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Araştırma Makalesi (Research Article)

Tracking the Performance of Soyabean Production in Nigeria

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Abstract: The present research empirically examined the growth performance of soyabean production in Nigeria using time series data which spanned from 1961 to 2017, sourced from FAO database. The collected data were analyzed using descriptive statistics, growth model, instability index, Hazell decomposition model, Nerlovian's model and ARIMA model. Empirical evidence showed that the growth in the production trend of soyabean in Nigeria is majorly driven by an increase in the area and not yield which is not favorable for sustainable soyabean food security in the country. Furthermore, risk and uncertainty were observed to be the major source of instability in the production of soyabean in the country. Therein, the risk impacted negatively on the area allocation decision of the soyabean farmers in the studied area. The forecasted production trend showed that the country's soyabean production will observe a paradigm shift from the area as the major driver of production to yield. Thus, technology will be the major driver of soyabean production in Nigeria. The trend if sustained will be a breakthrough for the country's soyabean food security and will curtail the incessant farmers/herders clashes and tenurial conflicts owing to high pressure and competing demand for arable land for other purposes. Therefore, policies which will convert one-quarter of the arable land to other agricultural uses should be welcome as the future production trend of soyabean will be driven by technological advancement. In addition, the government should do more in subsidizing farm inputs in order to enhance farmers' term of trade, thereby wading-off the risks that negatively impacted on the acreage allocation decision of the producers.

Nijerya'da Soya Fasulyesi Üretim Performansının İzlenmesi

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Öz: Mevcut araştırma, Nijerya'daki soya fasulyesi üretiminin büyüme performansını, FAO veri tabanından elde edilen 1961'den 2017'ye uzanan zaman serisi verilerini kullanarak deneysel olarak incelemiştir. Toplanan veriler, tanımlayıcı istatistikler, büyüme modeli, kararsızlık indeksi, Hazell ayrışma modeli, Nerlovian modeli ve ARIMA modeli kullanılarak analiz edilmiştir. Ampirik kanıtlar, Nijerya'daki soya fasulyesinin üretim eğilimindeki büyümenin, büyük ölçüde üretim alanı artışından kaynaklandığını ve bunun ülkede

Anahtar kelimeler

Arazi tepkisi,
Büyüme,
Tahmin,
İstikrarsızlık,
Soya fasulyesi,
Nijerya.

sürdürülebilir soya fasulyesi gıda güvenliği için elverişli olmadığını göstermiştir. Ayrıca, ülkede soya fasulyesi üretiminde en büyük istikrarsızlık kaynağının risk ve belirsizlik olduğu görülmüştür. Burada risk, incelenen alandaki soya fasulyesi çiftçilerinin alan tahsisi kararını olumsuz etkilemiştir. Öngörülen üretim eğilimi, ülkedeki soya fasulyesi üretiminin, üretimin ana itici gücü olarak bölgeden bir paradigma kayması gözlemleyeceğini göstermektedir. Bu nedenle teknoloji, Nijerya'daki soya fasulyesi üretiminin ana itici gücü olacaktır. Sürdürülebilirse eğilim, ülkenin soya fasulyesi gıda güvenliği için bir dönüm noktası olacak ve yüksek baskı ve diğer amaçlar için ekilebilir arazi için rekabet eden talep nedeniyle aralıksız çiftçi/çoban çatışmalarını ve mülkiyet çatışmalarını azaltacaktır. Bu nedenle, soya fasulyesinin gelecekteki üretim eğilimi teknolojik gelişmeler tarafından yönlendirileceğinden, ekilebilir arazinin dörtte birini diğer tarımsal kullanımlara dönüştürecek politikalar memnuniyetle karşılanmalıdır. Buna ek olarak, hükümet çiftçilerin ticaret süresini iyileştirmek için çiftlik girdilerini sübvansede etmede daha fazlasını yapmalı ve böylece üreticilerin ekim alanı tahsis kararını olumsuz yönde etkileyen riskleri azaltmalıdır.

1. Introduction

In the last half-century, the global production of soyabeans has increased by a factor of eight to reach its present level of over 100 million metric tons per year. USA (45 percent), Brazil (20 percent) and China (12 percent) are the leading producers of this crop in the globe. Most of this remarkable growth was due, according to the FAO (no date), to the rapid rise in US production between 1950 and 1970, and the introduction of soyabean to Brazilian agriculture in the sixties.

Twenty-one African countries now grow soyabeans, with Nigeria having the highest 6-year (2000-05) average production of 486 000 tons over an area of 553 260 hectares, followed by South Africa with 205 270 tons out of 122 870 hectares, and then Uganda with 155 500 tons out of 139,500. Currently, Nigeria produces about 500 000 metric tons of soyabeans annually making it the black continent's largest producer of the commodity.

Approximately 11 million tons of soyabeans are consumed worldwide; annual consumption in Africa is about 618 000 tons, and another 4 800 tons of animal feed are used. Nigeria is sub-Saharan Africa's largest consumer of soyabeans, and then Uganda. Nigeria currently produces soyabean worth \$85 million on the international market; while most soyabeans in the nation is consumed locally where it is used in soymilk production and specially formulated foods to support malnourished babies and children. The product's foreign market is rising, and sustainable.

Soyabeans development has received tremendous attention and direct government support in Nigeria in the last two decades (AMREC, 2007). The interest in promoting production and consumption of soyabean is related to the crop's tremendous economic and nutritional value. In addition, the crop has gained popularity in Nigeria since as far back as 1992; more than 200 000 hectares of land were devoted to cultivation. This was then the largest field of soya cultivation land in Africa as a whole (AMREC, 2007). Soya is extensively farmed, often by small-scale farmers, which accounts for its low yields. Despite this, there is a lot of hope to Nigeria's experiment in using soyabean as a food crop.

The current increase in soyabean development in Nigeria was due to several years of work from the mid-1960s to the 1980s, when scientists adopted a nationally organized soyabean research approach (Okoruwa, 2001). Soyabean cultivation in Nigeria has grown to a large extent over the years due to awareness of its economic advantages (Ojo, 2002). Due to increased knowledge among farmers about the versatility of soyabean and then the release of high-yielding varieties from research institutes working on soyabean growth in Nigeria, its production level has increased in some states.

As the largest producer of human and animal feed crops in West and Central Africa, Nigeria has a great potential to substitute certain imported vegetable oils for soy oil (RMRDC, 2004). Current domestic

demand and home consumption have made the crop a versatile, multifunctional agricultural commodity that could be processed for human, livestock and industrial purposes in almost 365 ways. With the current ban on the importation of vegetable oils, some of the hitherto idle mills across the country are now looking inward, generating soyabean-based edible oils, preventing vegetable oil processing facilities from becoming inefficient and preventing inadequate supply of the oils. Therefore, it implies that the crop is an essential economic commodity that contributes significantly to the livelihoods of the farming population in the region. It is in the light of the above that this work aimed to analyze the sustainability efficiency of the crop with a view to ensuring soyabean food security in the country as it is one of the richest and cheapest protein sources.

The broad objective of the research is, therefore, to monitor the output of soyabean production in Nigeria, while the basic objectives were to analyze the soyabean production trend; to determine the growth pattern of soyabean production; to determine the status of instability in soyabean production; to determine the sources of instability in soyabean production; and to forecast soyabean production in Nigeria.

2. Materials and Methods

The study made use of time series data for the area, yield, production and prices which spanned from 1961 to 2017 (56 years), sourced from FAO database. The collected data were analyzed using descriptive statistics, growth model, instability index, Hazell decomposition model, Nerlovian's model and ARIMA model. For a detailed analysis of the growth trend and instability, the data were classified into periods based on the reform regimes that marked the economy of the country *viz.* pre-Structural Adjustment Period (pre-SAP) (1961-1984), SAP (1985-1999) and post-SAP (2000-2017). In descending order, the objectives were achieved using descriptive statistics, growth model, instability index, Hazell's decomposition model, Nerlovian's model and ARIMA model

2.1 Empirical model

2.1.1. Growth rate

The compound annual growth rate calculated using the exponential model is given below:

$$\gamma = \alpha\beta^t \dots\dots\dots (1)$$

$$\ln\gamma = \ln\alpha + t\ln\beta \dots\dots\dots (2)$$

$$CAGR = [\text{Antilog}\beta - 1] \times 100 \dots\dots\dots (3)$$

Where, CAGR is compound growth rate; t is time period in year; γ is area/yield/production; α is intercept; and, β is the 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 soyabean. Following Sandeep et al. (2016) and Boyalet al. (2015) the CV is shown below:

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

Where, σ is standard deviation and \bar{X} is the mean value of area, yield or production

The simple CV overestimates the degree of instability in long-term trends in time series results, while the Cuddy-Della Valle Index corrects the coefficient of variability by the index of instability as it de-trends the annual output and shows the exact direction of instability (Cuddy-Della Valle, 1978). Thus, it is a better measure to capture the instability of agricultural production and prices, and it is given below:

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

Where CDII is the index of Cuddy-Della instability; where CV is the variance coefficient; and where R² is the multiple determination coefficient. In conformity with Dharke and Sharma (2009); and Debnath et al. (2015) the instability index was classified as low instability (≤15%) and high instability (>15%).

Unlike 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 the advantage is that it measures the instability in relation to the trend in production (Kumar et al., 2017). According to Kumar et al. (2017), a higher numerical value for the index represents a greater instability. Following Coppock (1962), the algebraic economic formula as used by Ahmed & Joshi (2013); Sandeep et al. (2016); Kumar et al. (2017); Umar et al. (2019) is given below:

$$CII = (\text{Antilog} \sqrt{\log V} - 1) * 100 \dots \dots \dots (6)$$

$$\log V = \frac{\sum [\log \frac{X_{t+1}}{X_t} - m]^2}{N-1} \dots \dots \dots (7)$$

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} and X_t ; and, $\log V$ = Logarithm Variance of the series

2.1.3. Source of change in soybean production

Instantaneous instability

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

$$P_0 = A_0 \times Y_0 \dots \dots \dots (5)$$

$$P_n = A_n \times Y_n \dots \dots \dots (6)$$

Where, P , A and Y represents the production, area and yield respectively. The subscript 0 and n represents the base and the n^{th} years respectively

$$P_n - P_0 = \Delta P \dots \dots \dots (7)$$

$$A_n - A_0 = \Delta A \dots \dots \dots (8)$$

$$Y_n - Y_0 = \Delta Y \dots \dots \dots (9)$$

From equation (5) and (9) we can write

$$P_0 + \Delta P = (A_0 + \Delta A)(Y_0 + \Delta Y) \dots \dots \dots (10)$$

Therefore,

$$P = \frac{Y_0 \Delta A}{\Delta P} \times 100 + \frac{A_0 \Delta Y}{\Delta P} \times 100 + \frac{\Delta A \Delta Y}{\Delta P} \times 100 \dots \dots \dots (11)$$

$$\text{Production} = \text{Area effect} + \text{Yield effect} + \text{Interaction effect} \dots \dots \dots (12)$$

2.1.4. Sources of instability

Hazell's decomposition model

Hazell's (1982) decomposition model was used to estimate the change in average output and change in the variance of output with respect to both regimes and the overall duration. Hazell decomposed the causes of change in the output average and modified the output variance into four (4) and ten (10) components as Umar *et al.* (2017 and 2019) quoted.

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 change in the area, productivity or their interaction.

- i. *Changes in average production:* Changes in the covariance between area and yield and changes in average area and mean yield are the causes. The model is shown below:

$$E(P) = \bar{A}\bar{Y} + COV(A, Y) \dots \dots \dots (13)$$

$$\Delta E(P) = E(P_2) - E(P_1) = \bar{A}_1 \Delta \bar{Y} + \bar{Y}_1 \Delta \bar{A} + \Delta \bar{A} \Delta \bar{Y} + \Delta COV(A, Y) \dots \dots \dots (14)$$

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	$\Delta COV(A, Y)$	$\Delta COV(A, Y)$

ii. *Change in variance decomposition:* It is caused by ten factors and shown below is the model:
 $V(P) = \bar{A}^2.V(Y) + \bar{Y}^2.V(A) + 2\bar{A}\bar{Y}COV(A, Y) - COV(A, Y)^2 + R..... (15)$

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	$\Delta V(AY)$

2.1.5. Nerlovian model

The basic model that has come to be called as Nerlovian’s price expectation model is as follows, following Sadiq et al. (2017).

$$A_t = \alpha + \beta_i P_t^* + \varepsilon_t (16)$$

$$(P_t^* - P_{t-1}^*) = \beta(P_{t-1} - P_{t-1}^*) 0 < \beta < 1..... (17)$$

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 hypothesis described in Equation (17) is the hypothesis of price expectation. The left-hand representation of this equation is the change of year-to-year demand forecasts. The expression on the right hand side is the error the farmers made in predicting the price during t-1. The price expectation coefficient (β) suggests that, during the current year, only a fraction of the last year's price prediction error is converted into revision in the expected price.

The Nerlovian’s model depicting farmer’s behavior in its simplest form is shown below:

$$A_t^* = \beta_0 + \beta_1 SP_{t-1} + \beta_2 CP_{t-1} + \beta_3 SPR_{t-1} + \beta_4 CPR_{t-1} + \beta_5 SY_{t-1} + \beta_6 CY_{t-1} + \beta_7 SYR_{t-1} + \beta_8 CYR_{t-1} + \beta_9 WI_{t-1} + \varepsilon_t \dots\dots\dots (18)$$

$$A_t - A_{t-1} = \beta(A_t^* - A_{t-1}) \text{ (Nerlovian adjustment equation)} \dots\dots\dots (19)$$

Since the predicted variables cannot be observed, a reduced form containing only measurable variables can be written for estimation purposes after replacing the value of A_t^* from equation (19) to equation (18), as follows:

$$A_t^* = \beta_0 + \beta_1 SP_{t-1} + \beta_2 CP_{t-1} + \beta_3 SPR_{t-1} + \beta_4 CPR_{t-1} + \beta_5 SY_{t-1} + \beta_6 CY_{t-1} + \beta_7 SYR_{t-1} + \beta_8 CYR_{t-1} + \beta_9 WI_{t-1} + \beta_{10} A_{t-1} + \varepsilon_t \dots\dots\dots (20)$$

The first equation is an equation of behaviour, which states that the optimal acreage (A_t^*) depends on the following independent variables:

Where,

A_t = current area under the crop;

SP_{t-1} = one year lagged price of soyabeans ; CP_{t-1} =

one year lagged price of cowpea (competing crop);

SPR_{t-1} = one year lagged price risk of soyabeans;

CPR_{t-1} = one year lagged price risk of cowpea;

SY_{t-1} = one year lagged yield of soyabeans;

CY_{t-1} = one year lagged yield of cowpea;

SYR_{t-1} = one year lagged yield risk of soyabeans;

CYR_{t-1} = one year lagged yield risk of cowpea;

WI_{t-1} = one year lagged weather index for soyabeans;

A_{t-1} = one year lagged area under soyabeans;

β_0 = intercept;

β_{1-n} = parameter estimates; and,

ε_t = Disturbance term

Price and yield risks were calculated using the standard deviation of the preceding three years. The weather effect on yield variability was calculated by means of a Stalling index (Stalling, 1960) for the environment index. To get the expected yield, the actual yield was regressed. The actual yield ratio to predict is known as the weather variable. The weather effects such as rainfall, temperature, etc. can be captured in the acreage response model through this index (Ayalew, 2015).

The magnitude of the adjustment to market and/or non-price adjustments is calculated by the "adjustment coefficient". The transition takes place in the previous year, in conjunction with the actual area planted. If the adjustment coefficient is one, farmers themselves will fully adjust the area under the crop during the current year and there will be 'no lags' in the adjustment. But if the adjustment coefficient is less than one, the adjustment will continue and cause lags, which will be 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):

$$(1 - r)^n = 5/100 \dots\dots\dots (21)$$

Where;

r = Change coefficient (1-lagged field coefficient); and,

n = number of year.

In the present analysis, both the area under the crop's short-run (SRE) and long-run (LRE) elasticities with respect to price are calculated to analyze and compare the impact of price on the area's responsiveness in both the short-run and long-run. Below are the price elasticities:

$$SRE = Price\ coefficient * \frac{Mean\ of\ price}{Mean\ of\ area} \dots\dots\dots (22)$$

$$LRE = \frac{SRE}{\text{Coefficient of adjustment}} \dots\dots\dots (23)$$

2.1.6. ARIMA

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

The order p Auto-regressive denoted as AR(p) is set out below:

$$Z_t = \alpha + \delta_1 Z_{t-1} + \delta_2 Z_{t-2} + \dots + \delta_p Z_{t-p} + \varepsilon_t \dots\dots\dots (24)$$

Where, α is the constant; δ_p is the p-th autoregressive parameter and ε_t is the error term at time 't'.

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

$$Z_t = \alpha + \varepsilon_t - \varphi_1 \varepsilon_{t-1} - \varphi_2 \varepsilon_{t-2} - \dots - \varphi_q \varepsilon_{t-q} \dots\dots\dots (25)$$

Where, α is the constant; φ_q is the q-th moving average parameter and ε_{t-k} is the error term at time 't-k'.

ARIMA in general form is as follows:

$$\Delta^d Z_t = \alpha + (\delta_1 \Delta^d Z_{t-1} + \dots + \delta_p \Delta^d Z_{t-p}) - (\varphi_1 \varepsilon_{t-1} + \dots + \varphi_q \varepsilon_{t-q}) + \varepsilon_t \dots\dots\dots (26)$$

Where, Δ denotes difference operator like:

$$\Delta Z_t = Z_t - Z_{t-1} \dots\dots\dots (27)$$

$$\Delta^2 Z_{t-1} = \Delta Z_t - \Delta Z_{t-1} \dots\dots\dots (28)$$

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

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

Forecasting Accuracy

Mean absolute prediction error (MAPE), relative mean square prediction error (RMSPE), relative mean absolute prediction error (RMAPE) (Paul, 2014), Theil's U statistics and R^2 were calculated using the following formulae for measuring the accuracy in fitted time series model:

$$MAPE = 1/T \sum_{i=1}^5 (A_{t-1} - F_{t-1}) \dots\dots\dots (29)$$

$$RMPSE = 1/T \sum_{i=1}^5 (A_{t-1} - F_{t-1})^2 / A_{t-1} \dots\dots\dots (30)$$

$$RMAPE = 1/T \sum_{i=1}^5 (A_{t-1} - F_{t-1}) / A_{t-1} \times 100 \dots\dots\dots (31)$$

$$U = \sqrt{\frac{\sum_{t=1}^{n-1} \frac{(Y_{t+1} - Y_t)^2}{Y_t}}{\sum_{t=1}^{n-1} \frac{(Y_{t+1} - Y_t)^2}{Y_t}}} \dots\dots\dots (32)$$

$$R^2 = 1 - \frac{\sum_{i=1}^n (A_{ti} - F_{ti})}{\sum_{i=1}^n (A_{ti})} \dots\dots\dots (33)$$

Where, R^2 = coefficient of multiple determination, A_t = Actual value; F_t = Future value, and T = time period

3. Results and Discussion

3.1. Trend pattern of soyabean production

Figure 1 showed the trend patterns of production, area and yield across the sub-periods and the overall period. A perusal of the graph depicted an irregular trend for the production of soyabean over the entire period under consideration with area been the major cause of fluctuation as evident from the year

1969 to 2017; with a trend break in the year 2010. From the year 1961 to 1975, the production trend was flat due to mix of marginal changes in both area and yield; and thereafter, in the year 1976 to 1982, there was a slight incline in the production trend due to pronounced increase in the area cultivated under soyabean. During the latter period, the yield of soyabean was observed to be on the decline which may be attributed to policy inconsistencies owing to regime shifts; while infancy of the Nigerian economy owing to relegation of administration by the colonial master immediately after the country was granted independence which effected the managerial efficiency of the economy and the episodic factor (civil war) may be the reasons for the almost stagnant trend during the former period. It was observed that the production trend plummeted sharply in the year 1982 and maintained a flattened trend till the year 1984 which may be due to political crises *viz.* corruption by the political elites and weak international trade policies which affected the production trend as evident by the stagnant area and yield trends. The production trend suddenly inclined from the year 1985 till 1989, and then suddenly decline in the year 1990 and thereafter maintained a flattened trend till the year 1994. It was observed that the increase in the production trend from 1985 to 1989 is due to an increase in both area and yield with the increase in area been more pronounced than the incremental change in yield. Furthermore, the result showed sharp incremental changes in the production trend from the year 1995 and it persisted till the year 2008 with incremental changes in both area and yield been responsible. The incremental change in the trend of the area is more pronounced than the incremental contribution change recorded by yield. However, there was a deep decline in the production trend in the succeeding year (2009) due to a sharp fall in the area cultivated for soyabean in spite of the high yield recorded in the same year. From the year 2009 to 2017, the production trend exhibited a *zig-zag* shape with more pronounced changes in the area than the yield been responsible for the upward and downward swings in soyabean production trend in the country. Summarily, from the year 1961 to 1994, the production trend of soyabean exhibited mild changes with the trend been flattened and thereafter, the changes sharply steep upward and downward. Incremental changes in area were more pronounced than the incremental changes in yield, thus the major source of change in the production trend of soyabean in Nigeria.

A decomposition analysis across the three policy regime periods (Pre-SAP, SAP and Post-SAP) showed incremental change in yield to be the major source of increase in soyabean production during the pre-SAP despite that the production trend is flattened i.e. almost stagnant during the pre-SAP regime (Figure 1b); incremental change in area is the major source of increase in the production trend during the SAP period (Figure 1c); while changes in both area and yield were the major source of incremental change in production trend during the post-SAP era (Figure 1d). This general outlook did not come as a surprise as the pre-SAP era place more priority on the agricultural sector but the Nigerian's economy been nascent and poor in global trade integration affected the production of soyabean in Nigeria, thus the reason for the mild changes in the production trend of soyabean during this regime. For the SAP period, liberalization of the economy which led to the prioritization of black gold (crude oil) affected the agriculture sector: agricultural innovations and market promotion, thus the reason for area increase to sprout production increase rather than yield. For the post-SAP period, a decentralized and deregulated economy, competing demand and pressure on the existing land for purposes other than agriculture and the consequence of climate change due to exploitative human activities shrink the available arable land for agriculture production, thus the reason for the changes in soyabean production to be due to mixed change between area and yield during this regime.

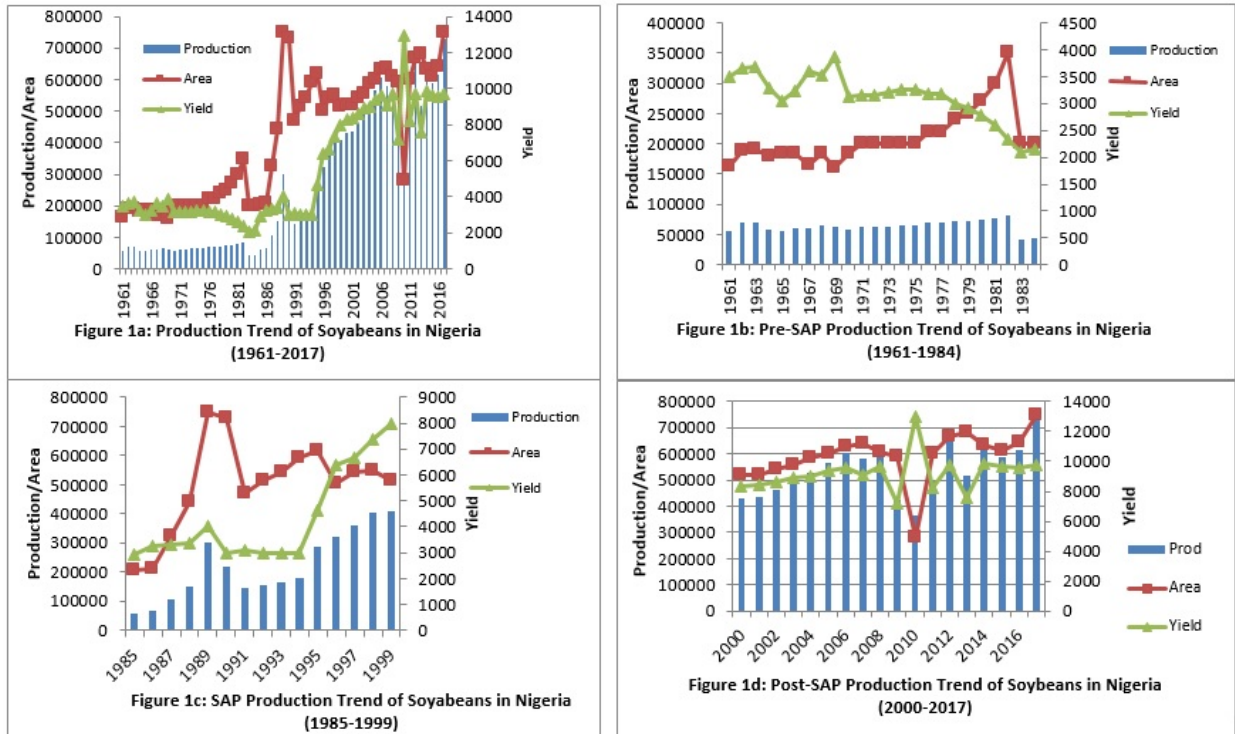


Figure 1. The trend patterns of production, area and yield across the sub-periods and the overall period.

3.2. Growth pattern of soybean production

A perusal of Table 3 showed the growth in the area, yield and production of soyabean in Nigeria to be magnificent over the three policy regimes considered. A significant increase in area was recorded during the SAP regime; a significant increase in yield was observed during the Post-SAP regime while a significant increase in production was recorded during the SAP and Post-SAP regimes. The annual average area under soyabean increased from 209 875 hectares during the pre-SAP era to 500 100 hectares during the SAP era, while the annual average yield sharply surged from 433 55kg during the SAP period to 919 62kg during the post-SAP regime. For the production, the annual average inclined steeply from 64208.33 tons during the pre-SAP regime to 221866.70 tons during the SAP regime, and thereafter geometrically increased to 538969.60 tons during the post-SAP regime. However, the growth in the area and yield were steady between the regimes that preceded post-SAP regime while that of the production was magnificent throughout the regimes.

The intra-year variation in area, yield and production of soyabean were observed to be considerably large as noticed from the variation in the annual compound growth rates across the three policy regimes and the overall period. The results showed the annual growth of production to have sharply increased from 0.1% during the pre-SAP era to 11.7% during the SAP era and then plummeted drastically to 1.9% during the post-SAP era. A similar trend was observed for the area as it steeply increased from 1.9% during the pre-SAP era to 5.2% during the SAP era and then sharply declined to 1.2% during the post-SAP regime. However, in the case of yield growth, unlike area and production growths it troughed (negative growth rate) during the pre-SAP regime (-1.8%) and thereafter revived steeply to 6.6% during the SAP regime, and then suddenly depressed to 0.6% during the SAP regime. Furthermore, the regime-wise analysis showed that the positive growth observed during the pre-SAP is solely due to increase in the area growth rate as the growth rate of yield was below the trough; while the positive production growth rates recorded during the succeeding regimes were due to both incremental growth rates in area and yield with yield and area growth rate increases been more pronounced during the

SAP and post-SAP periods respectively. For the overall period, the instantaneous increase in the soyabean production growth rate (5.4%) is due to increase in both the growth rates of area (2.9%) and yield (2.6%) as their difference is marginal. Therefore, it can be inferred that instantaneous increase in the growth rate of area contributed more to the instantaneous increase in the growth rate of production across the regimes while the instantaneous growth rate of the duo (area and yield) interchangeably contributed to the incremental production growth rate observed for soyabean during the overall period. Therefore, the similar rise and fall in the growth rates of area and production as noticed across the policy regimes clearly indicate that the prevailing risk in the production of soyabean in Nigeria has been quite high.

Table 3. Growth pattern of soyabean production

Variables	Pre-SAP	SAP	Post-SAP	Overall
Area (ha)	209875 (1.9)***	500100 (5.2)**	591761.8 (1.2) ^{NS}	406845.8(2.9)***
Yield (hg)	3116.208 (-1.8)***	4335.533 (6.6)***	9196.222 (0.6) ^{NS}	5357.088(2.6)***
Production (ton)	64208.33 (0.1) ^{NS}	221866.7 (11.7)***	538969.6 (1.8)**	255622(5.4)***

Source: Authors' computation, 2019.

Note: Figure in parenthesis is CAGR.

*** ** * & ^{NS} means significant at 1, 5, 10% and Non-significant respectively.

3.3. Instability in soybean production

For SAP and the overall periods, the growth rates for the area, yield and production were quite impressive but the extent of variability in the area, yield and production were quite large as evident from the percentage of the coefficient of variation (CV) index. Though the growth rates for the area, yield and production were not that quite impressive during the pre-SAP and post-SAP regimes but the extent of the variability was comparatively very less in terms of the measurement parameters (Table 4).

The CV of the area, yield and production for the overall period (1961-2017) were 49.06%, 54.53% and 85.68% respectively, while the same for the SAP regime were 31.63%, 41.95% and 52.90% respectively. Therefore, it can be inferred that the higher compound growth rates in the area, yield and production during the aforementioned periods were accompanied by a greater degree of variability. Decomposition analysis across the sub-periods with regard to the CV showed that Nigeria was in the comfort zone for soyabean production during the pre-SAP and post-SAP as evident by the CV indexes of 14.73% and 17.40% respectively, while during the SAP and overall periods it was not in the comfort zone despite its impressive production performance in terms of annual growth as indicated by the CV values of 85.68% and 52.90% respectively. However, both area and yield interchangeably were the cause of high fluctuation during the SAP and the overall periods, but yield fluctuation was more pronounced in both periods.

The results of the Cuddy-Della Valle instability index (CDII) for the area, yield and production across the three regimes and the overall period showed instability to be low, thus indicating that the production of soyabean during the three regimes were in the comfort zone. In order words, the exact direction of instability in the production of soyabean using CDII showed a low instability during the pre-SAP period while the succeeding policy regimes exhibited high instability in the production of soyabean. A similar trend of high instability was observed in the production of soyabean for the overall period. While CV is the simplest measure of instability, it overestimates the level of instability in data from time series that is characterized by long-term trends. The Cuddy Della Valle Index de-trends the yearly data and shows the exact direction of uncertainty (Cuddy & Della Valle, 1978), thus, the appropriate measure to capture instability in agricultural production. Also, in examining the year to year percentage variation in the production of soybean, the Coppock's instability index (CII) showed high instability in the soyabean production across the regimes and the overall period.

Table 4. Instability indices in soyabean production

Regimes	Variables	CV	CDII	CII
Pre-SAP	Area	0.21224	11.26994	44.05155
	Yield	0.14711	4.795786	41.57673
	Production	0.14732	12.37488	45.51702
SAP	Area	0.3163	23.78576	46.81591
	Yield	0.41945	15.18409	45.59728
	Production	0.52895	13.64691	47.2661
Post-SAP	Area	0.16302	13.20462	50.36041
	Yield	0.13257	12.32901	48.30737
	Production	0.17401	11.41506	50.76086
Overall	Area	0.49062	12.21644	50.89212
	Yield	0.5453	17.17695	49.12068
	Production	0.8568	14.73696	48.04758

Source: Authors' computation, 2019.

3.4. Sources of change in soyabean production

Given that the trend pattern of soyabean production has been analyzed, thus, it's imperative to know the sources of the growth in the production of soyabean and the variance *vis-a-vis* year in year out. For the intra-regime-wise, yield effect was identified to be the major source of production increase during the pre-SAP and SAP periods while area effect was found to be the major source of production increase during the post-SAP and the overall periods (Table 5).

Table 5. Sources of change in soyabean production (Intra-wise %)

Source of change	Pre-SAP	SAP	Post-SAP	Overall
Area effect	-154.226	25.83894	131.8764	76.32259
Yield effect	240.4686	73.50911	75.94499	71.77165
Interaction effect	13.76571	0.650943	-107.832	-48.0981
Total change	100	100	100	100

Source: Authors' computation, 2019.

Furthermore, for the inter-regime-wise, the major source of change in the production increase between pre-SAP and post-SAP periods was area effect (55.92%); while yield effect (76.42%) was discovered to be the major source of production increase between the SAP and post-SAP regimes (Table 6). Therefore, it can be inferred that low level of technological development was responsible for the dominant effect of area for the former transition while high technological advancement *viz.* introduction of hybrids, improved varieties, technological breakthrough, mechanization and development of research institutes were responsible for the dominant effect for the latter transition. Also, for the overall period i.e across pre-SAP, SAP and post-SAP, the dominant source of change in soyabean production in the study area is yield effect. This implies that the country is aiming towards output expansion for food security *viz.* high productivity as available arable land is shrinking due to high competing pressure on land for many uses thereby causing loss of lives and properties as evident by the frequent reoccurring farmers-herders clashes and communal conflicts.

Table 6. Sources of change in average production of soyabeans (Inter-regime wise %)

Source of change	Pre-SAP to SAP	SAP to Post-SAP	Overall
Area effect	15.82	76.42	14.43
Yield effect	55.92	12.49	-14.52
Interaction effect	21.88	14.01	-8.13
Covariance effect	6.38	-2.93	-3.27
Total change	100	100	100

Source: Authors' computation, 2019.

3.5. Sources of instability in soyabean production

The results of the decomposition analysis showed 'interaction between changes in mean area and yield variance effect' and 'interaction between changes in mean area and yield and change in area-yield covariance effect' to be the major sources of variation in the soyabean production between pre-SAP and SAP periods (Table 7). However, the effect of the former is marginally more pronounced than that of the latter. Between the SAP and post-SAP regimes, the dominant source of production variance is 'interaction between changes in mean area and yield and change in area-yield covariance' as it accounts for 70.21% variation in the total production variance of soyabean in the study area. However, for the overall period i.e. across the three regimes, the major source of soyabean production variance is 'change in residual' i.e. risk and uncertainty which accounts for 76.50% annual variation in soyabean production in Nigeria. This result is not surprising owing to the apprehension of capital loss by smallholder farmers who account for bulk production relies mostly on social capital due to lack of economic power and the heightened climate change effects.

Table 7. Sources of instability in soyabean production

Source of variance	Pre-SAP to SAP	SAP to Post-SAP	Overall
Change in mean yield	-0.54	-87.47	0.15
Change in mean area	0.85	-29.73	-0.32
Change in yield variance	7.52	53.00	9.99
Change in area variance	4.42	8.29	5.24
Interaction between changes in mean yield and mean area	-0.71	-9.55	-0.48
Change in area yield covariance	12.63	45.50	13.48
Interaction between changes in mean area and yield variance	35.18	21.21	-8.08
Interaction between changes in mean yield and area variance	4.13	29.01	7.51
Interaction between changes in mean area and yield and change in area-yield covariance	31.21	70.21	-3.98
Change in residual	5.32	-0.47	76.50
Total change in variance of production	100	100	100

Source: Authors' computation, 2019.

3.6. Acreage response of soyabean farmers

A perusal of Table 8 showed the Nerlovian acreage response model to be the best fit as it satisfied the ordinary least squares (OLS) criteria. The diagnostic test results showed the residual to be devoid of autoregression/serial correlation as indicated by the Durbin-Watson (DW) statistic of 2.424 which is greater than the benchmark value of 1.5; and the autocorrelation Langrage multiplier (LM) test statistic value of 1.648 which is not different from zero at 10% degree of freedom. In furtherance of the above test, the variance of the residual did not exhibit a correlation ($e_i^2 \neq e_j^2$) i.e. has no arch effect as evident by the LM test statistic value of 2.27 which is not different from zero at 10% degree of freedom. This clearly indicates that the result is not a spurious or nonsense regression. In addition, the variance of the residual variable was found to be constant (homoscedasticity) as indicated by the Breusch-Pegan LM test statistic value of 7.02 which is not different from zero at 10% degree of freedom, thus the absence of

heteroscedasticity. However, the residual variable did not exhibit a bell-shape (i.e. not normally distributed) as indicated by the Chi^2 test statistic value of 23.68 which is different from zero at 10% degree of freedom. Though, non-normality of the residual is not considered a serious problem as data in their natural form are not naturally distributed.

The test of multicollinearity indicates the absence of a collinear relationship between explanatory variables as evident by the explanatory variables variance inflation factors (VIF) which were below the VIF benchmark value of 10.0. The RESET test for specification test statistic value (3.71) not different from zero at 10% degree of freedom, implied that the structure of the model is appropriate i.e. rigid, thus suitable for prediction. It was also observed that there is no structural break in the equation i.e. the equation is stable as indicated by the CUSUM test statistic value of -1.007 which is not different from zero at 10% degree of freedom (Figure 2). In addition, it showed the population to be one and not subdivision(s). The coefficient of multiple determination is 0.8608, implying that 86.08% variation in the current acreage allocation is being influenced by the explanatory variables included in the model. In furtherance to the above, the R^2 value been normal indicates the absence of spurious correlation i.e. the estimated parameters does not drift with time trend. Thus, with these sufficient evidences it can be inferred that the model is the best fit and the estimated parameters are reliable for future prediction. The acreage allocation decision of soyabean farmers in Nigeria is influenced by lagged one year weather index, one year lagged yield, one year lagged cowpea and soyabean prices and one year lagged area cultivated under soyabean. Thus, the positive significant coefficients favorably influenced the area allocation decisions of the farmers while the negative significant coefficients negatively influenced the acreage allocation decisions of the soyabean farmers in the study area.

The negative significance of weather index implies that the effect of the one year lagged weather vagaries makes farmers decrease the current area cultivated under soyabean. Therefore, the marginal implication of an increase in weather vagaries will lead to a decrease in the current total area allocation to soyabean by 126393 hectares. In addition, the short-run (SR) and long-run (LR) elasticities implications of a unit change in the weather vagaries will lead to a decrease in the acreage allocation by 0.297% and 0.899% respectively. The positive significance of the one year lagged yield level indicates that high productivity owing to the adoption of improved varieties encouraged farmers to increase the current area allocation to soyabean in the study area. Thus, the marginal effect of a unit increase in the lagged year yield level by 1 kg will lead to an increase in the current area allocation to soyabean by 54.44 hectares. Also, the SR and LR elasticities implications of a unit increase in the lagged yield would lead to an increase in the current acreage allocation by 0.691% and 2.094% respectively.

The negative significance of the one year lagged soyabean price showed how fear of glut owing to cobweb effect decreased the current area allocation to soyabean. In addition, it implied high imperfection in the marketing of soyabean in the country. Therefore, the marginal effect of a unit increase in the producer price per ton will force farmers to decrease the current area allocation by 7.54 hectares. In addition, the SR and LR elasticities implications of a unit increase in the lagged producer price of soyabean would lead to a decline in the current acreage allocation to soyabean by 0.414% and 1.255% respectively. The positive significance of the one year lagged price of cowpea showed that soyabean farmers take advantage of the high price of the competing crop to increase their output supply in order to generate remunerative price i.e better farmers' term of trade. Thus, the marginal implication of a unit increase in the lagged producer price of the competing crop will lead to an increase in the current acreage allocated to soyabean by 3.22 hectares. In addition, the SR and LR elasticities implications of a unit increase in the lagged price of the competing crop will lead to a decrease in the current soybean area allocation by 0.201% and 0.608% respectively.

The positive significance of the one year lagged area cultivated under soyabean indicated partial adjustment or lesser rigidity in the current acreage allocated to soyabean in the study area. In addition, it implied that the producers of soyabean in the country not only considered the preceding year's price but also the past experience in the area allocation decision under soyabean. Thus, it can be inferred that the immediate lagged area allocation accounted for 67.04% of the current area allocation for soyabean production in the study area. In addition, the SR and LR elasticities implications of a unit increase in the

lagged area allocation to soyabean will lead to an increase in the current soyabean acreage allocation by 0.656% and 1.989% respectively. The positive sign of the intercept coefficient though non-significant implies that acreage allocation to soyabean responded to technology i.e. technological improvements viz. improved seed varieties, agrochemicals and mechanization influenced farmers' decision on current area allocation to soyabean production. Thus, the marginal implication of a unit increase in the level of technology will encourage farmers to increase area allocation under soyabean production by 32075.10 hectares in the study area.

Table 8. Farmers' acreage response

Variables	Parameters	t-stat	Mean	MPP	SRE	LRE	VIF
Intercept	32075.1(72256.4)	0.44 ^{NS}	-	-	-	-	-
SP _{t-1}	-7.539(2.104)	3.58***	22489.69	-7.54	-0.414	-1.255	25.001
CP _{t-1}	3.223(1.510)	2.13**	25497.52	3.22	0.201	0.608	17.326
SPR _{t-1}	1.687(8.142)	0.21 ^{NS}	2680.77	1.69	0.011	0.034	5.670
CPR _{t-1}	0.269(2.152)	0.12 ^{NS}	5935.84	0.27	0.004	0.012	4.675
SY _{t-1}	54.438(18.312)	2.97***	5195.40	54.44	0.691	2.094	19.668
CY _{t-1}	1.396(11.13)	0.13 ^{NS}	5239.98	1.4	0.018	0.054	6.028
SYR _{t-1}	11.035(31.865)	0.35 ^{NS}	497.55	11.04	0.013	0.041	3.580
CYR _{t-1}	24.116(26.703)	0.90 ^{NS}	784.55	24.12	0.046	0.140	4.151
WI _{t-1}	-126393(64705.3)	1.95*	0.9609	-126393	-0.297	-0.899	3.342
A _{t-1}	0.670(0.114)	5.84***	401021.2	0.67	0.656	1.989	3.361
R ²	0.861						
F-stat	22.27{1.5E-12}***						
DW	2.423						
Autocorr.	1.64{0.19} ^{NS}						
Arch eff.	2.27{0.51} ^{NS}						
Heterosc.	20.2{0.44} ^{NS}						
Normality	23.6{7.2E-6}***						
CUSUM	-1.007{0.32} ^{NS}						
RESET T	3.70{0.34} ^{NS}						

Source: Authors' computation, 2019.

Note: *** ** * ^{NS} means significant at 1%, 5%, 10% probabilities and Non-significant respectively.

Values in (), [] and { } are standard error, t-statistic and probability level respectively.

3.7. Short-run and long-run elasticities

A cursory review of the results showed that the farmers' response to a price change in the short-run was inelastic (-0.414) while in the long-run they were elastic (-1.255) to price change as indicated by the coefficients of the former and latter which were less than unit and greater than unity respectively (Table 9).

The short-run elasticity revealed soyabean farmers' acreage responsiveness to price changes during the preceding crop period. However, it should be noted that, as observed in many earlier studies, negative supply response is not an uncommon feature in the supply response. For example, in nearly six gram cultivating districts in Punjab, Sud and Kahlon (1969) observed negative price coefficients; Cumming (1975) also observed a negative price coefficient in nearly half of India's 100 wheat-growing districts; Jhala (1979) also observed a negative price response in six of his fourteen groundnut-growing cases. This kind of conflicting estimate was reported in studies of Krishna (1963); Krishna & Rao (1967); and Bhowmick and Goswami (1998). This result is similar to the finding of Jain et al. (2005), who in his study on oilseeds output growth in Rajasthan State of India, observed a negative price coefficient for soyabean. Sadiq et al. (2017) in their study on supply response of cereal crops in Rajasthan State of India observed negative price coefficients for maize and Bajra. Of recent, Sadiq et al. (2019) in their study on the dynamics of root and tuber crops' acreage allocation and yield adjustment in Nigeria observed a negative price coefficient for yam.

If given the requisite time to adjust, the long-run elasticity represents the soyabean crop's acreage sensitivity to price changes. Because the soyabean crop showed very low long-run elasticity, the long-run effect of the price policy instrument on this crop would not have been significant. Because the soyabean crop showed very low long-run elasticity, the long-run effect of the price policy instrument on this crop would not have been significant. The number of years needed to materialize the price impact depends on the technical and institutional constraints for a specific crop that the farmers face. The higher the restrictions, the more time for adjustment is needed. It has been observed that the crop has taken substantial large time for adjustment to materialize its price. A similar result for soyabean crop was discovered by Jain et al.(2005) in their study on oilseed crops in Rajasthan State of India. The shorter the time for adjustment, the more efficient the market policy instruments are in bringing about desired improvement in a crop's supply (Sadiq et al., 2017). Also, it was observed that the farmers' responses to changes for the remaining parameters in the short-run and long-run were inelastic except for the lagged yield and area which were elastic.

Table 9. Time required for the price effects to materialize

Crops	Price elasticity		Adjustment coefficient		Time (yr)
	SR	LR	SR	LR	
soybeans	-0.414	-1.255	0.656	1.989	7.48

Source: Authors' computation, 2019.

3.8. Production forecast of soyabean

The future trend of soybean production in Nigeria was forecasted using ARIMA at different Autoregression (AR) and moving average (MA) levels (Table 10). All the variables *viz.* production, area and yield did not converged when the ARIMA was tested at level, but converged when tested at first difference, thus indicating that the variables were non-stationary at level but at first difference. Thus, the variables were stationary before the forecasts were made. A perusal of the Table showed ARIMA (1,1,1) and ARIMA (1,1,0) to be the best fits for forecasting the production and area; and, yield respectively, as they have the lowest Akaike information criteria (AIC) value among all the ARIMA levels estimated. Furthermore, all the best fit ARIMAs have their residuals devoid of autocorrelation and auto-covariance (arch effect) as evident by their respective autocorrelation LM and Arch effect LM tests respectively, which were not different from zero at 10% degree of freedom. However, the diagnostic test results showed that the residuals failed the test of normality as indicated by the Chi² statistic values of the respective ARIMAs which were different from zero at 10% degree of freedom. Just as earlier mentioned, non-normality of residual is not considered a serious problem as data in their normal form are not normally distributed. Therefore, the absence of white noise means that the soyabean production variables are predictable, thus good for policymaking, farmers' decision on supply allocation and consumption pattern.

Table 10. ARIMA models

Variable	Model	AIC	Autocr	Arch effect	Normality test
Production	ARIMA (1,1,1)	1387.998	0.663(0.41) ^{NS}	7.93 (0.16) ^{NS}	12.95(0.0015)***
	ARIMA (1,1,0)	1388.08	-	-	-
	ARIMA (0,1,1)	1388.002	-	-	-
Area	ARIMA (1,1,1)	1439.91	2.483(0.11) ^{NS}	4.42(0.21) ^{NS}	64.1(1.2E-14)***
	ARIMA (1,1,0)	1441.50	-	-	-
	ARIMA (0,1,1)	1441.24	-	-	-
Yield	ARIMA (1,1,1)	931.22	-	-	-
	ARIMA (1,1,0)	929.57	0.309(0.85) ^{NS}	5.87(0.11) ^{NS}	18.8(8.08E-05)***
	ARIMA (0,1,1)	940.50	-	-	-

Source: Authors' computation, 2019.

Validation (ex-post prediction power)

To determine the predictive power of the estimated equation (Table 11a), a one-step forecast of the variables along with their corresponding standard errors using naïve approach for the period 2013 to 2017 (a total of 5 data points) was calculated with respect to the fitted ARIMA models. Through the sample periods, the calculated models were validated to determine how closely they could follow the actual observation path.

Table 11a. One step ahead forecast of soyabean production

Period	Production		Area		Yield	
	Actual	Forecast	Actual	Forecast	Actual	Forecast
2013	517960	642296.1	680000	638685.9	7617	8930.46
2014	623815	537925	633016	654318.4	9855	9171.97
2015	588523	626483	609333	623971.7	9658	8581.16
2016	614632	600761	641823	607800.2	9576	9968.74
2017	730000	624315.9	750000	633111.8	9733	9811.9

Source: Authors' computation, 2019.

The forecasting ability of the variables were measured using the mean absolute prediction error (MAPE), root mean square error (RMSE), Theil's inequality coefficient (U) and the relative mean absolute prediction error (RMAPE) (Table 11b). Generally, the values of the RMAPE were very low i.e. less than 5% and also the values of U were less than 1.

The implication of the findings is, therefore, that the predictive error associated with the estimated equations in monitoring the actual data (*ex-post* prediction) was very small and negligible, and could therefore be used for *ex-ante* projection with strong forecast validity and accuracy.

Table 11b. Validation of models

Variable	R ²	RMSE	RMSPE	MAPE	RMAPE (%)	Theil's U
Production	0.945532	63528.9	5977.491	33497.04	4.810509	0.868745
Area	0.96531	55656.98	4217.849	22993.98	3.023684	1.001981
Yield	0.97226	597.7599	36.83022	257.646	2.633716	0.542345

Source: Authors' computation, 2019.

Shown in Table 11c and Figure (3-5) are the computed one-step-ahead out of the sample forecasts for production (ton), area (hectare) and yield (hg) of soyabean spanning from 2018-2027. A perusal of the graphs showed that there will be a gentle rise in the future production trend of soyabean; there will be a gentle decline in the future area trend of soybean, while the yield will be marked by a flat-slight trend rise during the forecasted periods. In case of any fluctuation, the forecasted figures will not go below the lower limit nor exceed the upper limit. Therefore, it can be inferred that the gentle rise in the future trend of soyabean production will be due to steady-flat rise in the yield. Thus, technology will be the major driver of soyabean production in Nigeria. The country is expected to witness a paradigm shift from area as the major driver of production to yield. The trend if sustained will be a major breakthrough for the country food security and containing the incessant farmers/herders clashes and tenurial conflicts owing to high pressure and competing demand for arable land for other purposes. Any policy which will convert arable land to other agricultural uses should be welcomed as the future production trend of soyabean will be driven by technological advancement. For sustainability of soyabean food security, viable policies that will sustain the quality of the soil *viz.* containing excessive exploitation of agricultural resources which add to global warming should be put in place and implemented holistically, otherwise, this forecasted trend will be jeopardized.

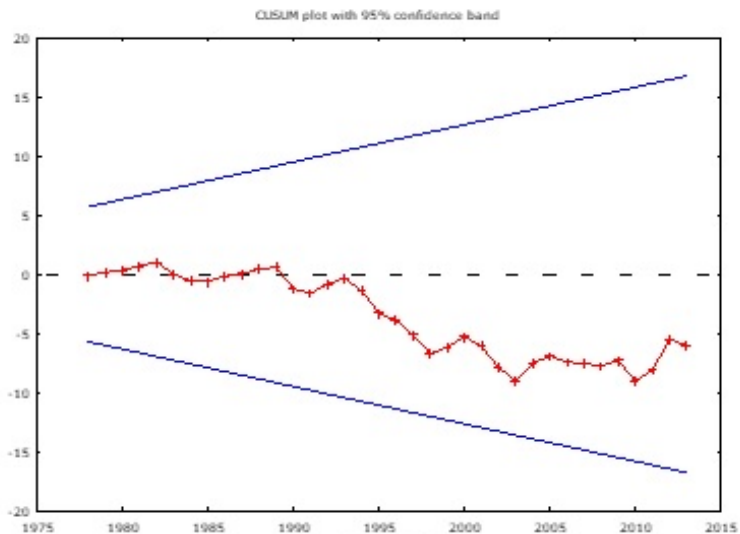


Figure 2: Stability Test

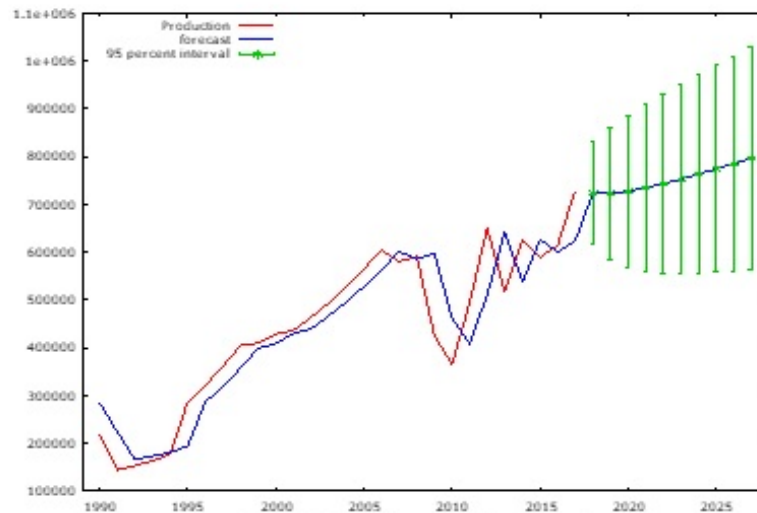


Figure 3: Production forecast of soyabeans in Nigeria

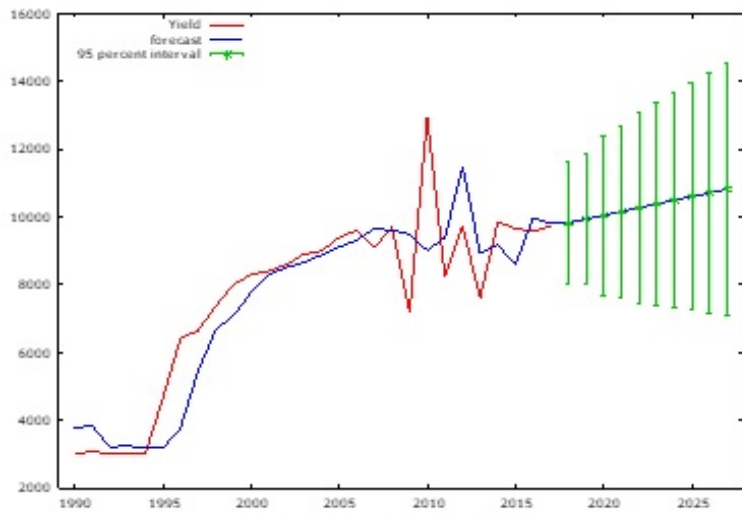


Figure 5: Yield forecast of soyabeans in Nigeria

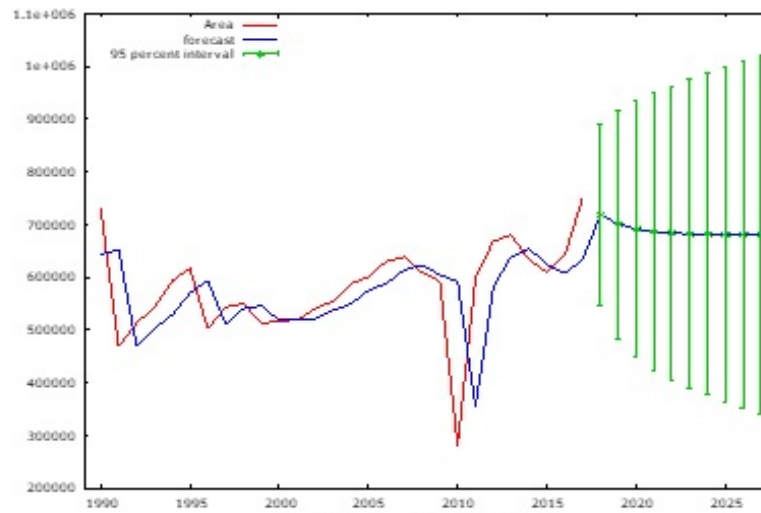


Figure 4: Area forecast of soyabeans in Nigeria

Figure 2: CUSUM test for parameter stability; Figure 3-5: Production forecast

Table 11c. Out of sample forecast of the variables

Year	Production			Area		
	Forecast	LCL	UCL	Forecast	LCL	UCL
2018	723019.2	616675.9	829362.4	718196.9	546204.2	890189.7
2019	723019	584422.6	861615.5	700889.3	483976.7	917801.9
2020	727363.6	568318.5	886408.7	691470.2	448032.9	934907.6
2021	734412.2	560136.3	908688.1	686344.2	423656.1	949032.3
2022	743143.8	556417.6	929870.1	683554.6	405125.9	961983.3
2023	752922.9	555396.2	950449.7	682036.4	389790.9	974282
2024	763354	556087.1	970620.8	681210.2	376319.3	986101.2
2025	774190.7	557913.5	990467.9	680760.6	364010.3	997510.9
2026	785280	560525.8	1010034	680515.9	352481.4	1008550
2027	796526.5	563706.5	1029347	680382.8	341516.4	1019249
Year	Yield					
	Forecast	LCL	UCL			
2018	9813.37	8013.79	11612.96			
2019	9943.61	8037.43	11849.79			
2020	10041.4	7681.89	12400.9			
2021	10160.3	7636.88	12683.73			
2022	10265.47	7463.73	13067.2			
2023	10379.57	7402.24	13356.9			
2024	10487.86	7298.29	13677.42			
2025	10599.93	7240.38	13959.48			
2026	10709.54	7170.43	14248.65			
2027	10820.75	7121.89	14519.62			

Source: Authors' computation, 2019.

4. Conclusion and Recommendations

Based on the results, it can be inferred that the increased growth trend of soyabean production in Nigeria was majorly due to the increase in the area cultivated under soyabean. Furthermore, the rise and fall in the growth of area which is the major driver of production growth as noticed across the policy regimes clearly indicate that the prevailing risk in the production of soyabean in Nigeria has been quite high. In addition, evidence of risk and uncertainty accounts for the chunk (76.50%) of annual variation in soyabean production in the studied area as indicated by 'change in residual' parameter. Also, the farmers had a preference for risk with respect to the price of the competing crop but are risk-averse with respect to the price of the soyabean crop in taken decision on acreage allocation. Empirical evidence showed a good future production trend for soyabean in the country which will be driven by technological changes. Thus, viable policies that will sustain soil health status and the environment should be put in place. Besides, policies which will convert one-quarter of the arable land to other agricultural uses should be welcomed as the future production trend of soyabean will be driven by technological advancement. Owing to the production and marketing risks, government should do more in subsidizing farm inputs so that the farmers can have favorable farmers' terms of trade.

References

- Agricultural Media Resources and Extension Centre (AMREC). (2007). Mapping of soybean production areas in Nigeria. *Monograph Series 28*, AMREC, University of Agriculture, Abeokuta, Nigeria.
- Ahmed, S.I., & Joshi, M.B.(2013).Analysis of instability and growth rate of cotton in three district of Marathwada. *International Journal of Statistika and Matematika*, 6(3), 121-124.
- Ayalew, B.(2015).Supply response of maize in Ethiopia: Cointegration and Vector Error Correction Approach. *Trends in Agricultural Economics*, 8 (1), 13-20.
- Bhowmick, B.C., & Goswami, J.(1998).Supply response of some important crops in Assam-An inter-district analysis. *Agricultural Situation in India*, 55(6), 349-356.

- Box, G.E., & Jenkins, G.M.(1976).*Time Series Analysis: Forecasting and Control*. Holden Day, San Francisco.
- Boyal, V.K., Pant, D.C., & Mehra, J.(2015).Growth, instability and acreage response function in production of cumin in Rajasthan. *The Bioscan*, 10(1), 359-362.
- Coppock, J.D.(1962).*International Economic Instability*. McGraw-Hill, New York, pp 523-525.
- Cuddy, J.D.A., & Valle, P.A.D.(1978).Measuring the instability of time series data. *Oxford Bulletin and Economic Statistics*, 40, 53-78.
- Cummings, J.T.(1975).The supply responsiveness of Indian farmers in the post-independence periods-major cereals and cash crops. *Indian Journal of Agricultural Economics*, 30(1), 25-40.
- Debnath, P., Singh, R., Feroze, S.M., & Sarkar, A.(2015).Study on growth and instability of sesame in north-eastern hill region of India. *Economic Affairs*, 60(2), 193-196.
- Dhakre, D.S., & Sharma, A.(2009).Growth and instability analysis of ginger production in North-East Region. *Agricultural Situation in India*, 66(8), 463-466.
- Gujarati, D., Porter, D., & Gunasekar, S.(2012).*Basic Econometrics*. McGraw Hill, New Delhi.
- Hazell, P.B.R.(1982).Instability in Indian food grain production.*Research Report 30*, Washington, D.C., USA: International Food Policy Research Institute.
- Jain, P.K., Singh, I.P., & Kumar, A.(2005).Risk in output growth of oilseeds in the Rajasthan State: A Policy Perspective. *Agricultural Economics Research Review*, 18 (Conference No.), 115-133.
- Jhala, M.L.(1979).Farmers response to economic incentive: An analysis of inter-regional groundnut supply response in India. *Indian Journal of Agricultural Economics*, 34(1), 55-67.
- Krishna, J., & Rao, M.S.(1967).Dynamics of acreage allocation in U.P.- A study of supply response. *Indian Journal of Agricultural Economics*, 22(1), 37-52.
- Krishna, R.(1963).Farm supply response in India-Pakistan: A case study of the Punjab Region. *Economics Journal*, 73(291), 477-487.
- Kumar, N.S, Joseph, B., & Muhammed, J.P.K.(2017).Growth and Instability in Area, Production, and Productivity of Cassava (*Manihot esculenta*) in Kerala. *International Journal of Advance Research, Ideas and Innovations in Technology*, 4(1), 446-448.
- Ojo, D.K.(2002).Food legume for health and wealth. *Lecture Series 4*, UNAAB Alumni Association, January 2002.
- Okoruwa, A.E.(2001).Nutritional value and uses of legumes in Africa. *Paper presented at the Legume Breeders Workshop*, IITA Ibadan, Nigeria.
- Paul, R.K.(2014).Forecasting wholesale price of pigeon pea using long memory time-series models. *Agricultural Economics Research Review*, 27(2), 167-176.
- Raw Materials Research and Development Council (RMRDC)(2004).*Soybeans*. A Report. Pp. 1-99.
- Sadiq, M.S., Singh, I.P., & Karunakaran, N.(2017).Supply response of cereal crop farmers to price and non-price factors in Rajasthan state of Nigeria. *Journal of Agricultural Economics and Rural Development*, 3(2), 203-210.
- Sadiq, M.S., Singh, I.P., Yusuf, T.L., Sani, T.P., & Lawal, M.(2018). Sustainable cowpea trade in West Africa Region. *Journal of Forestry, Environment and Sustainable Development*, 4(1), 91-105.
- Sadiq, M.S., Karunakaran, N., & Singh, I.P.(2019).Dynamics of root and tuber crops acreage allocation and yield adjustment in Nigeria. *International Journal of Research-Granthaalayah*, 7(2), 144-161.
- Sandeep, M.V., Thakare, S.S., & Ulemale, D.H.(2016).Decomposition analysis and acreage response of pigeon-pea in western Vidarbha. *Indian Journal of Agricultural Research*, 50(5), 461-465.
- Stalling, J.L.(1960).Weather indexes. *Journal of Farm Economics*, 42, 180-186.
- Sud, L., & Kahlon, A.S.(1969).Estimation of acreage response to price of selected crops in Punjab State. *Indian Journal of Agricultural Economics*, 34(3), 46-49.
- Umar, S.M., Suhasini, K., Jainuddin, S.M., & Makama, S.A.(2019).Sources of growth and instability in cassava production in Nigeria: An evidence from Hazell's Decomposition Model. *SKUAST Journal of Research*, 21(1), 86-95.