Reviving of Nigerian Rubber Industry through Export Potential Enhancement

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Abstract: *The need to shore-up the continuous widening gap of the nation's revenue owing to dwindling oil price has forced the Nigerian government to start looking towards non-oil products especially agricultural cash crops for foreign exchange earnings. Since agriculture was the mainstay of the Nigerian economy before the oil boom, the need to look into this sub-sector to keep the nation's economy afloat becomes a sine-qua-non. It is in view of this thrust that the present research intends to chart a course towards examining the potential of reviving the rubber sub-sector, being an important cash crop with high economic demand in the world. The research used dated data that spanned from 1961 to 2017 and it covered production, area, yield and producer's price (rubber). The data were sourced from the FAO database and analyzed using both descriptive and inferential statistics. Empirical evidence showed that the incremental change in the country's rubber production in Nigeria was majorly driven by area expansion which could be used for other purposes. Therefore, the future of the sub-sector is not promising to owe the fact that the slight gentle rise in the forecasted production trend will be driven by a gentle incremental rise in the annual production area while the level of productivity decreased year to year. The decrease in the forecasted annual yield levels is as a result of non-productive income and not technology. This is because the farmers are at the mercy of the Licensed Buyers (LBs) who exploit the producers through adopting collusive effects rather than to allow the market forces to determine the prevailing market price. The Licensed Buyers also served as the major link to the exporting markets. Therefore, the study recommends the establishment of farmer`s co-operative organizations so as to venture into export marketing and to increase their bargaining power. Moreover, both governmental and non-governmental organizations should facilitate viable export market linkages to these farmers' co-operatives. Furthermore, viable governmental policies should be framed to make the rubber market competitive for farmers, middlemen, local and international industrial consumers in the value chain.*

Keywords: Acreage response, Nigeria, Production forecast, Production instability, Rubber

1. Introduction

Today little is heard about foreign exchange earnings from the three major cash crops viz. palm oil, groundnuts and rubber which Nigeria was a leading exporter (SENCE Agric, 2020). Even though rubber plantation is one of the resources that thrive well in Nigeria, policy inconsistency of successive governments had neglected the sub-sector which used to be the fourth-largest source of foreign exchange earnings after crude oil, palm oil, and groundnut (Umar *et al*., 2011; Ogbebor, 2013; Mesike and Esekhade, 2014; Agbota, 2017). The mono-economy-sole dependence on crude oil has rendered this industry unattractive. In addition, the research institutes mandated to develop improved seed varieties have also gone comatose and even most of the existing plantations are old as they were established in the 1960s (Agbota, 2017). Besides, the dearth of modern equipment necessary for value addition of international standard has been attributed to be responsible for the decline in rubber production as argued by the stakeholders (SENCE Agric, 2020).

Due to the failure to replenish the old plantation and establish new ones, Agbota (2017) reported that experts have opined that the capacity of the country's rubber industry has plummeted from well above 130,000 MT per annum to between the ranges of

55,000 and 60,000 MT. Thus, the country`s export capacity has nosedived from about 100,000 MT per annum to between 60,000 and 80,000 MT, representing approximately a reduction by 40% to 20%, respectively (Ambrose, 2018). Furthermore, Ambrose (2018) reported that the exit of the global giants Michelin and Dunlop companies from Nigeria was the highpoint of the decline in the rubber industry. The rubber industry at its peak stage created over 54 companies while currently; only less than 20 companies are working in the sector (Ambrose, 2018).

Rubber as a cash crop is at the verge of extinction due to the neglect by the government despite being one of the most important inputs in virtually every industry. This caused the country colossal annual revenue losses of approximately $6 billion in the international market (Agbota, 2017). Rubber is regarded as a money-spinner in some countries due to its high demand for various purposes ranging from engineering, aviation, education, sports, health etc. The rate at which the automobile industry is mopping up natural rubber around the world explains how highly invaluable it is inhuman activities. Dependency on oil may not sustain the economy of a country where the price will continue to dampen (Mesike and Esekhade, 2014; Pro-share, 2017). In view of these, agriculture needs to be given desirable attention to be able to sustain the economy. In this regard, some countries are shifting from hydrocarbon- eco-unfriendly to green energy-eco-friendly approach (Agbota, 2017). Therefore, it is very imperative for the country to embark on large-scale cultivation of rubber to sustain the economy when the oil fails.

It is on this thrust that the present research was conceptualized with the aim of charting a pathway for the revival of the sub-sector with a view of exploring the economic potential of rubber commodity for national development. Revitalization of the neglected sector has the potential to drive the Federal Government's on-going economic diversification, job creation for the various stakeholders along the value chain and to spur industrialization. The specific objectives were to determine the trend and growth patterns of rubber production; determine the extent and sources of instability in rubber production; determine the sources of change in the average production; determine the factors influencing farmers' acreage response; and, to forecast the future production trend of rubber in the studied area.

2.   Materials and Methods

Nigeria lies between latitudes 4′ to14′ N and longitudes 2′ to 15′ E of the Greenwich meridian time (CIA, 2011). It has a vast area of land with suitable prevailing agro-climatic conditions for the production of various agricultural purposes viz. livestock, fisheries, crop production etc. The country has abundant untapped potential human and environmental resources.

The study used time series data which ranged for 56 years (1961-2017) and it covered production, area, yield and producer's price (rubber). The data were sourced from the FAO database and analyzed using both descriptive and inferential statistics. For better understanding, the study was categorized based on three economic reforms in the country viz. pre-Structural Adjustment Period (pre-SAP) (1961-1984), SAP (1985-1999) and post-SAP (2000-2017). The trend and growth pattern were determined using descriptive statistics and growth model while the extent and source of instability in the production were determined using instability indexes viz. coefficient of variation (CV), Cuddy-Della Valle index, Coppock's index and Hazell's variance decomposition model. Changes in average production and farmers' acreage response were determined using Instantaneous change and Hazell's average decomposition; and Nerlove's Adjustment models, while the Autoregressive Integrated Moving Average (ARIMA) model was used to forecast the future rubber production trend.

2.1. Empirical Model
2.1.1. Growth rate
The compound annual growth rate was calculated using the exponential model as indicated below:

$$\gamma = \alpha\beta^t \qquad [1]$$
$$ln\gamma = ln\alpha + tln\beta \qquad [2]$$
$$CAGR = [Antilog\beta - 1] \times 100 \qquad [3]$$

Where,
    CAGR is compound growth rate

t = time period in a year
γ = *area/yield/production*
α = *intercepting*
β = *estimated* parameter coefficient

2.1.2. Instability index

Coefficient of variation (CV), Cuddy-Della Valle Index and Coppock's index were used to measure the variability in the production, area and yield of rubber. Following Sandeep *et al*. (2016) and Boyal *et al*. (2015), the CV was calculated using the formula below.

$$CV(\%) = \frac{\sigma}{\bar{X}} * 100 \qquad [4]$$

Where,

σ = *standard deviation*
$\bar{X}$ = *mean value of area, yield production*

The simple CV overestimates the level of instability in time series data characterized by long-term trends, whereas the Cuddy-Della Valle Index corrects the coefficient of variation by instability index as it de-trend the annual production and show the exact direction of the instability (Cuddy-Della Valle, 1978). Thus, it is a better measure to capture the instability of agricultural production and prices using the formula indicated below.

$$CDII = CV*(1-R^2)^{0.5} \qquad [5]$$

Where,

CDII = Cuddy-Della instability index
CV = Coefficient of variation
R^2 = coefficient of multiple determination

Following Shimla (2014) as adopted by Umar *et al*. (2019), the instability index was classified as low instability (≤20%), moderate instability (21-40%) and high instability (>40%).

Unlike a CV, Coppock's instability index gives a close approximation of the average year-to-year percentage variation adjusted for trend (Ahmed and Joshi, 2013; Kumar *et al*., 2017; Umar *et al*., 2019) and it measures the instability in relation to the trend in prices (Kumar *et al*., 2017). According to Kumar *et al*. (2017), a higher numerical value for the index represents greater instability. Following Coppock (1962), the algebraic economic formula used by

Ahmed and Joshi (2013), Sandeep *et al*. (2016), Kumar *et al*. (2017) and Umar *et al*. (2019) is indicated below.

$$CII = \left(Antilog\sqrt{\log V} - 1\right) * 100 \qquad [6]$$

$$\log V = \frac{\sum\left[log\frac{X_{t+1}}{X_t} - m\right]^2}{N-1} \qquad [7]$$

Where,

X_t = Area or Yield or Production in year $'t'$,
N = number of year(s)
CII = Coppock's instability index
M = mean difference between the log of X_{t+1} & X_t
Log V = logarithm variance of the series

2.1.3. Source of change in rubber production

Instantaneous change: Following Sandeep *et al*. (2016) the instantaneous decomposition analysis model used to measure the relative contribution of area and yield to the total output changes indicated below.

$$P\_0 = A\_0 \times Y\_0 \qquad [8]$$
$$P\_n = A\_n \times Y\_n \qquad [9]$$

Where

P, A and Y represent production, area and yield, respectively
The subscript 0 and n represent the base and the nth years, respectively.

$$P\_n\text{-}P\_0 = \Delta P \qquad [10]$$
$$A\_n\text{-}A\_0 = \Delta A \qquad [11]$$
$$Y\_n\text{-}Y\_0 = \Delta Y \qquad [12]$$

From equation [5] and [9] we can write
$$P\_0+\Delta P = (A\_0 + \Delta A)(Y\_0+\Delta Y) \qquad [13]$$

Therefore,
$$P = (Y\_0\ \Delta A)/\Delta P \times 100 + (A\_0\ \Delta Y)/\ \Delta P \times 100+ \Delta A\Delta Y/\Delta P \times 100 \qquad [14]$$

Production = Area effect + Yield effect + Interaction effect   [15]

Hazell's decomposition model: In estimating the change in average production and change in the variance of production between regimes and the overall period, Hazell's (1982) decomposition model

was used. Hazell's decomposed the sources of change in the average of production and change in production variance into four (Table 1) and ten (Table 2) components as cited by Umar *et al.* (2017, 2019). Decomposition analysis of change in production assesses the quantum of increase or otherwise of production in year 'n' over the base year that results from a change in the area, productivity or interaction.

Changes in average production: It is caused by changes in the covariance between area and yield and changes in the mean area and mean yield. The model is shown below.

$$E(P) = \bar{A}\bar{Y} + COV(A,Y) \qquad [16]$$
$$\Delta E(P) = E(P_2) - E(P_1) = \bar{A}_1\Delta\bar{Y} + \bar{Y}_1\Delta\bar{A} + \Delta\bar{A}\Delta\bar{Y} + \Delta COV(A,Y) \qquad [17]$$

Table 1: Components of change in the average production

Sources of change	Symbols	Components of change
Change in mean area	$\Delta\bar{A}$	$\bar{A}_1\Delta\bar{Y}$
Change in mean yield	$\Delta\bar{Y}$	$\bar{Y}_1\Delta\bar{A}$
Interaction effect	$\Delta\bar{A}\Delta\bar{Y}$	$\Delta\bar{A}\Delta\bar{Y}$
Changes in area-yield covariance	$\Delta COV(A,Y)$	$\Delta COV(A,Y)$

Table 2: Components of change in variance production

Sources of change	Symbols	Components of change
Change in mean area	$\Delta\bar{A}$	$2\bar{Y}\Delta\bar{A}COV(A,Y) + \{2\bar{A}\Delta\bar{A} + (\Delta\bar{A})^2\}V(Y)$
Change in mean yield	$\Delta\bar{Y}$	$2\bar{A}\Delta\bar{Y}COV(A,Y) + \{2\bar{Y}\Delta\bar{Y} + (\Delta\bar{Y})^2\}V(A)$
Change in area variance	$\Delta V(A)$	$\bar{Y}^2V(A)$
Change in yield variance	$\Delta V(Y)$	$\bar{A}^2V(Y)$
Interaction effect I (changes in mean area and mean yield)	$\Delta\bar{A}\Delta\bar{Y}$	$2\Delta\bar{A}\Delta\bar{Y}COV(A,Y)$
Changes in area-yield covariance	$\Delta COV(A,Y)$	$\{2\bar{A}\bar{Y} - 2COV(A,Y)\}COV(A,Y) - \{\Delta COV(A,Y)\}^2$
Interaction effect II (changes in mean area and yield variance)	$\Delta\bar{A}\Delta V(Y)$	$\{2\bar{A}\Delta\bar{A} + (\Delta\bar{A})^2\}\Delta V(Y)$
Interaction effect II (changes in mean yield and area variance)	$\Delta\bar{Y}\Delta V(A)$	$\{2\bar{Y}\Delta\bar{Y} + (\Delta\bar{Y})^2\}\Delta V(A)$
Interaction effect IV (changes in mean area and mean yield and changes in area-yield covariance)	$\Delta\bar{A}\Delta\bar{Y}COV(A,Y)$	$(2\bar{A}\Delta\bar{Y} + 2\bar{Y}\Delta\bar{A} + 2\Delta\bar{A}\Delta\bar{Y})\Delta COV(A,Y)$
Residual	ΔR	$\Delta V(AY)$

Change in variance decomposition: The source of instability is caused by ten factors and the model is shown below.
$$V(P) = \bar{A}^2.V(Y) + \bar{Y}^2.V(A) + 2\bar{A}\bar{Y}COV(A,Y) - COV(A,Y)^2 + R \qquad [18]$$

2.1.4. Nerlovian model
Following Sadiq *et al.* (2017), the basic model which is called as Nerlovian price expectation model is indicated below.
$$A_t = \alpha + \beta_i P_t^* + \varepsilon_t \qquad [19]$$
$$(P_t^* - P_{t-1}^*) = \beta(P_{t-1} - P_{t-1}^*)\, 0 < \beta < 1 \qquad [20]$$

Where,
A_t = Actual acreage under the crop in year 't'
P_t^* = Expected price of the crop in year 't'
P_{t-1}^* = Expected price of the crop in year 't − 1'
P_{t-1} = Actual price of the crop in year 't − 1'
α = Intercept
β = Coefficient of price expectation
ε_t = Disturbance term

The Nerlovian model depicting farmer's behavior in its simplest form is indicated below.
$$A_t^* = \beta_0 + \beta_1 P_{t-1} + \beta_2 PR_{t-1} + \beta_3 Y_{t-1} + \beta_4 CYR_{t-1} + \beta_5 T_t + \beta_6 WI_t + \varepsilon_t \qquad [21]$$

$$A_t - A_{t-1} = \beta(A_t^* - A_{t-1})$$
(*Nerlovian adjustment equation*)   [22]

As expected, variables are not observable, for estimation purpose, a reduced form containing only observable variables may be written after substituting the value of A_t^* from equation (22) into equation (21), and is indicated below.

$$A_t^* = \beta_0 + \beta_1 P_{t-1} + \beta_2 PR_{t-1} + \beta_3 Y_{t-1} + \beta_4 YR_{t-1} + \beta_5 T_t + \beta_6 WI_t + \beta_7 A_{t-1} + \varepsilon_t \quad [23]$$

Equation (21) is a behavioral equation that states the desired acreage (A_t^*) depends upon the following independent variables:

Where,
A_t = current area under studied crop
P_{t-1} = one year lagged price of studied crop
PR_{t-1} = one year lagged price risk of studied crop
Y_{t-1} = one year lagged yield of studied crop
YR_{t-1} = one year lagged yield risk of studied crop
T_t = time trend at time t
WI_t = one year lagged weather index
A_{t-1} = one year lagged area under studied crop
β_0 = intercept
β_{1-n} = parameter estimates
ε_t = Disturbance term

Price and yield risks were measured by the standard deviation of the three preceding years. For the weather index, the impact of weather on yield variability was measured with a Stalling index (Stalling, 1960). The yield was regressed on time to obtain the expected yield. The actual to the predicted yield ratio is defined as the weather variable. The weather effects such as rainfall, temperature etc. may be captured by this index in the acreage response model (Ayalew, 2015).

The extent of adjustment to changes in the price and/or non-price factors is measured in terms of the "coefficient of adjustment". The adjustment takes place in accordance with the actual planted area in the preceding year. If the coefficient of adjustment is one, farmers fully adjust area under the crop in the current year itself and there will be 'no lags' in the adjustment. But if the coefficient of adjustment is less than one, the adjustment goes on and gives rise to lags, which are distributed over time. The number of

years required for 95 percent of the effect of the price to materialize is given below (Sadiq *et al.*, 2017).

$$(1 - r)^n = 0.05 \quad [24]$$

Where,
r = coefficient of adjustment (1-coefficient of a lagged area)
n = number of year

In the present study, both short-run (SRE) and long-run (LRE) elasticities of the area under the crop with respect to price were estimated to examine and compare the effect of price on the responsiveness of area in the short-run as well as in the long-run. The price elasticities were calculated using the formula indicated below.

$$SRE = \text{Price coefficient} * \frac{\text{Mean of price}}{\text{Mean of area}} \quad [25]$$

$$LRE = \frac{SRE}{\text{Coefficient of adjustment}} \quad [26]$$

2.1.5. *Autoregressive integrated moving average (ARIMA)*

Box and Jenkins (1976) posited that a non-seasonal ARIMA model is denoted by ARIMA (p,d,q), which is a combination of Auto-regressive (AR) and Moving Average (MA) with an order of integration or differencing (d). The p and q are the order of autocorrelation and the moving average, respectively (Gujarati *et al.*, 2012).

The Auto-regressive of order p denoted as AR (p) is indicated below:

$$Z_t = \alpha + \delta_1 Z_{t-1} + \delta_2 Z_{t-1} + \cdots..+\delta_p Z_{t-p} + \varepsilon_t \quad [27]$$

Where
α = constant
δ_p = the p-[th] autoregressive parameter
ε_t = the error term at time 't'

The general Moving Average (MA) of order q or MA (q) can be written as follow:

$$Z_t = \alpha + \varepsilon_t - \varphi_1 \varepsilon_{t-1} - \varphi_2 \varepsilon_{t-1} - \cdots..-\varphi_q \varepsilon_{t-q} \quad [28]$$

Where
α = constant
φ_q = the q-[th] moving average parameter
ε_{t-k} = error term at time 't-k'

ARIMA in general form is as follows:

$$\Delta^d Z_t = \alpha + \left(\delta_1 \Delta^d Z_{t-1} + \cdots + \delta_p \Delta^d Z_{t-p}\right) - \left(\varphi_1 \varepsilon_{t-1} + \cdots + \varphi_q \varepsilon_{t-q}\right) + \varepsilon_t \qquad [29]$$

Where

$\Delta\ denotes\ difference\ operator\ like$

$$\Delta Z_t = Z_t - Z_{t-1} \qquad [30]$$
$$\Delta^2 Z_{t-1} = \Delta Z_t - \Delta Z_{t-1} \qquad [31]$$

Here, $Z_{t-1} \ldots\ldots, Z_{t-p}$ are values of past series with lag 1,.., p, respectively.

Modeling using ARMA methodology consists of four steps viz. model identification, model estimation, diagnostic checking and forecasting.

2.1.6. Forecasting accuracy

For measuring the accuracy in fitted time series model, mean absolute prediction error (MAPE), relative mean square prediction error (RMSPE), relative mean absolute prediction error (RMAPE) (Paul, 2014), Theil's U statistic and R2 were computed using the following formulae

$$MAPE = 1/T \sum_{i=1}^{5}(A_{t-1} - F_{t-1}) \qquad [32]$$
$$RMPSE = 1/T \sum_{i=1}^{5}(A_{t-1} - F_{t-1})^2 / A_{t-1} \qquad [33]$$
$$RMAPE = 1/T \sum_{i=1}^{5}(A_{t-1} - F_{t-1})/A_{t-1} \times 10 \qquad [34]$$
$$U = \sqrt{\dfrac{\sum_{t=1}^{n-1}\dfrac{(\hat{Y}_{t+1} - Y_{t+1})^2}{Y_t}}{\sum_{t=1}^{n-1}\dfrac{(Y_{t+1} - Y_t)^2}{Y_t}}} \qquad [35]$$
$$R^2 = 1 - \dfrac{\sum_{i=1}^{n}(A_{ti} - F_{ti})}{\sum_{i=1}^{n}(A_{ti})} \qquad [36]$$

Where

   R^2 = coefficient of multiple determination

   A_t = Actual value

   F_t = Future value

   T = time period

3. Results and Discussion

3.1. Trend and growth patterns of rubber production

The trend pattern of rubber production during the pre-SAP period was marked by a slight increase and decrease throughout the studied period with yield been the driving force for the rise as the change in the area remains stagnant over a long period of time (Figure 1 and 2). During the SAP period, the production trend was marked by a gentle rise during the early and late nineties with the incremental rise in the area been the driving force as successive changes in yield trend plummeted throughout the specified study period (Figure 3). Furthermore, during the post-SAP period, a slight rise was only visible during the early twenties owing to slight incremental change in successive annual yield level as the successive annual area was stagnant. Thereafter, the production trend from the mid-twenties till the expiration period was marked by marginal rise due to small rise and fall in both the successive annual yield and area which interchange at different points in time (Figure 4). Therefore, it can be inferred that rubber production in the country was driven by incremental change in yield during the pre-SAP period while successive steep increase and a slight increase in the annual area were the driving forces behind rubber production during the SAP and post-SAP periods respectively. The explosive effect of yield during the pre-SAP period did not come as a surprise as the first national plan was export-oriented with a focus on cash crops as a source of raw material which was the driving force of western industrialization. Also, for the post-SAP period, it can be inferred that the sector was almost redundant as the successive annual production levels throughout the most part of the period remained stagnant owing to poor yield even with the slight rise in the area across the studied period.
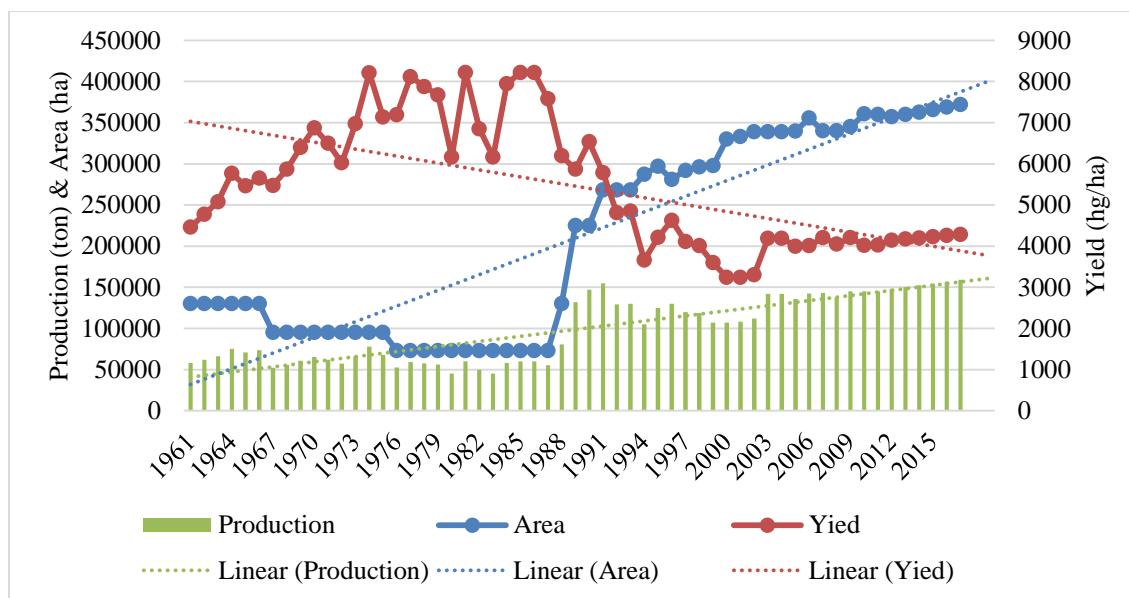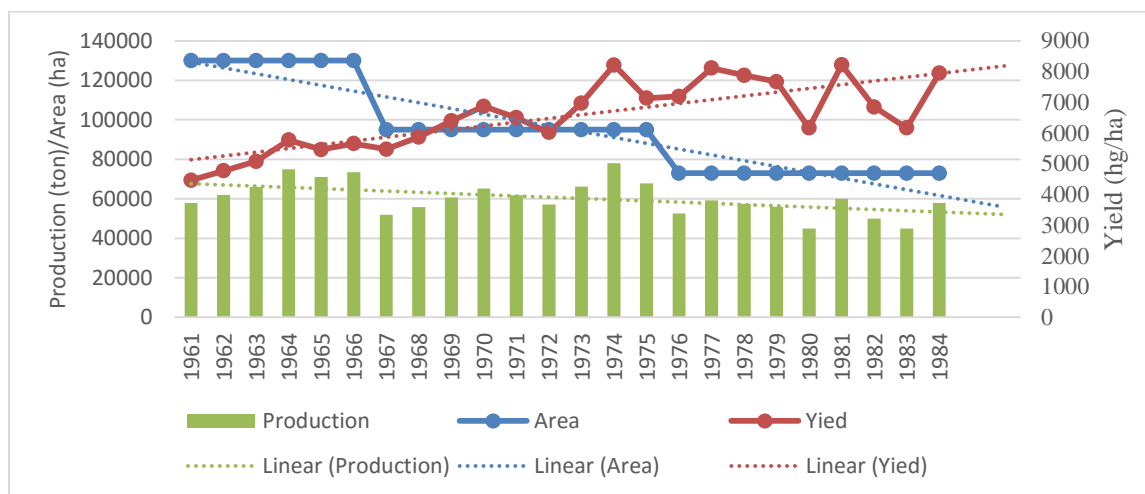
Figure 1: Production trend of Rubber (1961-2017)

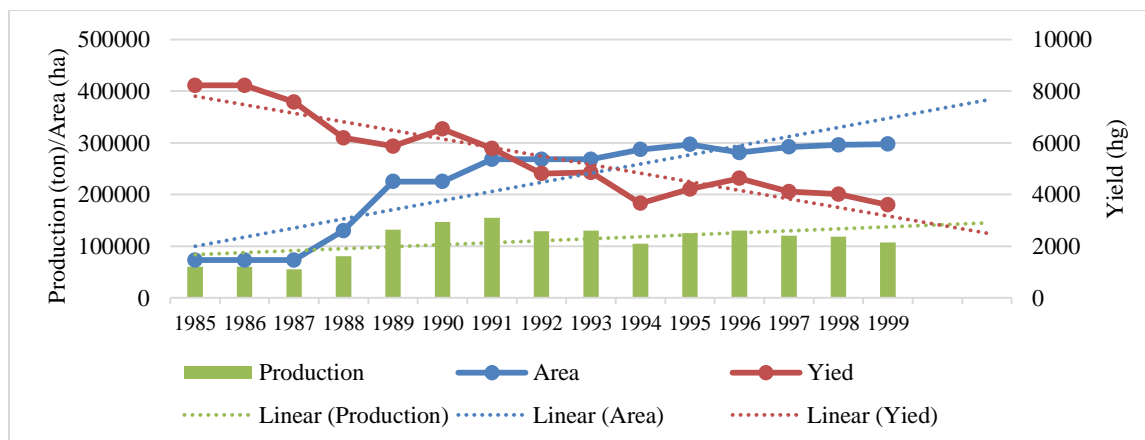**Figure 2: Pre-SAP production trend of Rubber (1961-1984)**

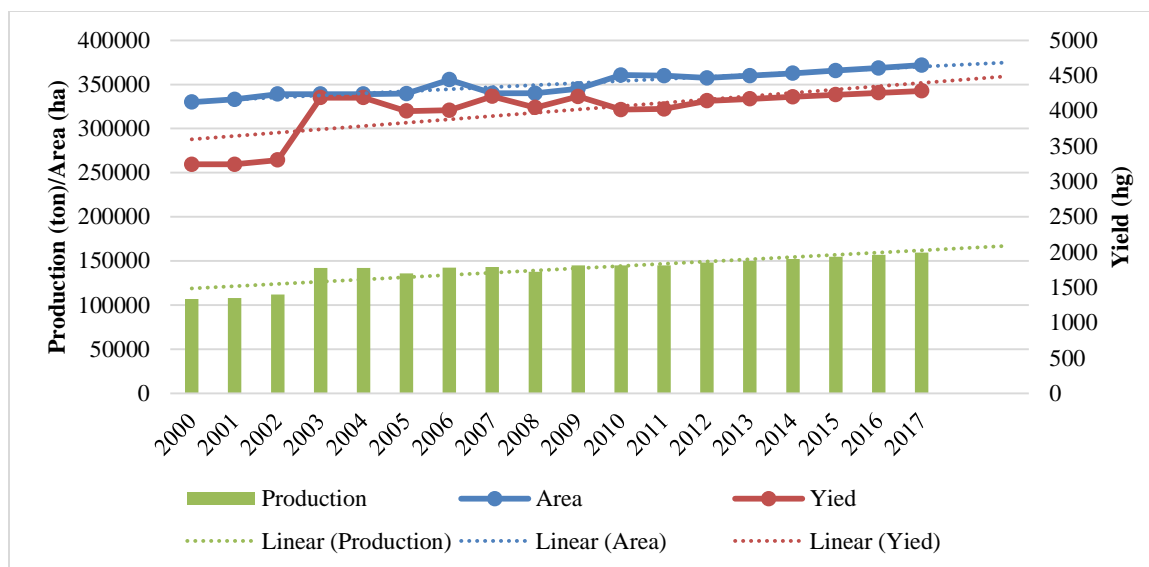**Figure 3: SAP production trend of Rubber (1985-1999)**

Figure 4: Post-SAP production trend of Rubber (2000-2017)

A cursory review of the results showed the average annual production of rubber to have increased by almost two-fold between pre-SAP and SAP periods and thereafter a small increase between the SAP and post-SAP period (Table 3). The explosive increase in area by almost three-fold was the major cause of the galloping rise in rubber production between pre-SAP and SAP regimes. Generally, the annual average area was on the increase across the regime shifts while the annual average yield was on the decrease across the regime shifts.

Furthermore, a perusal of the growth pattern results showed the annual growth rate of rubber production to be on the trough during the pre-SAP period despite that yield recorded a positive annual growth rate. However, the negative annual growth rate which makes the production to trough owes to negative annual growth rate observed for the area. During the SAP period, the annual production growth rate increased by 4.6% with an instantaneous 10.6% rise

in the growth rate of area been the only driving force as the yield was found to be on the trough due to the negative growth rate. The trending behavior of yield may be attributed to poor investment in technology and infrastructure, which intern affects the productivity of the crop. For the post-SAP period, the rubber production witnessed a small incremental change in the growth rate by 1.9% with the small incremental rise in the annual growth rates of both area and yield been the driving forces. Though, yield effect (1.3%) was more pronounced in incremental growth which marked rubber production during the post-SAP era. However, for the overall period, the incremental rise in the annual growth rate of production was due to a positive annual growth rate in the area as yield observed a negative growth rate. Therefore, it can be concluded that rubber production during the SAP period witnessed an impressive growth due to an increase in the area rather than technology, which is not a healthy growth (Table 3).

Table 3: Growth pattern of rubber production

Variables	Pre-SAP	SAP	Post-SAP	Overall
Area (ha)	95500 (-3.1)***	223566.7 (10.6)***	350347.9 (0.7)***	209680.1(3.2)***
Yield (hg)	6534.708 (2.0)***	5484.2 (-5.9)***	3997.667 (1.3)***	5457.088 (-1.1)***
Production (ton)	60560.38 (-1.1)***	110297.7 (4.6)**	140328.2 (1.9)***	98838.98 (2.1)***

Source: Authors' computation, 2019

Note: Values in parenthesis are CAGR

***, **, * = means significant at 1, 5 and 10%, respectively

3.2. Instability in rubber production and source of production risk

A perusal of the Table showed production instability to be low and moderate during the pre-SAP and post-SAP, and SAP regimes respectively as evident by the CV indexes which were less than 20% for the former and higher than 20% but less than 40% for the latter (Table 4). While for the overall period, rubber production was marked by high instability as evident by the CV index which is greater than 40%. However, the major reasons for low and moderate fluctuation in rubber production during the pre-SAP and SAP periods owed to low and moderate instability in the yield levels respectively. For high instability which marked the production for the overall period, high fluctuation in the area was observed to be the major cause. Therefore, it can be inferred that despite the poor production performance of rubber during the pre-SAP period, the extent of the production instability was low, thus exogenous factor may be the likely cause of negative production growth rate recorded during the stipulated study period.

Furthermore, a review of the exact direction of the production instability showed a similar trend with what was obtained when CV was applied except that the production instability for the overall period turn-out to be moderate as indicated by the CDII index which was between 20 to 39%. Therefore, it can be inferred that rubber production across the policy regime periods in the country was within the comfort zone from the exact directional point of view (Table 4).

The results of the CII index showed high fluctuation in rubber production across the policy regime periods as evident by the CII indexes which were higher than 40%. Evidence showed all the production parameters viz. area and yield to be marked by explosive fluctuation across all the policy periods under investigation. Therefore, from the point of production instability in relation to price trend, it can be inferred that rubber production in the country was not in the comfort zone across the policy regime periods (Table 4).

Furthermore, a critical investigation of the source of instability across regime shifts showed 'change in area variance' to be the major source of fluctuation in rubber production between pre-SAP and SAP periods; while between SAP and post-SAP regimes, 'change in the average yield' was the major cause of production instability. However, for the overall period i.e. across the policy regime shifts, 'interaction between change in average area and yield' featured as the major cause of instability in rubber production in the country (Table 5). Therefore, it can be inferred that the major cause of rubber production instability centered majorly on risk.

Table 4: Extent of instability in rubber production

Regimes	Variables	CV	CDII	CII
Pre-SAP	Area	0.236	8.509101	46.25296
	Yield	0.171	10.51337	43.83258
	Production	0.144	12.31179	42.53909
SAP	Area	0.398	21.28463	64.3402
	Yield	0.29	9.791527	48.79965
	Production	0.29	23.07278	51.71077
Post-SAP	Area	0.038	1.354208	38.21286
	Yield	0.088	6.172559	40.42428
	Production	0.112	5.968665	41.53075
Overall	Area	0.569	32.88407	70.8594
	Yield	0.282	21.66083	48.6214
	Production	0.40198	21.90699	56.27885

Source: Authors' computation, 2019

Table 5: Sources of instability in rubber production

Source of variance	Pre-SAP to SAP	SAP to Post-SAP	Overall
Change in mean yield	-177.30	2137.30	206.26
Change in mean area	11.56	-47.45	9.72
Change in yield variance	80.54	659.44	137.05
Change in area variance	1547.00	1098.46	1405.53
Interaction between changes in mean yield and mean area	30.49	-247.35	-45.75
Change in area yield covariance	-775.96	-1671.72	-749.69
Interaction between changes in mean area and yield variance	360.86	959.98	104.48
Interaction between changes in mean yield and area variance	-457.41	-514.79	-1332.79
Interaction between changes in mean area and yield and change in area-yield covariance	-687.37	-229.01	1042.51
Change in residual	167.57	-2044.86	-677.33
Total change in variance of production	100	100	100

Source: Authors' computation, 2019

Table 6: Sources of change in rubber production (Intra-wise %)

Source of change	Pre-SAP	SAP	Post-SAP	Overall
Area effect	0	305.4656	31.84607	134.7209
Yield effect	0	-168.753	69.06265	-16.5962
Interaction effect	0	-36.6874	-0.8735	-18.1263
Total change	100	100	100	100

Source: Authors' computation, 2019

Table 7: Sources of change in rubber production (Inter-regime wise %)

Source of change	Pre-SAP to SAP	SAP to Post-SAP
Area effect	160.17	257.71
Yield effect	-19.20	-123.18
Interaction effect	-25.75	-69.85
Co-variance effect	-15.22	35.33
Total change	100	100

Source: Authors' computation, 2019

3.3. Source of change in rubber production

The results of the instantaneous source of an increase in the average annual production level of rubber across the policy regimes independently showed area effect to be the major source of incremental change in the average annual output level during the SAP and the overall periods; while technology effect was observed to be the production incremental driving force during the post-SAP period. However, the average annual rubber output level was dormant during the pre-SAP period as evident by the parameter estimates which were zero (Table 6).

Furthermore, for the inter-regime wise, evidence showed an area effect to be the source of the incremental rise in the output level of rubber between the pre-SAP and SAP, and SAP and post-SAP. This indicates that technology was the driving force behind the increase in rubber production in the country when the sub-sector was undergoing a paradigm shift (Table 7).

3.4. Farmers' acreage response

The results of the Autoregressive distributed lag model showed the linear functional form to be the best fit for the specified equation as the classical

linear regression model satisfied the economic, statistical and econometric criteria, thus selected as the best fit (Table 8). The auto-regression test at lag four (4) showed the residuals to be independent as indicated by the Langrage Multiplier (LM) test which was not different from zero at 10% degree of freedom, thus no serial correlation. The test of heteroscedasticity using the robust variant test showed the variance of the residual to be constant as indicated by the LM test statistic which is not different from zero at 10% degree of freedom, thus implying that the sum of the square of the residual is homoscedasticity. This clearly showed that the least-squares are efficient and reliable for prediction. There is no evidence of a correlation between the variance of the residuals as indicated by the LM test statistic which is not different from zero at 10% degree of freedom, thus implying that the residual has no Arch effect. Furthermore, the diagnostic test results showed that the parameter estimates were stable and the specification of the functional form is adequate as indicated by the CUSUM (Figure 5) and RESET test statistics respectively, which were not different from zero at 10% degree of freedom, thus implying no change in the parameters and the model specification is adequate. However, the residual was found not to be normally skewed as indicated by the Chi^2 test statistic which is different from zero at 10% degree of freedom.

Though, literature has shown that non-normality in the distribution of residual is not considered a serious challenge as data in their natural forms are likely not to be normally distributed (Sadiq *et al*., 2017). Therefore, with the above ample evidence, it can be inferred that the least-squares are efficient and reliable to predict farmers' acreage response with high precision and certainty.
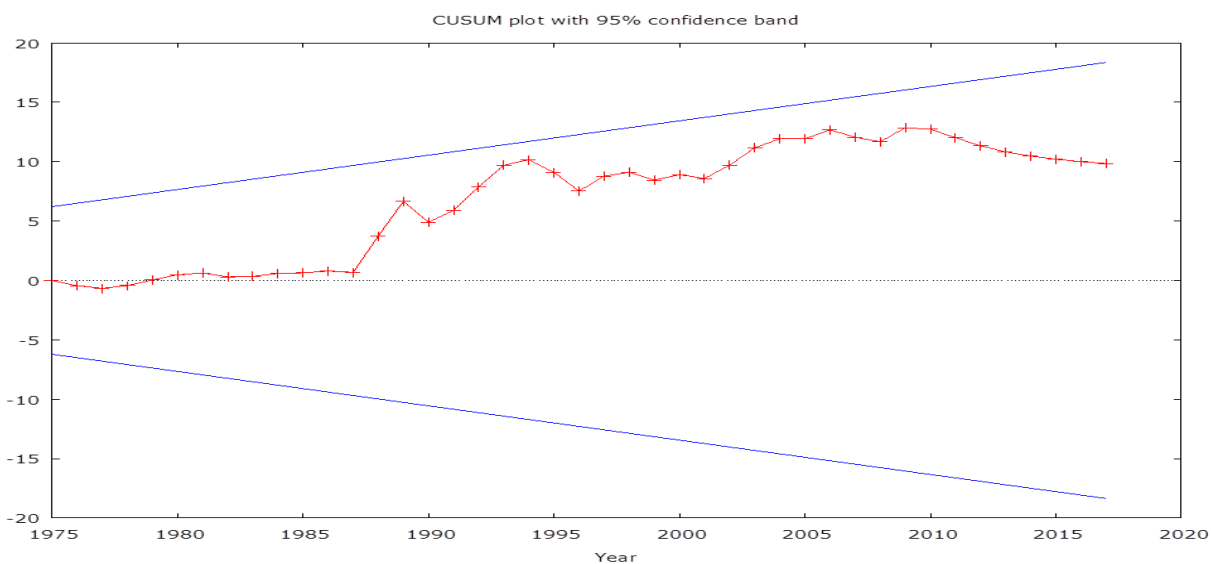

Figure 5: Parameter stability test

The value of the coefficient of multiple determination being 0.984 implies that 98.4% of the current acreage cultivated is been determined by the explanatory variables captured in the model while the disturbing economic reality accounts for the left-over percentage. The high value of the R^2 will create a suspicious of spurious correlation but with the absence of a serial correlation as indicated by the LM test, it can be affirmed that the variables did not move together with the time trend. Thus, the model is devoid of spurious correlation and is not a nonsense regression. Thus, the model is reliable for long-run prediction.

Furthermore, the variables found to have an impact on the current rubber acreage cultivated are weather vagaries, producer price, time factor and the lagged area under rubber cultivation as evident by their respective parameter estimates which were different from zero at 10% degree of freedom. The negative significant of the Weather Index (WI) implies that the current acreage under rubber production decrease

owing to weather vagaries which are caused by climate change. The decline in the productivity of rubber has dire consequences on the turn-over of the enterprise as it has the tendency of forcing the farmers to diversify to other cash crops, thus affecting the hectare cultivated for rubber in the country. The consequence of climate change due to indiscriminate human exploitation of the environmental resources caused dry-spell and flood with dare consequences on the production of rubber in the country.

The negatively significant producer price result showed how dampening of the price due to glut in the supply which intern affected the business turn-over led to a decrease in the current acreage cultivated for rubber. This did not come as a surprise as the farmers have no direct link with the exporting market and have to rely on the licensed buyers (LBs) who engaged in the exportation of the commodity. The LBs take advantage of lack of market tie-up between the producers and exporters to exploit the farmers with respect to the price to their advantage. This exploitation tendency of the middlemen i.e. LBs is what is killing the cash crop sub-sector in Africa as most of the farmers leased-in the plantations, thus living them with very marginal turn-over which can hardly sustain their family expenditure more or less the going concern of the business (Adelodun, 2017). In addition, the negative relationship has a link with the non-availability of remunerative substitute crops to cultivate, given that substitute crops require extra capital for cultivation, well known that capital is the major constraint affecting the farmers, they tend to glue themselves to the cultivation of this crop. Thus, they produce the crop irrespective of the prevailing price in the market.

The SRE and LRE showed acreage responsiveness of the rubber farmers to price changes in the preceding crop period and the elasticities were 0.05 and 0.18% respectively. Given that the LRE reflects the acreage responsiveness of rubber crop to a price change if given sufficient time for adjustment, thus the impact of price policy on rubber production in the long-run is small owing to the low LRE value. Furthermore, it will take approximately 2.29 years for the price effect to materialize. Since the required time for price effect to adjust is small, it can be inferred that the price

policy instrument in bringing the desired change in the supply of rubber production will be effective.

The positive significant of the time trend implies that the different policy regimes witnessed by the economy impacted positively on rubber production in the country thus encouraged an increase in the current acreage cultivated under the rubber. The establishment of rubber research institutes to develop technologies aimed at increasing rubber production, the establishment of agencies with the mandate of export promotion both at state and national level, bilateral and multilateral agreement in trade organization both at regional, continental and international (WTO) levels, foreign investment in the sub-sector, protection policies viz. embargo, tariff, export promotion etc. are all visible policies aimed at reviving the sub-sector in the country. Furthermore, empirical evidence showed that the rate of adjustment of the area under rubber was low as evident by the calculated adjustment coefficient value of 0.27. Thus, the adjustment in accordance with the actual planted area in the preceding year will go on and give rise to lags that are distributed over time. The positive significant of the efficiency parameter indicated that technology impacted positively on the current acreage under rubber production in the country.

3.5. Production Forecast of Rubber in Nigeria

The unit root test results showed that the residuals of variables *viz.* area, yield and production at the level were pure white noise but after differencing (first difference) the residuals became Gaussian white noise as evident by their respective Augmented Dickey-Fuller (ADF) test statistics which were not different from zero and different from zero at 5% error gap respectively (Table 9). This implies that the variables after differencing became stationary which is a pre-requisite for the efficiency of time series data. Thereafter, for forecasting, the variables were subjected to various ARIMA stages to determine the most suitable ARIMA model with the lowest Akaike information criterion (AIC). The empirical evidence showed that for the area, yield and production; ARIMA (1,1,0), ARIMA (0,1,1) and ARIMA (0,1,1) respectively, were chosen as the best fit for the forecast because they had the lowest AICs among all the tried ARIMA forms (Table 9). In addition, the residuals of the chosen ARIMAs were devoid of

autocorrelation, Arch effect and are normally distributed as indicated by their respective test statistics which were not different from zero at 10% error gap. However, the residual of the selected ARIMA for the production variable was found not to be normally skewed as it is different from zero at

10% degree of freedom. Though, literature has shown that non-normality in the distribution of the error term is not a serious problem given that data in their natural form in most cases are not normally distributed.

Table 8. Farmers' acreage response

Variables	Parameters	t-stat	Mean	SRE	LRE
Intercept	34928.9 (34928.9)	2.150**	-	-	-
P_{t-1}	-0.2468 (0.1355)	1.821*	41865.26	-0.04754	-0.17607
PR_{t-1}	0.066 (0.3195)	0.206^{NS}	5667.686	0.001721	0.006374
Y_{t-1}	-1.85 (4.39326)	0.421^{NS}	5387.075	-0.04585	-0.16983
YR_{t-1}	1.662 (9.364)	0.177^{NS}	419.4214	0.003207	0.011879
T_t	2449.38 (577.17)	4.244***	26	0.293013	1.085233
WI_t	-57703.4 (22012.0)	2.621**	1.003672	-0.26647	-0.98693
A_{t-1}	0.73 (0.0953)	7.655***	213240.8	0.716226	2.65269
R^2	0.9843				
F-stat	385.95{1.17e-36}***				
Autocorrelation	1.961{0.119}^{NS}				
Arch effect	0.0466{0.828}^{NS}				
Heteroscedasticity	7.932{0.338}^{NS}				
Normality	21.11{2.6e-5}***				
CUSUM test	1.502{0.140}^{NS}				
RESET test	5.2778{0.8208}^{NS}				

Source: Authors' computation, 2019

***, **, * = significant at 1%, 5%, 10% probabilities, respectively; NS = Non-significant
Values in ( ), [ ] and { } are standard error, t-statistic and probability level, respectively

Table 9. ARIMA model

ARIMA		Production (AIC)	Area (AIC)	Yield (AIC)
ARIMA (1,1,1)		1220.82	1258.15	894.406
ARIMA (1,1,0)		1218.84	1257.05	894.299
ARIMA (0,1,1)		1218.82	1257.69	892.839
Autocorrelation		2.959(0.3960)^{NS}	2.1319(0.545)^{NS}	2.922(0.495)^{NS}
Arch effect		2.488(0.477)^{NS}	8.0259(0.1548)^{NS}	14.786(0.1400)^{NS}
Normality		16.454(0.00026)***	28.888(5.33e-07)***	2.427(0.297)^{NS}
ADF	Level	-0.889(0.7846)^{NS}	-0.237(0.9313)^{NS}	-0.9223(0.7818)^{NS}
	1st Diff.	-6.542(6.08e-7)***	-5.674(1.19e-05)***	-7.340(3.86e-011)***

Source: Authors' computation, 2019
Note: *** = significant at 1% probability; NS = Non-significant
Values in ( ), [ ] and { } are standard error, t-statistic and probability level, respectively

In determining the predictive power of the chosen ARIMAs, one-step-ahead forecast of the variables along with their corresponding standard errors using the naïve approach for the periods 2013 to 2017 were

computed (Table 10). This was done to validate how closely the sample periods could track the path of actual observation.

Table 10. One-step ahead forecast of rubber production

Period	Production		Area		Yield	
	Actual	Forecast	Actual	Forecast	Actual	Forecast
2013	150110	150020.4	359859	359978.6	4171	4103.45
2014	152298	151932.6	362658	363721.1	4199	4145.14
2015	154571	154149.7	365622	366586.7	4228	4177.18
2016	156900	156428.6	368676	369590.4	4256	4207.08
2017	159264	158762.9	371775	372666.1	4284	4235.64

Source: Authors' computation, 2019

Table 11. Validation of models

Variable	R^2	RMSE	RMSPE	MAPE	RMAPE (%)	Theil's U
Production	0.997725	396.0568	1.003552	351.834	0.225509	0.193138
Area	0.997904	859.1978	2.013157	-766.67	-0.20894	0.322523
Yield	0.990446	45.2005	0.481984	40.392	0.952592	1.789165

Source: Authors' computation, 2019

In measuring the reliability of the selected ARIMAs for the forecast, the mean absolute prediction error (MAPE), root mean square error (RMSE), Theil's inequality coefficient (U) and the relative mean absolute prediction error (RMAPE) were determined. Empirical evidence showed the RMAPE and U coefficients to be less than 5% and 1 respectively, indicating the predictive error associated with the estimated equations in tracking the actual data (*ex-post* prediction) to be very low and insignificant, thus could be used for *ex-ante* projection with high projection validity, efficiency and consistency (Table 11).

Table 12 and Figure 6-8 showed the estimated one-step-ahead out of sample forecasts of rubber production (ton), area (hectare) and yield (hg) spanning through 2018 to 2029. It was observed that the production will be marked by a gentle rise throughout the forecasted period owing to a gentle rise in the area. It is saddened to observe that the yield will be marked by a gentle fall throughout the forecasted period as evidenced by the plummeting forecasted yield trend. Therefore, the study calls for urgent intervention by both government and non-governmental agencies in linking the producers with the importing market in order to have a better price for their products. In addition, the farmers should form viable co-operative organizations that will be directly involved in marketing, especially exportation in order to have strong bargaining power for their products, thus fetching them remunerative prices that will make their income productive.

Table 12: Production, area and yield forecasts of rubber (2018-2029)

Year	Production			Area		
	Forecast	**LCL**	**UCL**	**Forecast**	**LCL**	**UCL**
2018	161130.03	137205.30	185054.76	375775.92	342132.33	409419.52
2019	162943.19	127278.74	198607.63	379993.87	326383.81	433603.92
2020	164756.34	120354.62	209158.07	384264.04	315107.77	453420.30
2021	166569.50	114887.07	218251.93	388546.77	306496.08	470597.45
2022	168382.65	110325.49	226439.81	392832.52	299601.56	486063.49
2023	170195.81	106397.73	233993.88	397119.01	293900.24	500337.78
2024	172008.96	102945.55	241072.37	401405.67	289081.16	513730.18
2025	173822.12	99867.30	247776.93	405692.37	284946.29	526438.44
2026	175635.27	97093.09	254177.46	409979.08	281361.55	538596.60
2027	177448.43	94572.40	260324.45	414265.79	278231.50	550300.09
2028	179261.58	92267.36	266255.81	418552.51	275485.42	561619.60
2029	181074.74	90148.64	272000.84	422839.22	273069.21	572609.23
Year	**Yield**					
	Forecast	**LCL**	**UCL**			
2018	4263.80	2962.16	5565.45			
2019	4257.87	2665.23	5850.50			
2020	4251.93	2413.80	6090.06			
2021	4246.00	2191.50	6300.49			
2022	4240.06	1989.92	6490.21			
2023	4234.13	1804.03	6664.23			
2024	4228.19	1630.58	6825.81			
2025	4222.26	1467.30	6977.22			
2026	4216.32	1312.53	7120.12			
2027	4210.39	1165.02	7255.76			
2028	4204.46	1023.81	7385.10			
2029	4198.52	888.13	7508.91			

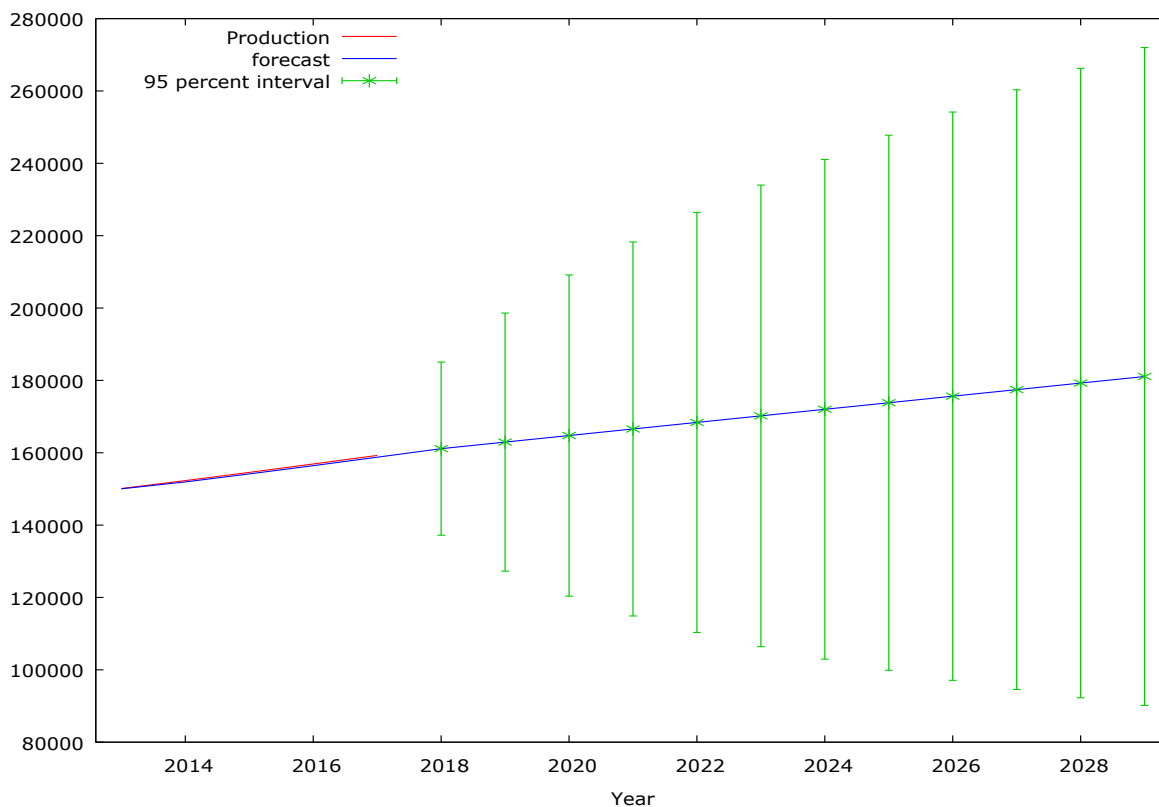Source: Authors' computation, 2019

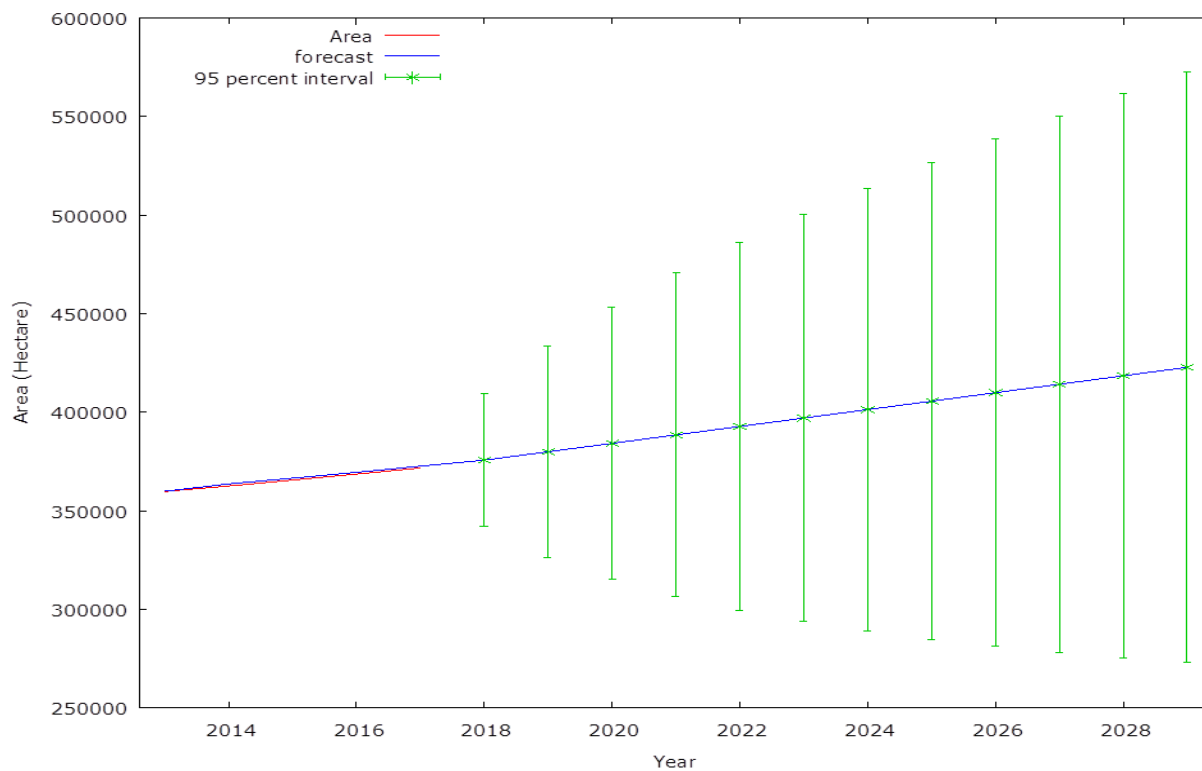Figure 6: Production forecast of Rubber in Nigeria

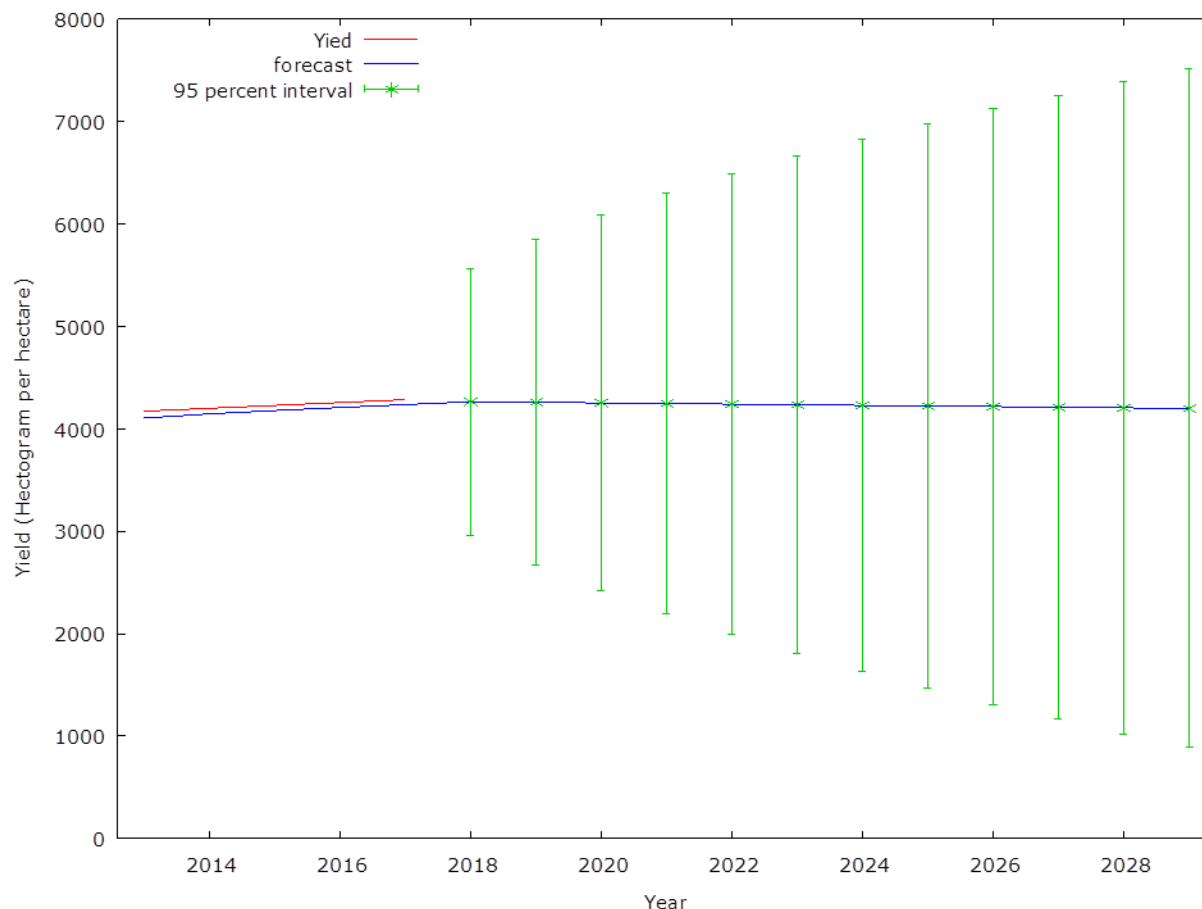Figure 7: Area forecast of Rubber in Nigeria

Figure 8: Yield forecast of Rubber in Nigeria

4.   Conclusion and Recommendations

From the findings, it can be inferred that the incremental changes in rubber production between the policy regime shifts in the country have been driven by area effect which does not signify healthy growth in the rubber sub-sector of the country. Furthermore, area risk due to competing demand for limited available land seriously affected the production of rubber in Nigeria. The future of the rubber sub-sector is not impressive as the gentle rise in the forecasted production trend will be driven by area increase as the future annual yield levels plummeted. Price dampening due to lack of market-tie of the producers with the importing markets which makes the farmers be at the mercy of the LBs will affect farmers' income productivity, thus affecting their livelihoods and the enterprise business going concerned. Therefore, for healthy market competition, the farmers should constitute themselves into viable co-operative associations in order to be competitive enough to venture into direct marketing i.e. exportation of their products and the government and non-government agencies should assist in linking these farmers' co-operatives directly with the importing markets. By doing so, the farmers will have bargaining power for their products, thus making them earn productive income owing to remunerative prices from their products.

Conflict of Interest
The authors declare no conflict of interest.

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