is the methodology introduced by Box and Jenkins in 1970, based on autoregressive integrated moving average (ARIMA) model. This method uses past data of univariate time series to analyze its own trend and forecast future cycle. Despite the effectiveness of ARIMA model to study time series, it applies only to one variable and it does not depict some turning points in the data and also could not convey relationships among variables well in the system. Hence the need for a statistical model that will capture external disruptions that may likely impact on the model. More so, Nigerian non oil export had a rubicund record contribution of up to 80% of the gross domestic product as well as providing employment for over 70% of the working population. All of these have changed due to a steady decline in non oil export; hence the need to investigate the role exchange rate plays on this decline.

In the last decades few methods have being proposed to model Nigerian non oil export, this work will concentrate its effort on well established time series method of a linear combination of past observed points and errors, extended by considering another time series as a forcing (external) input, also referred to as exogenous variable which usually shows an influence on the predictand to produce a model.

The ARIMAX model, first discussed by Box and Tiao in 1975, has the capacity to identify the underlying patterns in time series data and to quantify the impact of environmental influences. This provides the model with the capacity to isolate the influences of high impact changes of external type e.g. the economy, government policies and regulations etc as well as internal type e.g product rebranding, set target advances etc.

So far, there have been no studies in the field of non oil export modelling using ARIMAX. But some of such relevant study has been done in other fields besides non oil export. For instance, Durka and Pastorekova (2012), conducted a study to test which approach is better between ARIMA and ARIMAX in the analysis and forecast of macroeconomic time series in Slovakia. By applying Box – Jenkins modelling approach using Gross Domestic Product (GDP) per capita as an output series and unemployment rate as an input series, the ARIMAX model as fitted explained 92.7% of the variability in GDP. Tsingotis and Vlahogranni (2012), examined how information on weather affects the performance of short-term traffic forecasting models. Using several vector ARMAX models to evaluate effects of weather and traffic mix on the predictability of traffic speed, they concluded that inclusion of exogenous variables in the forecasting models marginally improved their prediction performance while modelling innovations such as vector and Bayesian estimation improves the model significantly. Akouemo and Povinelli (2014) used an algorithm which combines two statistical techniques ARIMAX and Hypothesis testing for the detection and imputation of outliers in time series data. By focusing on the distribution by the residuals, the time series characteristics of the data set are formed and the outlier detected. Results showed that outliers generally affect the estimation of the parameters of a time series data set and that removing them provides improvement to the forecasting model. Hamjah (2014) measured the climatic and hydrological effects on cash crop production in Bangladesh. Using these factors as input variables showed that climatic effects have significant effects on crops production. Wangdi, et al (2010), used ARIMA model to forecast the number of cases of malaria in endemic areas of Bhutan and further employed the ARIMAX model to determine the predictors (meteorological factors). Their findings generally revealed that the mean maximum temperature lagged at one month was a strong positive predictor of an increased malaria cases for four out of seven districts under study. De Felice, et al (2013), in forecasting electricity demand over Italy using numerical weather prediction models, the results obtained with ARIMAX outperformed the ARIMA and other considered models especially with accurate initial conditions. Some works has been done on Nigeria non oil export using methods other than ARIMAX. For instance, Ekesiobi et al (2016), investigated the relationship between the non oil exports and foreign reserves. Using the ordinary least square, findings revealed a weak positive relationship between non oil export and foreign reserves therefore implying that non oil plays no significant part in determining the level of foreign reserve in Nigeria. Onodugo et al, (2013) in another study examined the impact of non-oil export trade on economic growth in Nigeria. Using the long run regression model based on the Augmented Prediction Function it was concluded that the non oil export although statistically significant and positive variable, had infinitesimal level of contribution in stimulating growth of Nigeria economy. Imoughele and Mohammed (2015), examined the impact of exchange rate on Nigerian non oil exports using ordinary least square statistical technique. The result showed that depreciation in exchange rate has no robust effect on Nigeria non-oil export.

The purpose of this work is to use ARIMAX model to investigate the relationship between non oil export and exchange rate over time. This is in agreement with the major goal of Non oil export modelling, which is to get a more accurate estimate that can be applied in developing better informed policies. Specifically, the ARIMAX model will be used to test the relationship between non oil export and exchange rate.

2. Material and method.

2.1 Data

Two sets of monthly data namely- Nigerian Nonoil export data and Exchange rate (in $) data both covering a period from January 1996 to September 2015 are used for this analysis. Both sets of data are sourced from National Bureau of Statistics (NBS).

2.2 Statistical Data Analysis Tool

This work used a statistical package - Eviews 8 for the data analysis. Both the non-export data and the exchange rate (in $) data were fed into the package and most of the results used for this work were obtained.

2.3 ARIMAX model

The ARIMAX model is an extension of Autoregressive Integrated Moving Average (ARIMA) model. The ARIMA model has three parameters namely; p, d and q, where p is the autoregressive term, q is the moving average term and d indicated the series is differenced to make it stationary. An ARIMA (p,q) model is states as follows:

$$\Phi(L).\Delta^d y_t = \theta(L)\varepsilon_t \quad (1)$$

where

$\Phi(L)$ is the autoregressive polynomial expressed as;

$$\Phi(L) = (1 - \Phi_1 L^1 - \Phi_2 L^2 - \cdots - \Phi_p L^p). \quad (2)$$

And $\theta(L)$ is called the moving average polynomial expressed by;

$$\theta(L) = \left(1 - \theta_1 L^1 - \theta_2 L^2 - \cdots - \theta_q L^q\right) \quad (3)$$

y_t, is the dependent variable in period t, Δ^d denotes the difference from d degree and finally, ε_t is the white noise process. By adding the leading indicator to equation (1), we have;

$$\Phi(L).\Delta^d y_t = \varphi(L)X_t + \theta(L)\varepsilon_t \quad (4)$$

Where $\varphi(L) = (1 - \varphi_1 L^1 - \varphi_2 L^2 - \cdots - \varphi_r L^r)$ (5)

X_t is the exogenous variable at time t.

The equation (4) is the general form of ARIMAX (p,d,q) model.

3. ARIMAX model fitting

The ARIMAX model follows the Box-Jenkins iterative three-stage modelling approach and this research strictly adopts this approach namely; identification, estimation and diagnostic checking. A visual inspection of the time plots of the two series revealed some important feature like the upward and downward movement at least inconclusively. This provided useful information concerning outliers, missing values and structural breaks in the data to ensure the time series is stationary. Regressions with non stationary series are spurious and analyses are not valid. For this work, we test if there is stationarity by applying the **Augmented Dickey-Fuller** (ADF). Visually examining the autocorrelation function (ACF) and partial autocorrelation function (PACF) combined patterns should reveal some important features at least inconclusively which should help to identify the orders of AR and MA parameters of the model. At the estimation stage, each of the selective models is estimated and the various coefficients examined. The suggestive models are compared using the Akaike information criterion and the most adequate model is selected.

3.0 Results and Discussion

The time plots of the non-oil export (NONOL) and that of exchange rate in dollars (DEXRATE) shown in figures 1 and 2 respectively revealed a highly volatile pattern. The NONOL in figure 1 showed a slow but gradual movement over a period of time. The period from 1996 through to 2001 recorded no rise. Gradual upward and downward fluctuation began in 2002 through to 2009, with sudden rapid rise and fall from 2010, an indication that the mean and variance are time variant. EXRATE on the other hand showed constant trend from 1996 to 1998 and a rapid fluctuation thereafter.

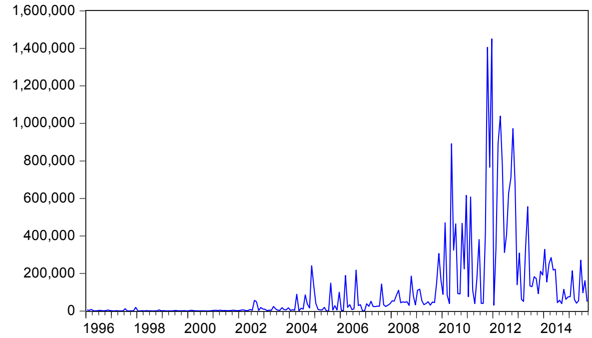

Figure 1:Time Plot of Non oil data NONOL.

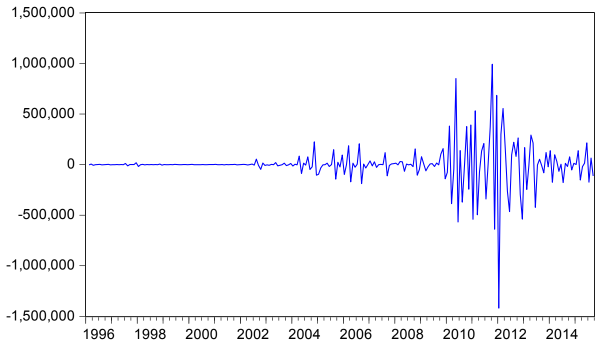

Figure 2:Time Plot of differenced Non oil data DNONOL

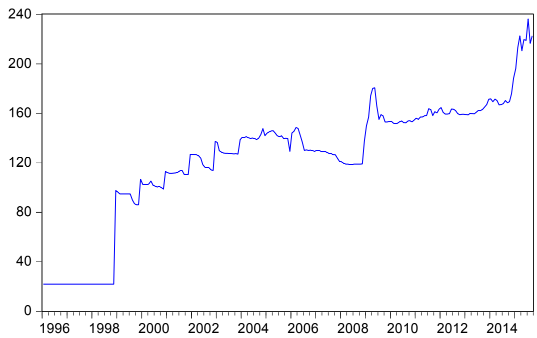

Figure3:Time Plot of Exchange rate data(EXRATE)

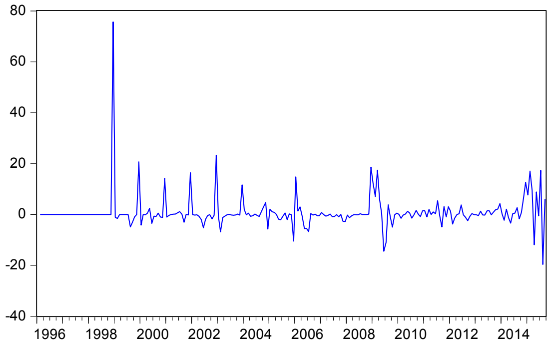

Figure 4:Time Plot of Differenced Exchange rate data DEXRATE

The ADF test considers both NONOL (p-value=0.1218) and EXRATE (p-value=0.7188) both values judged at 0.05 level of significant, as non-stationary.

A first differencing of NONOL and EXRATE yield series DNONIL (with p=0.0000) figure 2 and DEXRATE (with p=0.0000) in figure 4 respectively showing stationarity.

The ARIMAX model shows the effect of EXRATE (input variable) on NONOL. The Autocorrelation function (ACF) patterns suggested autoregressive model up to order 2 i.e. AR(2) while the Partial autocorrelation function (PACF) suggested a moving average up to order 6 ,MA(6). By comparing these suggestive models using Akaike information criteria (AIC), the parsimonious model was estimated as ARIMAX (2,1,5).

Table 1 : ARIMAX Estimate for NONOL with EXRATE(X) as exogenous variable

Dependent Variable: D(NONOL)

Method: Least Squares
Sample (adjusted): 1996M04 2015M09
Included observations: 234 after adjustments
Convergence achieved after 287 iterations
MA Backcast: 1995M01 1996M03

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	29.93921	8621.728	0.003473	0.9972
X	3.706650	65.02456	0.057004	0.9546
AR(1)	0.114367	0.035083	3.259911	0.0013
AR(2)	-0.889061	0.029998	-29.63720	0.0000
MA(1)	-0.801666	0.046148	-17.37144	0.0000
MA(2)	1.010827	0.014273	70.81965	0.0000
MA(3)	-0.770710	0.043102	-17.88099	0.0000
SMA(12)	0.195741	0.066942	2.924031	0.0038

R-squared	0.377843	Mean dependent var	176.3607
Adjusted R-squared	0.358573	S.D. dependent var	198824.5
S.E. of regression	159236.8	Akaike info criterion	26.82776
Sum squared resid	5.73E+12	Schwarz criterion	26.94589
Log likelihood	-3130.848	Hannan-Quinn criter.	26.87539
F-statistic	19.60750	Durbin-Watson stat	1.933301
Prob(F-statistic)	0.000000		

The probability of the variable X at 0.05 (p-value = 0.9546) failed to be significant, this is an indication that exchange rate does not impact Non-oil export.

The result of the group unit test in figure 5 shows the roots of the characteristics polynomial revealing that no root of the estimated model lies outside of the unit root circle, an indication that the model satisfied the stability condition.

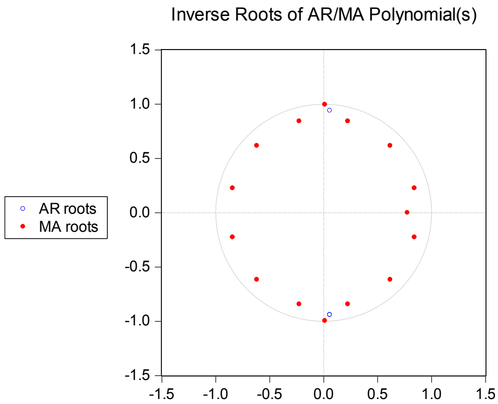

Figure 5: Roots of Characteristics Polynomial

The plot of the actual and the fitted in figure 6 agree very closely and so are mostly uncorrelated thereby meeting white noise assumptions. The plots of the Q-statistics became insignificant at most lags, the Serial Correlation LM test in Table 2, taken up to lag 2 is insignificant (p-value = 0.7578) accepting the hypothesis of no serial correlation up to order two. Thus, the Q-statistics and the LM test both indicate that the residuals of the estimated model are serially uncorrelated, consequently, the model specifications are adequate, an indication that the model is very adequate.

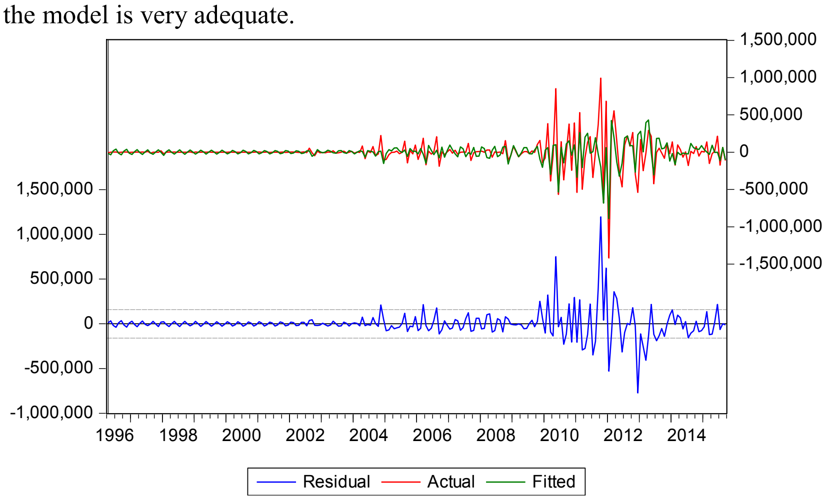

Figure 7: Graph of Actual, Fitted and Residuals.

Table 2. Serial Correlation Test Table

Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	0.277687	Prob. F(2,224)	0.7578
Obs*R-squared	0.578648	Prob. Chi-Square(2)	0.7488

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