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Time series modelling for forecasting artisanal fish production in Nigeria

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Keywords

ARIMA model, forecasting, Artisanal Fish production.

Abstract

Forecasting of Artisanal fish production is a need for planning purposes and import policy of fish should be based on such forecasts. The objectives of this study are to investigate the past, present and future trends of Artisanal fish production in Nigeria and to develop a time series model to detect the long term trend and prediction for future changes of Artisanal fish production for the five leading years. Autoregressive Integrated Moving Average (ARIMA) was used to fit the data set which is complementary to the approach and forecasting of the concerned variable to the near future. Time series forecasting analysis utilized the secondary data of the Food Agriculture Organization for the period of 1970 to 2015. Non-stationarity in mean was corrected through differencing of the data of order 1. ARIMA (1, 1, 0) was the most suitable model used as this model has the lowest AIC and BIC values. The Mean absolute Percentage Error (MAPE) for Artisanal Fish production was 15.1. The forecasts for Artisanal fish production during 2016 to 2020 were 516,352.5, 526,603.5, 536,854.6, 547,105.7 and 557,356.7 Mt tones respectively. This model can be used by researchers for forecasting of Artisanal fish production in Nigeria .

Introduction

Fisheries and Aquaculture are important sources for food and livelihoods for people along the world's seashores and waterways (Smith etal, 2010a) and influence the livelihoods for more than one billion people. Fisheries as a subsector occupy a unique position in the agricultural sector of the Nigerian economy. Nigeria's fisheries sector is made up of capture fisheries and aquaculture. Capture fisheries encompasses both marine and inland fisheries. Available fish statistics indicate that overall fish production from captured fisheries has increased by roughly 57% over the years, from 320,955 metric tons in 1995 to 1 027 000 tonnes, metric tons in 2015 to which marine catches contributed 36 percent, inland waters catches contributed 33 percent and aquaculture 31 percent. Fishery sector contributed to 0.5 percent of national GDP in 2015.

Fish is an important source of protein especially in developing countries. Fish accounts for 20 percent of animal derived protein in low-income, food deficit countries compared with 13 percent in the industrialize countries (L. Christopher *et al*.,2002). Despite the rapid growth in fish production in Nigeria, the level of per capita consumption is still much lower than the actual requirement. Hence, the expansion of fish demand is likely to continue for some more years. The consumption of fish such as carps and other low-valued fish have shown a higher rate over the recent past. Accordingly, adequate supply of these low valued species is needed to cope with the requirement for the present and the future as well. Rapid population growth along with increase in income level and average per capita fish consumption leads to soaring demand for food fish production in Nigeria. Though production from capture fisheries has leveled off, production of fish from aquaculture has exploded in past 5 years as evidenced from the time series data of FishStat Plus, FAO. But, the question arises whether sufficient quantity from aquaculture would be produced to meet the anticipated requirement of people during the next 10 years . From the declining growth rate in capture fisheries for the period from 1970 to 2015 compared to that of aquaculture, it is presumed that the estimated production from capture fisheries in 2020 will be less than aquaculture production. Over exploitation of capture fisheries and its declining growth rate suggest for projection of fish production from capture fisheries. The production of high value shrimps always supports for export earnings Nigerian marine sector has been on the downward slope for a number of years, most markedly in the industrial shipping sector, where the numbers of fishing trawlers and boats have reduced significantly. Artisanal fishing within the inland waterways also show signs of decline since the river systems are now over-exploited due to obnoxious capture fishing methods which include the use of undersized nets, chemicals, dynamites and destructions of nursery grounds. Nigeria's river system cannot therefore sustain any serious agri-business in capture fisheries to meet the burgeoning fish demand of the country's growing populace. Consequently, aquaculture has been rapidly expanding to meet the demand shortfall caused by capture fisheries.

Fisheries and aquaculture have been of great importance to a nation economy in the areas of fish production, raw materials to industries, employments, household and other purposes.

The present study was undertaken with the following objectives:

i. To estimate growth trends in artisanal fish production.
ii. To forecast artisanal fish production for the period 2015 through 2020.
iii. To suggest policy measures for increasing capture fishing production in Nigeria

Literature Review

Raymond Y.C. Tse, (1997) suggested that the following two questions must be answered to identify the data series in a time series analysis: (1) whether the data are random; and (2) have any trends? This is followed by another three steps of model identification, parameter estimation and testing for model validity. If a series is random, the correlation between successive values in a time series is close to zero. If the observations of time series are statistically dependent on each another, then the ARIMA is appropriate for the time series analysis.

Meyler et al (1998) drew a framework for ARIMA time series models for forecasting Irish inflation. In their research, they emphasized heavily on optimizing forecast performance while focusing more on minimizing out-of-sample forecast errors rather than maximizing in-sample 'goodness of fit'.

Stergiou (1989) in his research used ARIMA model technique on a 45years' time series data (from 1964 to 1980 and 204 observations) of monthly catches of pilchard (Sardina pilchardus) from Greek waters for forecasting up to 12 months ahead and forecasts were compared with actual data for 1981 which was not used in the estimation of the parameters. The research found mean error as 14% suggesting that ARIMA procedure was capable of forecasting the complex dynamics of the Greek pilchard fishery, which, otherwise, was difficult to predict because of the year-to-year changes in oceanographic and biological conditions.

Materials and Methods

Time series data for the years 1970-2015 were used for the present study. The data were collected from the Food and Agriculture Organization Website (www.fao.org). Log Linear Model was used for estimating growth trends (Gujrati, 2003).

The equation used is:

$$LnX_t = b_0 + b_1T + u_t$$

Where: X_t is the aquaculture Production of in year t and T is a trend variable. The growth rate, which we get from this equation, will be instantaneous (r) (at a point in time). The compound growth rate (over a period of time) (R) for aquaculture will be estimated by taking anti-log of X_t, i.e., X_t = antilog ($b_0 + b_1t$).

Given the type of data, nature of research and reliability of forecast, ARIMA model was selected from amongst available time series models for forecasting artisanal fish production.

Time series data for this study were collected from Food Agricultural Organistion (FAO). Box and Jenkins (1976) linear time series model was applied. Auto Regressive Integrated Moving Average (ARIMA) is the most general class of models for forecasting a time series. Different series appearing in the forecasting equations are called "Auto-Regressive" process.

Appearance of lags of the forecast errors in the model is called "moving average" process. The ARIMA model is denoted by ARIMA (p,d,q), where "p" stands for the order of the auto regressive process, 'd' is the order of the data stationary and 'q' is the order of the moving average process. The general form of the ARIMA (p,d,q) can be written as described by Judge, *et al*. (1988).

Δdyt =δ+θ1 Δdyt-1+θ2 Δdyt-2+----- + θpyt-p+et-lα et-1-α2 et-2 αqe t-2 (1)

Where, Δd denotes differencing of order d,i.e., Δyt = yt-yt-1, Δ2yt=Δyt-Δt-1 and so forth, Y t-1 ----- yt-p are past observations (lags), δ,θ1 -------- θp are parameters (constant and coefficient) to be estimated similar to regression coefficients of the Auto Regressive process (AR) of order "p" denoted by AR (p) and is written as

Y = δ+θ1 y t-1+θ2 y t-2 + ---------- + θpy t-p +et (2)

Where, et is forecast error, assumed to be independently distributed across time with mean θ and variance θ2e, et-1, et-2 ------ et-q are past forecast errors, α1, ---------- αq are moving average (MA) coefficient that needs to be estimated.While MA model of order q (i.e.) MA (q) can be written as

Yt = et-α1 αt-1 - α2et-2 ------------- αqet-q (3)

The major problem in ARIMA modeling technique is to choose the most appropriate values for the p, d, and q. This problem can be partially resolved by looking at the Auto correlation function (ACF) and partial Auto Correlation Functions (PACF) for the series (Pindyk &Rubinfeld, 1991). The degree of the homogeneity, (d) i.e. the number of time series to be differenced to yield a stationary series was determined on the basis where the ACF approached zero.

After determining "d" a stationary series Δd yt its auto correlation function and partial autocorrelation were examined to determined values of p and q, next step was to"estimate" the model. The model was estimated using computer package "E-view9.5".

Results and Discussion

Growth Trends

Growth trends were estimated by employing log linear Model:

$LnX_t = b_0 + b_1T + u_t$

Where: $\mathbf{X_t}$ is aquaculture Production in year t and T is a trend variable.

$LnX_t = 11.3758 + 0.0406T$

S. E = (0.0406) (0.0030)

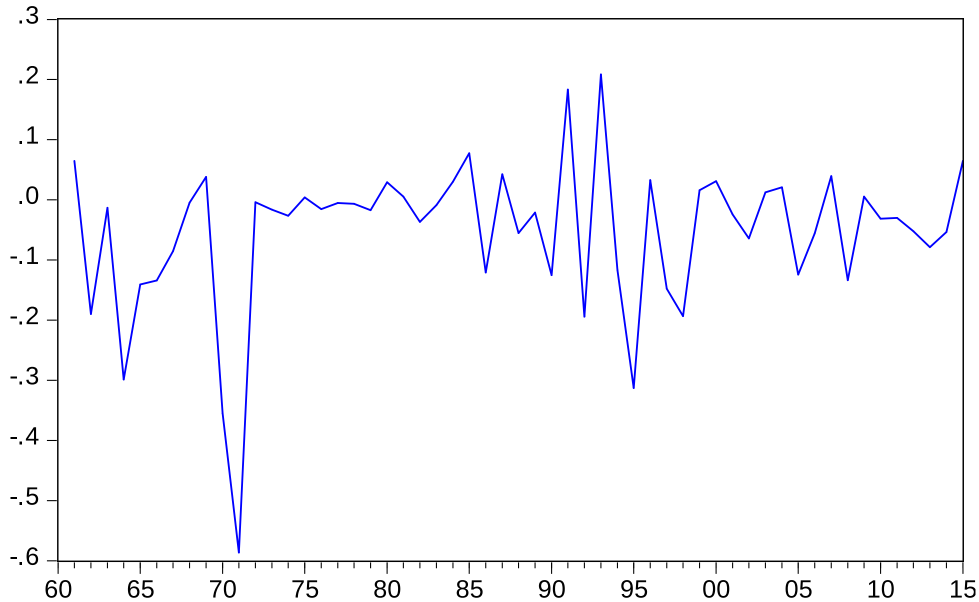
t =(139.8728) (13.4727)

R^2 = 0.81

Growth rate (r) =4.06%

The result illustrate that artisanal fish production grew at a rate of 4. 06% for the period of 1970 -2015. The Standard Error (SE) of the slope coefficient was 0.003**,** which is very low and confirms reliability of results. Estimated coefficients were found significant at one percent level of significance. The calculated value of R^2 was 0.81 which shows that 81% regressand (Xt) is explained by the regressor (t), thereby confirming reliability of the estimated model.
Figure 1

GROWTH OF ARTISANAL PRODUCTION



Forecasting of Artisanal fish Production

Time series data for the period, 1970-2015 was analyzed by employing ARIMA model in four steps (Box and Jenkins, 1970). Correlogram of the first differenced series ("d") showed appropriate stationary behaviour than the second differenced series ("d"). The selected value of 'd' was '1'. The selected value of parameters 'p' and 'q' were also found '1' and '0' respectively. As such, ARIMA (1,1, 0) model was selected and estimated, by using E –View soft ware.

Augmented Dickey – Fuller (ADF) unit root test was applied to confirm reliability and fitness of the selected model. The absolute value of ADF test statistic (7.65135) was found greater than the critical values at both 1% (3.5885) and 5% (2.9297) levels of significance. This established that time series was stationary for the ARIMA (1, 1, 0). Hence, ARIMA (1, 1, 0) was found as the best fit for forecasting.

Forecasts for artisanal production (with 95% confidence intervals) were generated by using ARIMA (1, 1, 0`) model for the period 2015 to 2020.

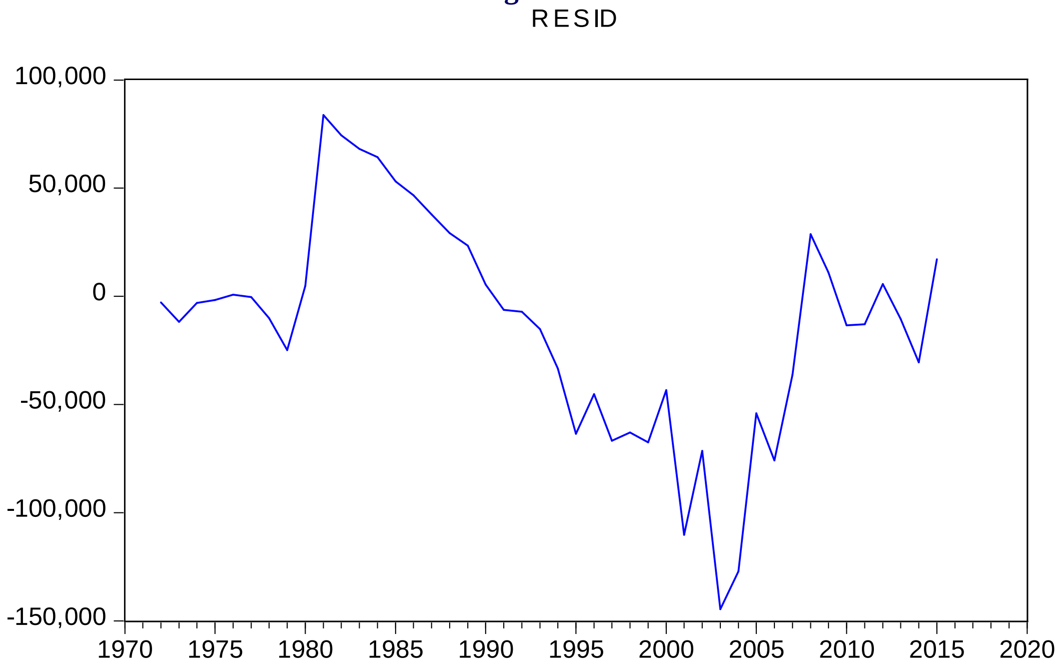
Table 1 : Estimation Model ARIMA (1,1,0)

Method: ARMA Maximum Likelihood (OPG - BHHH)

Sample: 1971 2015
Included observations: 45
Convergence achieved after 5 iterations
Coefficient covariance computed using outer product of gradients

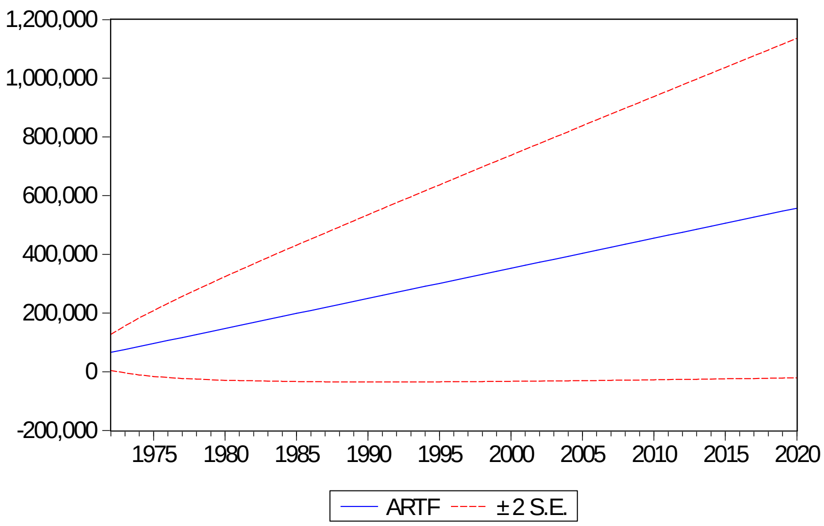
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	10251.06	4643.691	2.207524	0.0328
AR(1)	-0.189536	0.179878	-1.053688	0.2981
SIGMASQ	8.34E+08	1.40E+08	5.937101	0.0000

Figure 2



Forecasting

In figure 3: we represent the criteria for the forecasting of the model ARIMA(1,1,0)



Forecast: ARTF	
Actual: ART	
Forecast sample: 1970 2020	
Adjusted sample: 1972 2020	
Included observations: 44	
Root Mean Squared Error	52110.52
Mean Absolute Error	38804.09
Mean Abs. Percent Error	15.11695
Theil Inequality Coefficient	0.085307
Bias Proportion	0.068260
Variance Proportion	0.047590
Covariance Proportion	0.884150

The results in figure above indicate that the inequality of Theil coefficient has a low value of U =0.085 which means that our model have a good forecasting ability .

Table 2 : The Artisanal Fish Production Forecasts

Years	Fish
2016	516352.5
2017	526603.5
2018	536854.6
2019	547105.7
2020	557356.7

Forecast Using ARIMA (1,1,0)

The observed and the predicted values of artisanal fish production along with percentage deviation are presented in appendix.

Conclusion

The trend analysis of the artisanal fish production showed an increasing production but the growth rate trend shows decreasing rate, this may be attributed to overexploitation of the resources due to overfishing. Box- Jenkins technique was employed in this paper to forecast the Artisanal fish production in Nigeria for the period of five years with an ARIMA model.

This study made the best endeavor to develop the best ARIMA model to efficiently forecasting the Average annual artisanal fish production. The empirical analysis indicated that the ARIMA (1,1,0) model is best for forecasting the Average artisanal fish production data series as far as the diagnostic criteria are concerned.

Finally, Time series forecasting analysis utilized the secondary data of the Food Agriculture Organization for the period of 1970 to 2015. Non-stationarity in mean was corrected through differencing of the data of order 1. ARIMA (1, 1, 0) was the most suitable model used as this model has the lowest AIC and BIC values. The Mean absolute Percentage Error (MAPE) for Artisanal Fish production was 15.1. The forecasts for Artisanal fish production during 2016 to 2020 were 516,352.5, 526,603.5, 536,854.6, 547,105.7 and 557,356.7 Mt tones respectively.

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Appendix

Period(t)	Artisan fish production	Forcasted artisan fish production	Residual
1970	56505		
1971	52837		
1972	62869	65726.22	-2857.22
1973	63703	75477.25	-11774.3
1974	82740	85823.09	-3083.09
1975	94376	96056.18	-1680.18
1976	107016	106310.6	705.3535
1977	116155	116561.1	-406.061
1978	116696	126812.2	-10116.2
1979	112237	137063.3	-24826.3
1980	152090	147314.3	4775.657
1981	241303	157565.4	83737.6
1982	242211	167816.5	74394.54
1983	246186	178067.5	68118.48
1984	252706	188318.6	64387.42
1985	251640	198569.6	53070.36
1986	255498	208820.7	46677.3
1987	256849	219071.8	37777.24
1988	258506	229322.8	29183.18
1989	262971	239573.9	23397.12
1990	255265	249824.9	5440.063
1991	253849	260076	-6227
1992	263156	270327.1	-7171.06
1993	265470	280578.1	-15108.1
1994	257414	290829.2	-33415.2
1995	237461	301080.2	-63619.2
1996	266117	311331.3	-45214.3
1997	254806	321582.4	-66776.4
1998	268883	331833.4	-62950.4
1999	274609	342084.5	-67475.5
2000	308981	352335.5	-43354.5
2001	252340	362586.6	-110247
2002	301327	372837.7	-71510.7
2003	238409	383088.7	-144680
2004	266202	393339.8	-127138
2005	349482	403590.8	-54108.8
2006	337993	413841.9	-75848.9
2007	387923	424092.9	-36169.9
2008	463024	434344	28679.99

2009	455628	444595.1	11032.93
2010	441377	454846.1	-13469.1
2011	452146	465097.2	-12951.2
2012	481056	475348.2	5707.753
2013	475162	485599.3	-10437.3
2014	465251	495850.4	-30599.4
2015	523182	506101.4	17080.57

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