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TOTAL FACTOR PRODUCTIVITY CHANGE IN THE PRODUCTION OF CASSAVA IN NORTH-CENTRAL NIGERIA

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Abstract

This study examined total factor productivity change in the production of cassava in North-Central Nigeria. Secondary production data for cassava from 1992 to 2016 were collected from National Bureau of Statistics (NBS), Food and Agriculture Statistical (FAOSTAT) data banks and Federal Ministry of Agriculture. Malmquist Total Factor Productivity Index (MTFPI) using Data Envelopment Analysis (DEA) was used to empirically analyze efficiency change, technical progress and total factor productivity growth of cassava, while Tobit regression was used to analyze the determinants of total factor productivity in the study area. The results of the MTFPI analysis revealed that cassava contributed 0.2% technical efficiency change to the productivity growth over the period studied. The mean technological change indicated 3.6%, improvement in its production technology to achieve a productivity growth of 1.4%. Tobit regression showed rainfall had significant and positive relationship with the productivity of cassava at 1% probability level, which implied that increase in rainfall led to increase in cassava productivity. Credit borrowed and labour used had positive and significant relationships with productivity growth at $P \leq 0.05$ and $P \leq 0.01$,respectively, over the period studied. This implies that increase in both credit and labour led to increase in cassava productivity growth. Government policy (ATA) and capital had significant but negative relationship with the productivity at 1%. probability level. This implied that increase in capital used in cassava production led to reduction in its productivity growth. Capital-labour ratio had positive and significant relationships with cassava productivity growth at $P \leq 0.10$ level of significance and the farmers' utilization of capital led to increase in cassava productivity growth. However, utilization of labour in a greater proportion than capital led to productivity regress. The study recommends training on farm practices, techniques and proper allocation of production resources to achieve productivity growth in the study area. Policies on public security and insurance of farms against risk of all kind will increase productivity.

Key words: *Productivity growth, technical progress, efficiency change*

Introduction

Nigeria's current estimated population of about 200 million people grows at about 2.7% per annum (United Nations, 2018). The agricultural sector on the other hand produces at a production growth rate of about 1.7% (World Bank, 2008; and Food and Agriculture Organization (FAO, 2016)). Thus, there is food supply deficit in the country. The major agricultural produce in the country includes tree and root crops, cereals, legumes and wide range of livestock. The report of National Bureau of Statistics (NBS) (2016) indicated the Gross Domestic Product (GDP) of cassava output in Nigeria increased from1,227.23 billion Naira in 2013 to about 1,310.24 billion Naira in 2015. Considerable decline observed in food crop production from the 1970s could be attributed to the neglect of the sector.

Cassava is one of the major staple crops in Nigeria and the country is known to be the world's largest producer and consumer of it. The crop yield is estimated at 54million tonnes as at 2013 (United Nations Commission for Africa (UNCA), 2015 and Food and Agriculture Organization Statistical Data (FAOSTAT), 2015), which was at a reduced33 million tonnes in 2014 at 3% productivity growth rate (Central Intelligence Agency (CIA), 2015 and FAO, 2015). The knowledge of agricultural total factor productivity of a country, region or state is important as it enables the country to achieve economic development. Nigerians' food consumption has increased to about 214kg per person for root crops. Previous studies on agricultural productivity in Nigeria (Jatto *et al.,* 2015; Ajao, 2011and Adepoju, 2008) did not link food demand and supply to total factor productivity. This study, therefore, aimed to assess the total factor productivity change of cassava in North-Central Nigeria from 1992 to 2016. This was carried out to determine the evolution of efficiency and total factor productivity change in the production of cassava in the study area; determine the technical change or progress observed in the production of the crop and ascertain the determinants of total factor productivity growth or change in cassava

Theoretical and Conceptual Framework

Most empirical studies on productivity rely on economic theory of production for analytical framework. The expression of the relationship between variable inputs and fixed input at a minimum level to produce maximum output is referred to as the production function. Ojo *et al*., (2013) defined this as a quantitative description of input-output relationship in the production process. Total factor productivity measurement is commonly carried out by using either of the two approaches (parametric or non-parametric). The parametric approach relies on econometric techniques, such as the simple regression analysis (SRA) and stochastic frontier analysis (SFA) (Dharmasiri, 2001). Total factor productivity index can be obtained bymultiplying the technical change with efficiency change.

The non-parametric approach involves the construction of index numbers, such as, Malmquist, Fisher, Tornquist and Laspeyes index numbers (Daskovska *et al*., 2010, Ojo, *et al*., 2012). This does not require input or output prices and is thus, the most often preferred method in situations where there are price fluctuations, inaccuracy or non-existence and cost minimization or profit maximization assumptions are not necessary. The non-parametric model is expressed as in equation (1), thus: $A_t = T_t / I_t$ (1)

Where: A_t measures the TFP level; T_t is an index of output quantity, while I is the input quantity, and 't' is the time frame. Subsequent growth rate may not be the same as that of the parametric estimation. This Data Envelopment Analysis (DEA)-based Malmquist productivity index methodology allows the evaluation of relative efficiency of combined units of multiple inputs into multiple outputs, to produce a single comprehensive measure of performance (efficiency score) for each unit (Cooper *et al*., 2011). The Malmquist productivity index, when compared to other indices could be used in situations where the objectives were unknown, differ, or were difficult to implement, as it does not require the cost minimization or profit maximization assumptions (Mohammadi and Ranaei, 2011). To accommodate the sources of productivity changes in the case of scale efficiency, Mayer and Zelenyuk (2014) generalized the Malmquist productivity index and defined it as the difference between the average growth rates of outputs and inputs.

Malmquist TFP index distance functions, from output is defined as expressed in equation (2)

$$d_0(x, y) = \min\{\theta : (y/\theta) \in P(x)\} \quad (2)$$

Where:

$P_{(x)}$ = Output set for all output vector, y, which can be produced using the input vector x. and according to Brümmer *et al.* (2002), the MI TFP change between a base period (t) and a period (t+1) can be expressed as:

$$M_0 = (y_s x_s y_t x_t \ ) = -\left[\frac{d^s{}_0(y_t, x_t \ )}{d^s{}_0(y_s, x_s \ )} \times \frac{d^s{}_0(y_t, x_t \ )}{d^t{}_0(y_t, x_t \ )}\right]^{1/2} \quad (3)$$

Where:

$d^s{}_0(y_t x_t \ )$ = distance from period t observation to the period t+1 technology; y is the output and x is the input variable. When M>1 indicates positive TFP growth from period t to period t+1 or otherwise, if M<1. Equation (2) is the geometric mean of two TFP indices. The first index is evaluated with respect to period t technology, while the second is in respect to period t_{+1} technology. In equation (3), the term outside the square brackets measures the Farrell technical efficiency change in the output-oriented measure between period t and t+1; while the term inside measures technical change. This is the geometric mean of the shift in the technology between the two periods, which means that the efficiency change is equivalent to the ratio of the technical efficiency in period t to technical efficiency in period t+1. The Malmquist productivity indexes, when decomposed gives the technical change and the efficiency change and the two terms in equation (3) are as expressed in equations (4) and (5):

$$\text{Efficiency Change (Technical Efficiency Change)} = \frac{d^s{}_0(y_t, x_t \ )}{d^s{}_0(y_s, x_s \ )} \quad (4)$$

$$\text{Technical Change (Technological Change)} = \frac{d^s{}_0(y_t, x_t \ )}{d_{s0}(y_t, x_t \ )}\left[\frac{d^s{}_0(y_t, x_t \ )}{d^s{}_0(y_s, x_s \ )} \times \frac{d^s{}_0(y_t, x_t \ )}{d^t{}_0(y_t, x_t \ )}\right]^{1/2} \quad (5)$$

Where:

$d^s{}_0(y_t x_t \ )$ = distance from period t observation to the period t+1 technology. The efficiency change [technical efficiency change ($TEFFCH_{crs}$)] component is equivalent to the ratio of the Farrell technical efficiency in period t to the Farrell technical efficiency in period t+1, under the constant return to scale.Pure technical change measures the shift in the reference production frontier curve, while the efficiency change measures the catch-up attempt. Jatto *et al.,* (2015) and Ajao, (2011) attempted the DEA approach for determinants of agricultural productivity in Nigeria but concentrated mainly on identifying socio-economic factors as the major determinants of agricultural productivity, without assessing total factor productivity of agricultural output.

Methodology

The Study Area

This study was carried out in North-Central Nigeria, which is made up of Benue, Kogi, Kwara, Niger, Nasarawa, Plateau States and the Federal Capital Territory (FCT), Abuja. The zone covers a total land area of about 296,898 km^2, with a population of about 22,887,250 people as at 2016 (National Bureau of Statistics (NBS), 2016). It is located between Longitudes 2^o 30′ to 10^o 30′ East and Latitudes 6^o 30′N to 11^o 20′ North. More than 77% of the people in this zone are rural dwellers, who are mostly engaged in one form of agricultural activity or the other (Aregheore, 2009). The zone has two main seasons, namely, dry and wet seasons. The wet season occurs from March till to October, while the dry season begins from November and ends in March. The annual rainfall ranges between 1,000 and 1,500mm with average monthly temperature ranges of 21^{o}C to 37^{o}C. The zone has Forest Savannah Mosaic, Southern Guinea Savannah and the Northern Guinea Savannah vegetation. Geographically, the zone is characterized by varying topographical landforms, such as, the swampy features around the lowland areas rivers Niger and Benue; large hills, mountains, plateaus and deep valleys land areas. The vegetation, soil and weather of the zone favour the cultivation and production of wide spectrum of agricultural crops of various types. The rivers and dam enable irrigation farming during the dry seasons. The zone consists of more than 40 ethnic groups, such as the Idoma, Tiv, Egbira, Koro, Bassa, Nupe, Agatu, and Gbagyi among others. The people in the zone are mainly farmers, hunters, fishermen and artisans. The major crops grown in the zone include rice, maize, millet, sorghum, yam, potatoes, cassava, cowpea, soybean and vegetables.

Method of Data Collection

Secondary production data on cassava from 1992 to 2016 for each selected State in the zone were collected from National Bureau of Statistics (NBS), States' Agricultural Development Programmes (ADPs), States and Federal Ministry of Agriculture. This data included the cassava’s annual outputs measured in tonnes, the production inputs, such as farm size cultivated (in hectares), seed (in tonnes) or cassava cuttings (in tonnes), labour (in man-days) and fertilizer (in tonnes) and capital (measured in Naira and Kobo).

Analytical Techniques

The evolution of efficiency and total factor productivity change in the production of cassava in the study area were estimated with the use of a non-parametric approach (Data Envelopment Analysis (DEA)), based on Malmquist Total Factor Productivity Index (MTFPI). 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 Tables or graphs. Tobit regression analysis, was used to ascertain the determinants of total factor productivity change. Chepng'eptich *et al.,* (2015), Akinseinde (2006), Ogunyinka and Ajibefun (2003) did use it for similar studies.

Model specification: Malmquist total factor productivity index (MTFPI)

Malmquist TFP index (MTFPI), based on distance functions were calculated for the TFP change between the two periods (t and t+1). Linear Programming (LP) problems solved, with the use of constant return to scale (CRS) helped to maintain uniformity of the variables. This is defined as inverse of Farrell's ratio between an output quantity change index and input quantity change index (Farrell, 1957) The required LPs are as expressed in equations (6) and (7):

$$[D_0(X^{k*}, Y^{ky})]^{-1} Z^k, \theta^k = \text{Max } \theta^{k*} \tag{6}$$

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

$$[D_0^{t+1}(X_{t+1}^{k*}, Y_{t+1}^{k*})]^{-1} = \text{Max } \theta^{k*} \tag{7}$$

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 State 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. Linear programmes LP (6) and (7), 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 and Ludena, 2010) . Equations (6) and (7) can be expressed as in equation (8):

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

Subject to:

$$A_{11}X_1 + A_{12}X_2 + A_{13}X_3 + A_{14}Z_4 + A_{15}Z_5 \leq H$$
$$A_{21}X_1 + A_{22}X_2 + A_{23}X_3 + A_{24}Z_4 + A_{25}Z_5 \leq L$$
$$A_{31}X_1 + A_{32}X_2 + A_{33}X_3 + A_{34}Z_4 + A_{35}Z_5 \leq C \quad (8)$$
$$A_{41}X_1 + A_{42}X_2 + A_{43}X_3 + A_{44}Z_4 + A_{45}Z_5 \leq S$$
$$A_{51}X_1 + A_{52}X_2 + A_{53}X_3 + A_{54}Z_4 + A_{55}Z_5 \leq F$$
$$Y^kZ^k \geq 0$$

Where:

Y^k denotes selected food crop 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). In using these models, the technical efficiency change (TEFFCH), technological change (TECHCH) and total factor productivity (TFP) growth over the years obtained were presented with the use of graphs and Tables to show their evolution.

Tobit regression model

Tobit regression model is a censoring model and was used to ascertain the determinants of TFP change of the production of cassava, as expressed in equation (9). Following Tobin's definition in 1958, the model is defined as

$$Y_i^* = X_i\beta + \varepsilon_i^* \quad (9)$$

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

Where:

Y_i* is a latent (unobservable) variable; > 0 = greater than zero ; ≤0 = less than /equal to zero.; 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 in equation (10).

$$Y_i^* = \beta_0 + \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 \quad (10)$$

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 (Millimeter); X_2= Institutional Factor: Amount of Credit (Naira and Kobo); X_3 = Government Policy: Agricultural Transformation Agenda (0 = period before the programme, and 1= during the programme) and X_4 = Capital-Labour ratio. In using Tobit regression model, β is not interpreted as the effect of X on TFP, but the estimation of relationships for limited dependent variables. The change in TFP of those above the limit, weighted by the probability of being the limit or the expected value of TFP change if above. A value of 1, indicates TFP change (efficiency) and 0 indicates no-change (inefficiency).

Results and Discussion

Evolution of Efficiency and Total Factor Productivity Change in the Production of Cassava in North-Central Nigeria

The evolution of efficiency and total factor productivity changes in cassava production in North-Central zone is shown in Table 1. The results reveal that, although, cassava production was efficient slightly for more than half of the period studied, the mean pure and scale efficiency changes were both less than one, which adversely led to negative contribution of their efficiency changes to the crop's productivity growth. The mean technical efficiency change of 0.998, implied a 0.2% reduction in its contribution to the overall total factor productivity change. Technical efficiency change fluctuated throughout the period of study and greater technical changes were recorded in the technology of the cassava production over the years studied.

The highest growth of 1.110 in total factor productivity was recorded in 2012. This implied that TFP grew to about 11% in 2012, which was during the period of Agricultural Transformation Agenda (ATA) between 2011 and 2015. This was the period when agriculture was reintroduced on business-like attitude, to be managed by key stakeholders from the private sector to achieve self-sustained economy through improved funding.

Technological change of cassava production was on the increase for slightly more than half of the period, and its mean was positive and greater than that of the technical efficiency change, which implied that technological change contributed more to the cassava productivity than technical efficiency change. This resulted to some form of productivity growth for more than half of the period, which is in agreement with the findings of Fakayode *et al.,* (2008) and Alene (2010), where agricultural productivity growth in Africa was found to have emanated from technological change, rather than efficiency change. The graphical presentation and confirmation of the fluctuations of the productivity of cassava production explained is as shown in Appendix C, where it can be observed that at the earlier years of the study, the evolution of all the efficiencies were marginal and moved in the same smooth undulating slope between 1992 and 1995.

Table 1. Efficiency changes and total factor productivity (TFP) changes in cassava Production in North-Central Nigeria

Year	Pure Efficiency Change PECH	Scale Efficiency Change SECH	Technical Efficiency Change TEFFCH	Technological Change TECHCH	Total Factor Productivity Change TFPCH
1992					
1993	0.890	0.899	0.899	1.008	0.831
1994	0.962	0.992	0.965	0.998	0.953
1995	1.031	1.006	1.037	1.013	1.050
1996	0.996	0.951	0.947	1.026	1.066
1997	1.022	1.028	1.051	0.969	1.018
1998	0.995	0.945	0.940	1.037	1.069
1999	1.005	1.045	1.051	1.049	1.100
2000	1.000	0.991	0.991	1.060	1.052
2001	1.000	1.027	1.027	0.749	0.900
2002	1.000	0.957	0.957	1.126	1.055
2003	1.000	1.031	1.031	1.071	1.104
2004	1.000	0.978	0.978	0.977	0.955
2005	1.000	0.991	0.991	1.127	1.067
2006	1.000	1.012	1.012	0.820	0.997
2007	1.078	1.045	1.045	1.054	1.072
2008	0.992	0.909	0.991	1.093	1.085
2009	0.988	1.030	1.017	1.036	1.054
2010	1.003	1.055	1.058	0.952	1.009
2011	1.018	0.924	0.940	1.032	1.108
2012	1.000	1.105	1.105	1.103	1.110
2013	1.000	0.887	1.099	1.086	1.099
2014	0.990	1.067	1.056	1.016	1.093
2015	1.002	1.065	1.067	1.105	1.109
2016	0.976	0.975	0.952	1.102	1.103
Mean	0.999	0.999	0.998	1.036	1.014

Source: Computed results from field survey, 2017

Efficiency and total factor productivity change in the production of cassava on States basis in North-Central Nigeria

The results of the technical efficiency, with its components, technological and total factor productivity changes in the production of cassava in the selected States in North-Central Nigeria as shown in Table 2, where the result shows all the States to be technically efficient, except Plateau State, which indicated a 0.1% decrease in technical efficiency. Overall mean technical efficiency for the states, suggesting a 9% increase in technical efficiency change over the period studied. Technological change for cassava production was positive for all the states, but Benue and Plateau States recorded 0.4% and 1% reduction in efficiency respectively. Kogi, Kwara and Niger States achieved 0.9%, 3.4% and 5.2% production improvement with the technology employed by the three states respectively. However, TFP change for Plateau State was the least at 1.9% regress and the least efficient in cassava productivity. The low productivity in Plateau State can be attributed to miss-allocation of production resources or environmental factors.

Niger State had the highest total factor productivity change which indicated a 5.2% productivity growth over the years studied. However, the mean total factor productivity change for the crop's production for the period was 1.014, suggesting a productivity growth of 1.4% in the zone. This growth was driven more by technological change than technical efficiency change. This result is in agreement with the findings of Ojo (2013), where cassava production in Kogi and Niger States in North-Central Nigeria was found to be technically efficient. Also, Asogwa *et al.,* (2006) and Adewuyi and Adekunle (2013) found cassava production in North-Central Nigeria and Nigeria, respectively to be technically efficient.

Table 2, Mean technical efficiency changes in cassava production according to the States in North-Central Nigeria

STATES	PECH	SECH	EFFCH	TECCH	TFPCH
CASSAVA					
BENUE	1.000	1.000	1.000	0.996	0.996
KOGI	1.000	1.000	1.000	1.009	1.009
KWARA	1.000	1.000	1.000	1.036	1.034
NIGER	1.000	1.000	1.000	1.053	1.052
PLATEAU	0.993	0.997	0.990	0.990	0.981
MEAN	0.999	0.999	1.090	1.016	1.014

Source: Field survey, 2017

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

The mean technical progress and total factor productivity of cassava production in the study area are presented in Table 3. Technical progress is often derived from technological change and is calculated as a difference between maximum efficiency score, which is 1.000 and technological change, thus, the need to mention technological change in the discussion. The highest technological change was achieved in 2015 at 10.5% as a result of technological improvement or change from the production technique with the available inputs used. This was the ending period of Agricultural Transformation Agenda (ATA) (2011-2015), when sustainable agriculture based on business-like attitude through the private sector was emphasized to boost agricultural productivity in Nigeria.

The least or lowest technological change took place in 2001 at a reduction in production technology to about 25.1%. This may have resulted from the outcome of the policy of liberalization (1995-2010), when agricultural sector was marginalized and funds were not sufficient for the acquisition of good farm tools. The overall mean technological change of cassava production over the period studied was positive at 3.6% improvement as technical progress recorded. This result is in agreement with the findings of Adedeji *et al.* (2017), where increase in the output of cassava production in Nigeria between 1962 and 2016 was found to be as a result of improvement in the technology used. The mean technical progress of cassava production over the years in the study area, therefore, was 0.036technical progress over the years in the study area. The highest total factor productivity change for cassava production recorded was in 2007 at 11.2%.

Table 3 Technical progress in cassava production in North-Central, Nigeria

Year	Technological Change TECHCH	Technical Progress (TECHPR)	Total Factor Productivity Change TFPCH
1992			
1993	1.008	0.008	0.997
1994	0.998	0.002	0.953
1995	1.013	0.013	1.050
1996	1.026	0.126	1.066
1997	0.969	-0.031	1.018
1998	1.037	0.137	1.069
1999	1.049	0.049	1.100
2000	1.060	0.060	1.052
2001	0.749	-0.251	0.900
2002	1.102	0.102	1.055
2003	1.071	0.071	1.104
2004	0.977	-0.023	0.955
2005	1.103	0.103	1.067
2006	0.820	-0.180	0.831
2007	1.054	0.154	1.112
2008	1.093	-0.107	0.805
2009	1.036	0.036	1.054
2010	0.952	-0.048	1.009
2011	1.032	0.032	1.108
2012	1.103	0.103	1.109
2013	1.086	0.086	1.099
2014	1.016	0.106	1.093
2015	1.105	0.102	1.109
2016	1.102	0.251	1.103
Mean	1.036	0.036	1.014

Source: Field survey, 2017

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

The results of the factors that determined the total factor productivity change in the study area is as presented in Table 4.5. The results indicated that climatic factor (rainfall) was statistically significant and positively related to cassava production at 5% probability level. This indicates that increase in rainfall in the study area led to increase in productivity growth of the crop. Institutional factor (amount of credit borrowed) had positive and significant relationship with cassava 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. Government policy (ATA) had positive and significant relationship with the productivity of cassava at 5%probability levels. The result also indicated that capital was statistically significant and positively related to the crop's productivity at 1% probability level. This indicated that increase in the amount of capital used in the crop's production led to increase in its productivity growth.

The lowest total factor productivity change for cassava production over the years was in 2008 at 19.5% regress due to the lowest technical regress of -0.107 recorded that year. The fall in cassava productivity maybe attributed to the fall in the technology employed in the crop's production over the period studied. Average total factor productivity change for cassava implied a 1.4% productivity growth as a result of positive contribution of the mean technical progress at 3.6% to the growth. This result agrees with the findings of Odemenem and Otanwa (2011) and Oni *et al.* (2007), where cassava production in Nigeria was found to be technically efficient. The peak of growth was observed to occur in 2015 at 54%, while the lowest regress took place in 2001 at about 25.1%. This result agrees with the findings of Adedeji *et al.* (2017), where agricultural crops productivity in Nigeria was found to be on the increase from 2005.

Cassava productivity performance in terms of technical efficiency change (TEFFCH)and technological change (TECHCH) was compared since the use of data envelopment analysis (DEA) model based on Malmquist index is less data demanding and allows the index to be decomposed into technical efficiency and technological changes, thus, the need for the multilateral comparison. It was observed that TECHCH was greater than TEFFCH (TECHCH>TEFFCH), which implied that the production investment of cassava was efficiently carried out by 1.6% over the years. Technological change, on the other hand, implied that there was improvement of about 9% per year in the production technique used for the crop.

Labour used had positive and significant relationship with cassava productivity growth at $P \leq 0.01$ during the period of the study, which implies that increase in the farmers' utilization of labour led to increase in cassava productivity growth. The result further revealed that capital-labour ratio had positive and significant relationships with cassava productivity growth at $P \leq 0.10$ level of probabilities during the period of the study. The farmers' utilization of capital in a greater magnitude than labour led to increase in cassava productivity growth. On the other hand, the utilization of labour in a greater proportion than capital would lead to reduction or regress in cassava productivity growth.

Table 4. 5. Tobit model of the determinants of total factor productivity change in the selected food crops in North-Central Nigeria

Variables	Coefficient
Climatic Factor: Rainfall (mm^3)	0.02** (2.17)
Institutional Factor: Amount of Credit (₦/K)	2.33e-07** (2.16)
Government Policy: ATA (Before = 0; During = 1)	0.05** (4.9)
Capital (₦/K)	0.02*** (2.91)
Labour (Manday)	0.01*** (2.68)
Capital-labour (Ratio)	0.14* (1.91)
Rice imports (Tonnes)	
Constant	0.61(1.14)
Chi2	3.43***
PseudoR^2	-0.64
Log Likelihood	4.41

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

Conclusion and Recommendations

Analysis of productivity growth, technical progress and efficiency change in the production of cassava in North-Central Nigeria were carried out with the use of secondary data, gotten from the field survey. Generally, productivity growth was observed in cassava produced in North-Central Nigeria over the period studied. Technical efficiency change, technological change and technical progress were the major drivers of cassava productivity growth. Technical change contributed more to the productivity growths of cassava. Plateau State was the least efficient in cassava production. Technical progress was at a less optimum level. Productivity growth, generally, was influenced more by technological change, which emanated from the combinations of both proper allocation of production resources (to gain technical efficiency change) and the application of good technology to ensure technical progress.

The study therefore recommends that policies on agricultural implement acquisition for improved production should be formulated, since both technical efficiency change and technological changes were found to be the contributors to cassava productivity growth in the study area. Information on resource allocation of cassava should be conveyed to farmers by agricultural extension officers and they should be assisted in improving the production technology to achieve greater technical progress than the existing one.

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