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Email: tajar2011@yahoo.com, tajar2011@gmail.com

ANALYSIS OF TOTAL FACTOR PRODUCTIVITY OF COWPEA FARMERS IN NORTH-CENTRAL NIGERIA

Isonguyo, R. G., Ojo, M. A., Jirgi, A. J. and Yisa, E.S.
Department of Agricultural Economics and Farm Management
Federal University of Technology, Minna, Nigeria

Corresponding Author's email address: risonguyo@yahoo.com

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ABSTRACT

Analysis of total factor productivity change in cowpea production in North-Central Nigeria between 1993 and 2017 was carried out with secondary production data. The data of cowpea from 1993 to 2017 were collected from National Bureau of Statistics, States, Food and Agriculture Statistical (FAOSTAT) data banks. Malmquist Total Factor Productivity Index (MTFPI) obtained from data envelopment analysis (DEA) was used in analyzing total factor productivity growth of the cowpea, while Tobit regression was used to analyze the determinants of total factor productivity. The results of the MTFPI analysis revealed that technical efficiency change contributed 0.7% to cowpea productivity growth, while technology regressed at 0.5%, leading to cowpea productivity growth at 0.2%. Tobit regression result showed rainfall to have significant and positive relationships with cowpea productivity at 1% level of significance. Credit borrowed for cowpea production had positive and significant relationship with productivity growth at $P \leq 0.05$ over the period studied. Capital was statistically significant but negatively related to productivity at 10%. The study recommends farmers' training on farm practices and techniques to increase productivity. They should be encouraged to accept innovations from research institutes and properly allocate production resources to achieve cowpea productivity growth in the area.

Key words: Efficiency change, productivity growth, technical progress,

INTRODUCTION

Nigeria is currently facing food scarcity, since the agricultural sector is producing at a production growth rate of about 1.7% (Food and Agriculture Organization (FAO, 2016). The country operates subsistence and traditional agriculture with low production output which leads to the productivity growth rate of between 0.03 and 0.09 (Central Intelligence Agency (CIA), 2016), while Nigeria's population growth rate is estimated at about 2.7% per annum (United Nations, 2018). However, Nigeria is known to be the world's largest producer and consumer of cowpea from about 5 million hectares of land at over 2 million tonnes annual production (FAO, 2016). Although, the National Bureau of Statistics (NBS) (2016) had reported that the Gross Domestic Product (GDP) of cowpea was valued at about 127.23 billion Naira in 2013, which rose to about 135.84 billion Naira in 2015, the gap between demand and supply for food in Nigeria still needs to be bridged. This is because food consumption has increased to about 150kg and 214kg per person for grains and root crops respectively.

The per capita consumption of cowpea in Nigeria, for example is about 25 to 30kg per annum (Ajetomobi, 2009), yet, previous studies on agricultural productivity (Jatto *et al.,* 2015; Ajao, 2011 and Adepoju, 2008) did not link food demand and supply to productivity growth. These studies are yet to provide adequate information to solve the food inadequacy in the country. However, Durodol (2010) did observe total factor productivity growth to be a key player and the most important role in the economic development of Nigeria. This study assessed the extent and direction in which cowpea crops' productivity has changed in North-Central Nigeria from 1993 to 2017, regardless *of the existing political regime*. It is also aimed to establish the source of the productivity change as it set out to: (i) determine the evolution of efficiency and total factor productivity change in its production; (ii) determine the technical change or progress observed in the production and (iii) ascertain the determinants of total factor productivity growth in the study area

Agricultural productivity derived from the combination of variable production inputs

with a fixed input to produce output is referred to as the production function. Ojo *et al*., (2013) defined it as a mathematical or quantitative description of input-output relationship which provides direct measurement of resource productivity parameters and coefficients to enable minimization of inputs or maximization of output in production economics. The concept can be traced to the pioneer work of Farrel (1957). Production efficiency is made up of pure and technical efficiency (Brümmer *et al*., 2002). Total factor productivity growth is derived from technological progress, innovation, improved social infrastructure and increased technological investment, which relates an index of output (Y) to aggregate index of all factors employed in the production of the output (Kohli, 2002). It remedies the shortcomings of partial measures of productivity, when an index of agricultural inputs is compared to that of outputs, which factor that cause the change is difficult to identify (Chavas and Di Falcon, 2014).

Conceptually, productivity in agriculture is used synonymously with efficiency and the four major independent sources of its change are; technical efficiency change (TEFFCH), technological change (TECHCH), scale efficiency change (SEC), and an input mix effect (IME). The calculation of the index depends on the use of DEA technique, which involves the use of distance function, expressed as: $D^{t}{}_{0}Q^{t}X^{t}$ which, if equals to 1, implies technical efficiency or inefficiency if otherwise (Daskovska *et al*., 2010).

METHODOLOGY

The Study Area

This study was conducted in North-Central Nigeria, which is made up of Benue, Kogi, Kwara, Niger, Nasarawa, Plateau States and the Federal Capital Territory (FCT), Abuja, as shown in Figure 1. The zone is located between Longitude $2^{0}30'$ to $10^{0}30'$ East and Latitudes $6^{0}30'$N to $11^{0}20'$ North. It occupies a total land area of about 296,898 km^{2}, with estimated population of about 23,505,206 people as at 2017 (National Bureau of Statistics (NBS), 2016).. More than 77% of the people in this zone are rural dwellers and are mostly engaged in one form of agricultural activity or the other (Aregheore, 2009). The zone has wet seasons from March to October, and dry season from November to March. Annual rainfall ranges between 1,000 and 1,500mm at an average of about 187 to 220 days, with average monthly temperature ranges of 21ºC to 37ºC. The zone has Forest Savannah Mosaic, Southern Guinea Savannah and the Northern Guinea Savannah vegetation. The people are mainly farmers, hunters, fishermen and artisans and the major crops grown include rice, maize, millet, sorghum, yam, potatoes, cassava, cowpea, soybean and vegetables.

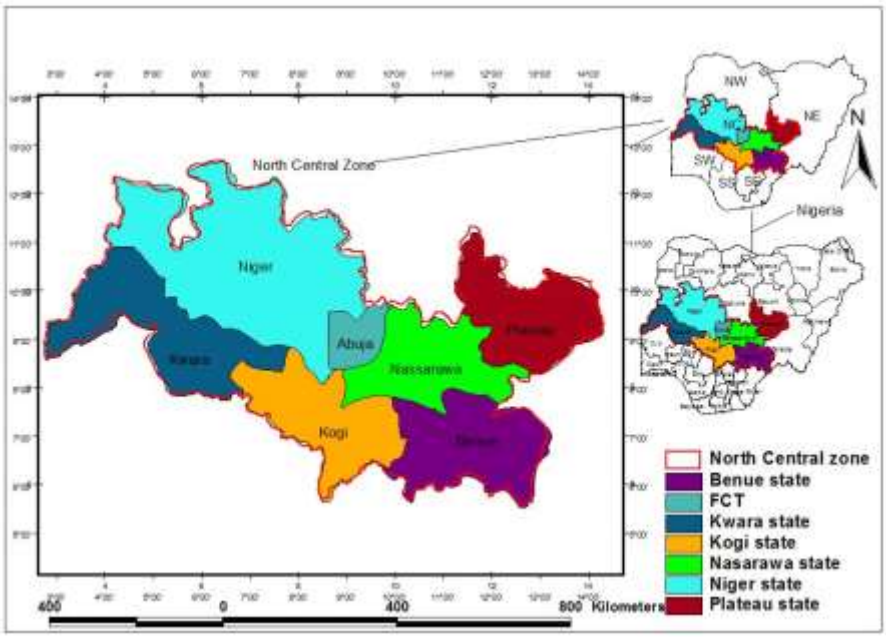

Figure 1. Map of North-Central Nigeria showing the States that make up the zone

Sampling Techniques

Sampling Techniques

Multi-stage sampling technique was used to select the states that are known to produce cowpea, in North-Central Nigeria in order to get the sample size of the secondary data for this study. The first stage involved random selection of five states in the zone which include Benue, Kwara, Niger, Kogi and Plateau. The second stage involved proportional sampling of 12 Local Government Areas (LGAs) from the compiled list of all the Local Government Areas from the five selected states combined. The third stage also involved random selection of five villages from each of the selected LGAs. Ten food crop farmers were randomly selected from each of these villages to give a total of 600 cowpea farmers as the sample size of the secondary data.

Method of Data Collection

The secondary production data on cowpea from 1993 to 2017 for each State and the zone were collected from National Bureau of Statistics (NBS), States' Agricultural Development Programmes (ADPs), States and Federal Ministry of Agriculture, Abuja, Food and Agriculture Organization Statistical data bank (FAOSTAT). The secondary data collected from these establishments for the States studied included cowpea annual outputs measured in tonnes, the production inputs, such as farm size cultivated (in hectares), seed (in tonnes), labour (in man-days) and fertilizer (in tonnes) and capital (measured in Naira and Kobo).

Analytical Techniques

The Objectives (i) and (ii) of this study were achieved using a non-parametric approach of Data Envelopment Analysis (DEA), based on Malmquist Total Factor Productivity Index (MTFPI).This is because DEA approach is a deterministic method based on linear programming for determining the evolution of efficiency, total factor productivity and technical changes or progress observed in the production of cowpea (objectives i and ii), which does not consider the random errors (statistical noise), and as such, requires no predefinition of the distribution of the error term. The results of the analysis were compared across the selected States in the study area. The evolution of different estimated efficiencies (technical, pure and scale efficiency changes) and productivity growth over time were presented using graphs and Tables. Tobit regression analysis, which offers the best option was used to identify the determinants of total factor productivity change (objective iii).

Model specification

Malmquist total factor productivity index (MTFPI)

In using the Malmquist TFP index (MTFPI), distance functions were calculated for the TFP change between the two periods (t and t+1). Linear Programming (LP) problems were solved with the use of constant return to scale (CRS) to maintain uniformity of the variables. This distance is defined as inverse of Farrell's ratio between an output quantity change index and input quantity change index (Farrell, 1957) The required LPs equations are expressed as follow:

$[D_0(X^{k*}, Y^{ky})]^{-1} Z^k, \theta^k$ = Max θ^{k*}……..(1)
Subject to:
$\sum_{k=1}^{N} Z^k Y_j^k \geq Y_j^k, \theta^{k*}$ j=1..., j
$\sum_{k=1}^{N} Z^k X_h^k \geq X_h^{k*}$ h=1..., H
$Z^k \geq 0$ k=1..., N

$[D_0^{t+1}(X_{t+1}^{k*}, Y_{t+1}^{k*})]^{-1}$ = Max θ^{k*} …….(2)
Subject to:
$\sum_{k=1}^{N} Z^{k*} X_{t+1}^{k*} \geq Y^{kh} \theta^{k*}$ j=1..., J
$\sum_{k=1}^{N} Z^k X_h^k \geq X_h^{k*}$ h=1..., H
$Z^k \geq 0$ k=1..., N
Where:
D_0 is the output distance function; t is the initial period ; t+1 is the proceeding period; Y is the output quantity; X is the input quantity; N is the total population of farmers studied; k is the number of the States studied; $k*$ is the particular State, whose efficiency is being measured; j is the set of outputs; h is the set of inputs; Z^k is the weight of the k^{th} State's data and θ is the efficiency index, which is equal to 1 if k* State is efficient in producing the output vector. A less than one efficiency index indicates inefficiency in production. The Malmquist Index between period t and t-1 is still defined as the geometric mean of two Malmquist Index vectors (Ludena, 2010).

Linear programmes LP (1) and (2), therefore, are the point at which production points were compared to technologies from different time periods, which θ parameter is

between 0 and 1. (Daskovska *et al.,* 2010) . Equations (1) and (2) are further expressed as:

Maximize: $Y^k = Y_1Z_1 + Y_2Z_2 + Y_3Z_3 + Y_4Z_4 + Y_5Z_5$

Subject to:

$A_{11}X_1 + A_{12}X_2 + A_{13}X_3 + A_{14}Z_4 + A_{15}Z_5 \leq H$

$A_{21}X_1 + A_{22}X_2 + A_{23}X_3 + A_{24}Z_4 + A_{25}Z_5 \leq L$

$A_{31}X_1 + A_{32}X_2 + A_{33}X_3 + A_{34}Z_4 + A_{35}Z_5 \leq C$…….. (3)

$A_{41}X_1 + A_{42}X_2 + A_{43}X_3 + A_{44}Z_4 + A_{45}Z_5 \leq S$

$A_{51}X_1 + A_{52}X_2 + A_{53}X_3 + A_{54}Z_4 + A_{55}Z_5 \leq F$

$Y^kZ^k \geq 0$

Where:

Y^k denotes cowpea output in tonnes); X_1, X_2, X_3, X_4, X_5, denotes decision variables; Y_1, Y_2 Y_3 , Y_4 denotes output coefficients maximized; A_{ij} denotes Input-Output coefficients. H = Farm /size cultivated (hectares); L = Labour used for the period of t activity (man-day); C = Working capital used at period t (Naira and Kobo); S = Quantity of seeds planted during period t (tonnes); F = Quantity of fertilizer used at period t (tonnes); Z^k = Weight of the k^{th} state's data (tonnes). Equation (3) was used for Table 1-3.

Tobit regression model

Tobit regression model is a censoring model and was used to estimate the determinants of TFP change of the production of cowpea. The model is defined as;

$Y_i^* = X_i\beta + \mathcal{E}_i^*$

……. (4)

$Y_i^* = \begin{cases} Y_i^* \; if \; Y_i^* > 0 \\ 0_i \; if \; Y_i^* \leq 0 \end{cases}$

Where:

Y_i^* is a latent (unobservable) variable; > = greater than; ≤ = less than /equal to.; Y_i is the observed dependent variable, observed 0's on the dependent variables could mean real 0 or censored data. The explicit form of the Tobit model is as expressed as follows:

$Y_i^* = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4$

……. (5)

Where:

Y_i^* = Total Factor Productivity Change (TFPCH); β_0 = Intercept; $\beta_{1\text{-}6}$ = Parameter to be estimated, which determines the relationship between TFP and X_1-X_6 (Independent variables); X_1 = Climatic Factor: Rainfall (Milimetre); X_2 = Institutional Factor: Amount of Credit (Naira and Kobo); X_3 = Government Policy: Agricultural Transformation Agenda (Score 0 = period before the programme, and Score 1= during the programme); X_4 = Capital-Labour ratio.

RESULTS AND DISCUSSION

Trend of Efficiency and Total Factor Productivity Change in the Production of Cowpea in North-Central Nigeria

The trend of efficiency and total factor productivity changes in cowpea production in North-Central Nigeria is shown in Table 1. The result of the study revealed that resources in cowpea production were efficiently allocated in most of the years (16 years) and inefficiently allocated in 8 years studied. Average pure and scale efficiency changes indicated 0.5% and 0.2% positive contributions to technical efficiency change respectively, which led to its positive contribution to the total productivity change of 1.002. This implied a 0.2% growth in cowpea productivity in the study area. However, the highest total factor productivity change, which indicates increase in the crop productivity, was observed in 2012 at 1.162, signifying a 16.2% growth in the productivity, as a result of the positive contributions of technical efficiency and technological changes. This could have been as a result of the indirect benefit of the reform of the agricultural sector through Agricultural Transformation Agenda (ATA) of 2010 to 2015. The lowest and regressed productivity was recorded in 1994 at 0.855, indicating a 14.5% decrease in productivity. This could be attributed to the lingering effect of the SAP period of 1986 to 1994 when the sector was neglected.

The overall mean technical efficiency change for the whole period was positive and indicated 0.7% efficient resource allocation in the cowpea production over the period studied. The mean total factor productivity change was at 0.2% growth. Cowpea's productivity growth was in regress for about 8 years, as the TFPCH scores were less than one and in progress or growth for about 16 years, as the TFPCH scores were more than one for those years, although, not consecutively. This suggests that the crop's production was generally efficient in the study area. The result is in agreement with the findings

of Jirgi *et al.* (2010), Ojo *et al.* (2009) and Nurudeen and Rasaki (2011), where the production of cowpea was found to be generally efficient in various North-Central States.

Table 1. Efficiencies and Total Factor Productivity (TFP) Changes in Cowpea Production in North-Central Nigeria (1993-2017)

Year	Pure Efficiency Change (PECH)	Scale Efficiency Change (SECH)	Technical Efficiency Change (TEFFCH)	Technological Change(TECHCH)	Total Factor Productivity Change (TFPCH)
1993	1.050	0.980	1.030	0.870	0.915
1994	0.873	0.702	0.835	0.880	0.855
1995	1.007	1.059	1.067	0.930	0.924
1996	1.028	1.015	1.047	1.037	1.019
1997	1.001	0.861	0.762	1.164	0.962
1998	0.975	1.111	1.084	0.995	1.078
1999	0.975	1.098	0.960	1.086	1.039
2000	1.022	0.895	0.905	0.851	0.876
2001	0.984	1.037	1.020	0.994	1.014
2002	1.010	0.997	1.008	0.876	0.893
2003	0.973	1.012	0.985	1.104	1.016
2004	0.989	0.997	0.986	0.973	0.959
2005	1.033	0.974	0.999	0.924	0.939
2006	1.025	1.016	1.006	0.939	1.075
2007	0.959	1.090	1.042	1.012	1.014
2008	0.915	0.990	0.832	1.124	1.018
2009	1.063	1.098	1.167	0.889	1.004
2010	1.037	1.095	1.136	1.125	1.027
2011	1.019	1.094	1.096	1.020	1.099
2012	1.099	1.089	1.109	1.137	1.162
2013	1.060	1.140	1.110	1.023	1.140
2014	0.954	1.024	1.072	1.011	1.010
2015	1.048	1.006	1.054	1.116	1.115
2016	1.000	0.924	0.924	1.134	1.052
2017	1.047	0.911	0.901	1.038	1.011
Mean	1.005	1.002	1.007	0.995	1.002

Source: Computed results from field survey, 2017)

Trend of Efficiency Change, Technical Change and Total Factor Productivity Change in the Production of Cowpea on States Basis in North-Central Nigeria

Technical efficiency, technical and total factor productivity changes of cowpea on state basis in North-Central Nigeria are presented in Table 2. Technical efficiency change for cowpea production was positive for all the States studied with a mean of 1.007, which indicated a 0.7% increase in the resource allocation of cowpea production. Benue State was the most efficient in cowpea production. Benue, Niger and Plateau States achieved 2.7%, 5% and 2% reduction in technological changes respectively. These led to the reduced mean technical change at 0.5% reduction in the cowpea production technique.

However, Benue, Niger and Plateau States' total factor productivity changes indicated 0.9%, 5% and 2% productivity regress for the optimum technological change, respectively. The mean total factor productivity change for the States was 1.002, implying a 0.2% increase in productivity growth in the crop's production over the period studied. This result is in agreement with the findings of Ojo *et al.* (2012) and Jirgi *et al.* (2010), where the production of cowpea in Niger State was found to be technically efficient.

Table 2. Technical Efficiency, Technical and Total Factor Productivity Changes in Cowpea Production on State Basis in North-Central Nigeria

STATES	PECH	SECH	TEFFCH	TECHCH	TFPCH
BENUE	1.018	0.999	1.018	0.973	0.991
KOGI	1.007	1.009	1.016	1.021	1.037
KWARA	1.000	1.000	1.000	1.053	1.052
NIGER	1.000	1.000	1.000	0.951	0.950
PLATEAU	1.000	1.000	1.000	0.980	0.981
MEAN	1.005	1.002	1.007	0.995	1.002

PECH= Pure efficiency change; SECH = Scale efficiency change; TEFFCH = Technological change; TFPCH = Total factor productivity change
Source: Field survey, 2017

Technical Progress in the Production of Cowpea in North-Central Nigeria

Technological change, technical progress and total factor productivity change of cowpea production in the study area are presented in Table 3. The highest technological change, which is 1.186 was observed in 1999. This implied that 18.6% growth was achieved in the technology used in the crop's production, which led to the production of the crop at its highest total factor productivity at 1.169 that year. Technical progress of the crop's production thus, was 0.186, which implied that there was an improvement in the production technology of the crop to about 18.6% that year. The mean technological change recorded indicated a 0.5% reduction in the technology used in the crop's production.

Average technical progress indicated a 0.5% reduction recorded in the cowpea production technology over the period studied. The mean total factor productivity for the crop indicated a 0.2% growth in productivity achieved, despite the low contribution of the mean technological change at 0.5% over the period studied. Thus, the achievement of growth in total factor productivity was achieved irrespective of the regressive contribution of the technological change and technical regress at 0.5% observed throughout the period studied. This result is in agreement with the findings of Abdullahi and Tsado (2014), where cowpea productivity growth in Niger State was found to be positive. It also agrees with the findings of Nkamleu (2008), where technological change was also found to be the main contributor to high level of total factor productivity in African agriculture.

Table 3 Technical progress in Cowpea Production in North-Central, Nigeria (1993-2017)

Year	Technological Change TECHCH	Technical Progress TECHPR	Total Factor Productivity Change TFPCH
1993	0.870	-0.130	0.876
1994	0.880	-0.120	0.915
1995	0.930	-0.070	0.824
1996	1.037	0.037	1.109
1997	1.164	0.164	0.962
1998	0.995	0.005	1.078
1999	1.086	0.186	1.139
2000	0.851	-0.149	0.855
2001	0.994	-0.005	1.014
2002	0.876	-0.124	0.883
2003	1.104	0.104	1.169
2004	0.973	-0.027	0.959
2005	0.924	-0.076	0.739
2006	0.939	-0.061	1.075
2007	1.012	0.012	1.114
2008	1.124	0.124	0.860
2009	0.889	-0.111	1.154
2010	1.125	0.125	1.157
2011	1.020	0.020	0.791
2012	1.137	0.037	1.096
2013	1.023	0.023	1.120
2014	1.011	0.110	0.840
2015	1.116	0.116	1.125
2016	1.134	0.134	1.052
2017	1.038	0.038	1.011
Mean	0.995	-0.005	1.002

Source: Field survey, 2017

The cumulative technical progress of cowpea production in the study area is also presented in Figure 2, where bar charts are used in describing the performances of the 5 States studied in terms of their technical progress in the crop's production. Benue State was the worst performer as its negative technical regress was the longest recorded bar in the cowpea production, thus, indicating regress in the productivity.

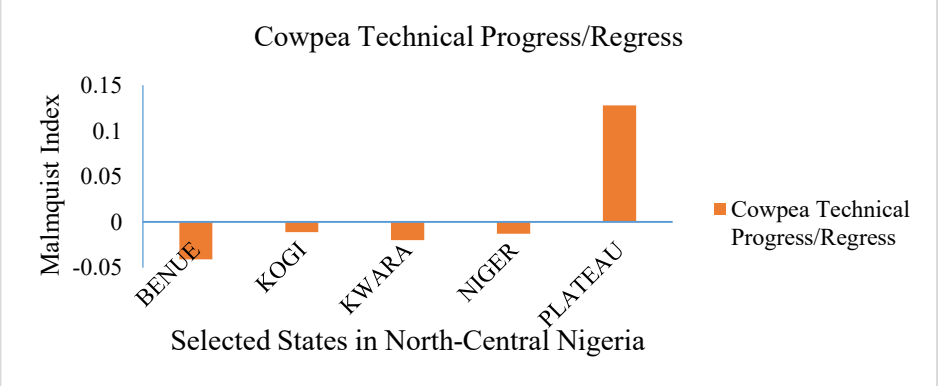

Figure 2. Cumulative technical progress of cowpea according to the States in North-Central Nigeria

Determinants of Total Factor Productivity Change (TFPCH) in Cowpea Production in North-Central Nigeria

The determinants of total factor productivity change in the production of cowpea in the study area is as presented in Table 4. The results indicate that climatic factor (rainfall) was statistically significant and positively related to cowpea production at 5% probability level. This indicates that increase in rainfall in the study area led to increase in productivity growth of the crop

Table 4 Determinants of Total Factor Productivity Change in Cowpea in North-Central Nigeria

Variables	Cowpea Coefficient
Climatic Factor: Rainfall (mm^3)	0.03** (2.15)
Institutional Factor: Amount of Credit (₦/K)	2.73e-07*** (2.63)
Government Policy: ATA (Before = 0; During = 1)	-0.10 (1-0.52)
Capital (₦/K)	0.10* (1.80)
Labour (Manday)	0.09 (1.12)
Capital-labour (Ratio)	0.03* (1.82)
Constant	2.21 (2.07)
Chi2	2.41***
PseudoR^2	0.67
Log Likelihood	0.61

*= significant at 0.10; ** = significant at 0.05; *** = significant at 0.01.
Figures in parenthesis are the values of t-ratio
Source: Field survey, 2017

Institutional factor (amount of credit borrowed) for the productions of cowpea had positive and significant relationship with cowpea productivity growth at $P \leq 0.05$ during the period of the study. This implies that increase in the farmers' utilization of the credit led to increase in the crop's productivity growth. Capital was statistically significant but negatively related to the cowpea's productivity at 10% probability level. This indicates that increase in the amount of capital used in the crop's production led to increase in the productivity growth.

CONCLUSION AND RECOMMENDATIONS

Analysis of Total Factor Productivity Change in Cowpea production in North-Central Nigeria between 1993 and 2017 was carried out with the use of secondary data, gotten from data banks. Generally, productivity growth was observed in cowpea production in North-Central Nigeria over the period studied. Technical efficiency change, technological change and technical progress were the major drivers of the crop's productivity growth. Benue, Niger and Plateau States regressed in the cowpea production over the period studied. Productivity growth, generally, was influenced more by technological change than other efficiencies and productivity growth of cowpea, thus, emanated from the combinations of both proper allocation of production resources (to gain efficiency change) and the application of good technology, which technological change ensures technical progress.

In view of the findings of this study, it was recommended that cowpea farmers should concentrate on self-capacity building. They should form cooperatives for ease of dissemination of research findings on farm practices for increased productivity, output and income. They should be encouraged to pool resources together to acquire quality and low-cost machineries to ensure improved farming techniques and increased output. Acquisition of more credit for the crop's production will boost productivity.

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