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Non-parametric decomposition of total factor productivity growth in yam production in North-Central Nigeria

R.G. Isonguyo*, M.A Ojo, A.J. Jirgi, E.S. Yisa

Department of Agricultural Economics and Farm Management, Federal University of Technology, Minna, Nigeria

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Abstract. *Non-parametric analysis of total factor productivity change in yam production in North-Central Nigeria from 1992 to 2016 was carried out with the use of secondary data. The secondary production data of yam for that period were collected from Food and Agriculture Statistical (FAOSTAT) data bank. Malmquist Total Factor Productivity Index (MTFPI) based on Data Envelopment Analysis (DEA), was used to empirically analyse the total factor productivity of the yam, while Tobit regression was used to analyse the determinants of total factor productivity in the study area. The results of the MTFPI analysis reveal that yam contributed 1.4% of technical efficiency change to productivity growth over the period studied. The technological contributions to productivity growth regressed at 1.8%. The study revealed the productivity growth of yam to be 0.2%. Tobit regression result showed credit borrowed, government policy (Agricultural Transformation Agenda - ATA), capital, and labour to have significant and positive relationships with the productivity of the crop at either p≤0.05 or p≤0.001 level of probability, which implies that increase in them led to increase in the crop's productivity. Capital-labour was statistically significant but negatively related to yam productivity at p≤0.01, which implied that utilization of labour in a greater proportion than capital led to reduction or regress in its productivity growth. The study recommends farmers' training on farm practices and techniques to increase yam productivity. They should be encouraged to accept improved yam varieties from research institutes, properly allocate the production resources and adopt improved technology to achieve productivity growth in the study area.*

Keywords: capital, change, labour, technical efficiency, total factor productivity

Introduction

Nigeria operates subsistence and traditional agriculture with low production output despite its estimated population of about 200 million people, which grows at about 2.7% per annum (United Nations, 2018). The country is blessed with both natural and human resources to be self-sufficient, yet, it is currently facing food scarcity as a result of the low productivity growth rate of between 0.03 and 0.09 (CIA, 2016). However, Nigeria is known to be the world's largest producer and consumer of yam from about 5 million hectares of land at over 2 million tonnes annual production (UNCA, 2015; FAO, 2016). The report of National Bureau of Statistics (NBS, 2016) indicated the Gross Domestic Product (GDP) of yam output in Nigeria to increase from 1,227.23 billion Naira in 2013 (7.6 billion USD) to about 1,310.24 billion Naira in 2015 (6.6 billion USD). However, the gap between demand and supply for food in Nigeria still needs to be bridged. This is because food consumption has increased to about 150 kg and 214 kg per person for grains and root crops, respectively.

Yam 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 about 40 million tonnes (UNCA, 2015; FAOSTAT, 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. Studies by Ajao (2011) and Jatto et al. (2015) on agricultural productivity in Nigeria did not link food demand and supply to total factor productivity. Thus, this study aimed to assess the total factor productivity change of yam in North-Central Nigeria from 1992 to 2016, using a non-parametric method of analysis. This was carried out to determine the evolution of efficiency and total factor productivity change in the production of yam 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 yam.

Theoretical and conceptual framework

Contemporary 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 (2013) defined

*e-mail: risonguyo@yahoo.com

this as a quantitative description of input-output relationship in the production process. Total factor productivity (TFP) 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 by multiplying the technical change with efficiency change.

The non-parametric approach adopted for this study 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:

$$A_t = T_t / I_t \tag{1}$$

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 (MPI), 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):

$$D_o(x, y) = \min \{\theta: (y / \theta) \; \varepsilon \; P(x)\} \tag{2}$$

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:

$$Mo = \left(y_s x_s y_t x_t\right) = -\left[\frac{d^s o\left(y_t, x_t\right)}{d^s{}_o\left(y_s, x_s\right)} X \frac{d^s o\left(y_t, x_t\right)}{d^t o\left(y_t, x_t\right)}\right]^{-1/2} \tag{3}$$

Where: $d^s{}_o(y_t, xt)$ = 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):

Efficiency change (Technical efficiency change) =

$$\frac{d^s{}_0\left(y_t, x_t\right)}{d^s{}_0\left(y_s, x_s\right)} \tag{4}$$

Technical change (Technological change) =

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

Where: $d^s{}_o(y_t, x_t)$ = 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. Ajao (2011) and Jatto et al. (2015) 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.

Material and methods

Study area

This study was conducted in North-Central Nigeria, made up of Benue, Kogi, Kwara, Niger, Nasarawa, Plateau States and the Federal Capital Territory (FCT), Abuja. The zone occupies a total land area of about 296,898 km^2, with a population of about 22,887,250 people as at 2016 (NBS, 2016). It is located between Longitudes 2°30′ to 10°30′ East and Latitudes 6°30′N to 11°20′ North. More than 77% of the people are rural dwellers, mostly engaged in one form of agricultural activity or another (Aregheore, 2009). The zone has the wet season from March to October and the dry season from November to March. The annual rainfall ranges from 1,000 to 1,500 mm with average monthly temperature ranges of 21°C to 37°C. The zone has vegetation that consists of the Forest Savannah Mosaic, Southern Guinea Savannah and the Northern Guinea Savannah. The zone is characterized by the extensive and swampy features found around the lowland areas along the valleys of rivers Niger and Benue; large hills, mountains, plateaus and deep valleys. The vegetation, soil and weather patterns of the zone favour the production of wide varieties of food, industrial and cash crops. The rivers and dam enable irrigation farming during dry seasons. The zone consists of more than 40 ethnic groups, such as; The Egbira, Koro, Gade, Idoma, Tiv, Nupe, Kadara, Agatu, Basa, Eggon and Gbagyi ethnic groups, among others. The people are mainly farmers, hunters, fishermen and artisans. The crops grown in the zone include rice, maize, millet, sorghum, yam, potatoes, cassava, cowpea and soybean.

Data collection

Secondary production data on yam 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 yam's 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 evolution of efficiency and total factor productivity change in the production of yam 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) and Akinseinde (2006) did use it for similar studies.

Model specification

Malmquist Total Factor Productivity 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):

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

Subject to:

$$\Sigma^N_{K=1} Z^k Y^k_j \geq Y^k_j, \theta^{k^*} \quad (j=1..., j)$$
$$\Sigma^N_{K=1} Z^k X^k_h \geq X^{k^*}_h \quad (h=1..., H)$$
$$Z^k \geq 0 \quad (k=1…, N)$$

$$[D_o^{t+1}(X^{k^*}_{t+1}, Y^{k^*}_{t+1})]^{-1} = \text{Max } \theta^{k^*} \quad (7)$$

Subject to:

$$\Sigma^N_{k=1} Z^{k^*} X^{k^*}_j \geq Y^{kh}_j, \theta^{k^*} \quad (j=1..., j)$$
$$\Sigma^N_{K=1} Z^k X^k_h \geq X^{k^*}_h \quad (h=1..., H)$$
$$Z^k \geq 0 \quad (k=1…, N)$$

Where: D_o 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' i*s 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. 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):

$$\text{Maximize: } Y^k = Y_1Z_1 + Y_2Z_2 + Y_3Z_3 + Y_4Z_4 + Y_5Z_5 \quad (8)$$

Subject to:

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

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, Y_5, 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 or 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 yam, as expressed in equation (9). Following Tobin's definition in 1958, the model is defined as

$$Y_i^* = X_i\beta + \varepsilon_i^*$$
$$Y_i^* = Y_i^* \text{ if } Y_i^* \geq 0; \; 0_i \text{ if } Y_i^* \leq 0 \quad (9)$$

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).

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

Where: Y_i^*= Total Factor Productivity Change (TFPCH); β_0= Intercept; β_{1-6}= 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 yam

The evolution of efficiency and total factor productivity changes in yam production in North-Central zone is shown in Table 1. The results reveal that, although, yam 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 0.986 implied a 1.4% reduction in its contribution to the overall total factor productivity change. Technical efficiency change fluctuated throughout the period of study but greater technical changes were recorded in the technology of the yam production over the years studied.

Table 1. Efficiencies and total factor productivity (TFP) changes in yam 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	0.998	0.816	0.876	0.893	0.839
1994	1.043	0.912	1.012	0.918	0.929
1995	1.000	0.984	0.984	1.025	1.009
1996	0.982	1.006	1.006	0.957	0.963
1997	0.978	1.020	0.998	1.025	1.024
1998	1.019	1.066	1.045	0.961	0.913
1999	1.000	0.914	0.914	1.131	0.990
2000	1.004	0.981	1.085	0.901	0.869
2001	0.990	1.010	1.000	1.047	0.915
2002	0.959	0.999	0.958	1.028	0.975
2003	1.027	0.994	1.021	1.014	1.025
2004	0.993	0.982	0.992	0.959	0.951
2005	1.015	0.987	1.011	1.027	1.021
2006	0.954	1.000	0.985	0.999	0.999
2007	0.962	1.030	0.991	1.037	1.026
2008	0.939	1.001	1.041	0.926	0.977
2009	1.022	0.924	0.940	1.168	0.984
2010	1.022	0.924	0.943	1.083	0.984
2011	0.920	0.900	0.910	1.043	0.900
2012	0.916	1.042	0.972	0.912	0.980
2013	1.000	0.992	1.010	0.957	0.955
2014	0.970	0.980	0.960	0.937	0.980
2015	0.990	0.980	0.890	0.982	0.979
2016	1.160	1.102	1.118	0.918	1.139
Mean	0.995	0.991	0.986	0.982	0.998

Source: Field survey, 2017

The highest growth of 1.139 in total factor productivity was recorded in 2016. This implied that TFP grew to about 13.9% in 2016, which was just at the ending of the period of Agricultural Transformation Agenda (ATA) between 2011 and 2015. This was the period when the outcome of agriculture reintroduced on business-like attitude, to be managed by key stakeholders from the private sector to achieve self-sustained economy through improved funding was still occurring. This resulted from the boost in the agricultural output during the ATA. Technological change of yam production was on the increase for about 11 years of the period but its mean is less than 1.000. The mean technical efficiency change is less than one, which indicated a 1.4% regressive contribution to the yam's productivity regress at 0.2% over the period studied. This result is in agreement with the findings of Ekunwe and Orewa (2007), Etim et al. (2013) and Ani et al. (2014), where yam production in Nigeria was found to be technically inefficient.

Efficiency and total factor productivity change in the production of yam

The results of the technical efficiency, with its components, technological and total factor productivity change in the production of yam in the selected States in North-Central Nigeria as shown in Table 2 where all the States are technically inefficient, except Benue State. Technologically, only Kwara State recorded a technical efficiency increase of 0.2% while the overall mean total factor productivity change was 0.968. This suggests a 3.2% regress in the productivity of yam over the period studied.

Table 2. Mean technical efficiency and technological changes in yam production according to the States studied in North-Central Nigeria

States	PECH	SECH	TEFFCH	TECHCH	TFPCH
Benue	1.000	1.000	1.000	0.996	0.996
Kogi	0.979	1.010	0.989	0.994	0.983
Kwara	1.000	0.953	0.953	1.002	0.956
Niger	0.996	0.995	0.991	0.966	0.958
Plateau	1.000	0.996	0.996	0.952	0.949
Mean	0.995	0.991	0.986	0.982	0.968

Source: Field survey, 2017; PECH- Pure efficiency change, SECH- Scale efficiency change, TEFFCH- Technical efficiency change, TECHCH- Technological change, TFPCH- Total factor productivity change.

Yam production, therefore, was not favourable in the study area in terms of resource allocation and technology of production employed. This, perhaps, could be attributed to the non-specification of the policy to favour yam production. No stability of the policies influences yam production negatively in the study area. This result conforms with the finding of Kolawole (2009), Zaknayiba and Tanko (2013), and Ojo (2013), where yam production in North-Central Nigeria was found to also be technically inefficient.

In the evolution of efficiency changes in yam production shown in Figure 1, technical efficiency change evolved diminishingly in 2012, but rose to its peak in 2016. Total factor productivity change was the highest in 2016. This may have resulted from the lingering positive effects of the ATA programme, where targeted input subsidies, improved seeds and financial assistances were given to farmers prior to 2016 farming season. The pure and scale efficiency changes also evolved in the same undulating direction to show the low productivity observed in the crop‘s production over the period studied. This result conforms with the finding of Kolawole (2009), Zaknayiba and Tanko (2013), and Ojo (2013), where yam production in North-Central Nigeria was found to be technically inefficient.

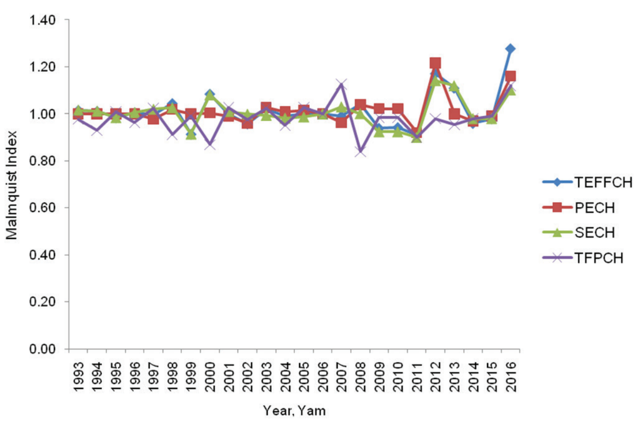

Figure 1. Evolution of efficiencies and total factor productivity changes in yam production over time in North-Central Nigeria (TEFFCH- Technical Efficiency change; PECH-Pure Efficiency Change; SECH-Scale Efficiency Change; TFPCH-Total Factor Productivity Change)

Technical progress in the production of yam in North-Central Nigeria

The mean technical progress and total factor productivity of yam 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, its inclusion in the Table and in the discussion. The highest technological change was achieved in 2016 at 16.8% 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 (2011-2015), when sustainable agriculture based on business-like attitude through the private sector was emphasized to boost agricultural productivity in Nigeria.

The least technical progress was observed in 1993 at -0.107, which indicated 89.3% required improvement in the technique of yam production in the study area that year. Average technical progress in the production of yam was observed to be 0.018, which implied that about 1.8% reduction was observed in the technique used in the production of the crop over the years studied. This together with other factors contributed to the regressive productivity of yam over the period studied. This may be attributed to the Structural Adjustment Programme period (1986-1994), when the agricultural sector was still marginalized despite the policy of liberalization (1995-2010) being initiated. This result agrees with the findings of Udah et al. (2015), where agricultural production was found to be inefficient in Nigeria during the SAP period. Technical progress, therefore, contributed regressively to the total factor productivity growth of the yam production over the years studied.

Comparison between efficiency change and technical change in the production of yam

The comparison of yam productivity growth in terms of technical efficiency change and technological change is presented in Table 4. This is often done, although the study is not a comparative one, but because the use of data envelopment analysis (DEA) model based on Malmquist index in the analysis is less data demanding and allows the index to be decomposed into technical efficiency and technological changes, thus, the need for the multilateral comparison. In the production of yam in the study area, the mean technical efficiency change was 0.986 against 0.988 mean technological change. This suggests that yam was produced at a greater technological change than technical efficiency change in the study area. This implied that, although, there was improper production resource allocation in yam in the zone, the technology used was improved by about 0.02%. Technical efficiency change recorded a 1.4% regress in its contribution to the productivity growth, while the technological change indicated a 1.2% reduction in the technology employed and its contribution to the productivity growth over the period studied.

Table 3. Technical progress in yam production in North-Central Nigeria

Year	Technological change (TECHCH)	Technical progress (TECHPR)	Total factor productivity change (TFPCH)
1992			
1993	0.893	-0.107	0.839
1994	0.918	-0.082	0.929
1995	1.025	0.025	1.009
1996	0.957	-0.043	0.963
1997	1.025	0.025	1.024
1998	0.961	-0.039	0.913
1999	1.131	0.131	1.129
2000	0.901	-0.099	0.869
2001	1.047	0.047	1.027
2002	1.028	0.028	0.975
2003	1.014	0.014	1.025
2004	0.959	-0.041	0.951
2005	1.027	0.027	1.028
2006	0.999	-0.001	0.999
2007	1.137	0.137	1.126
2008	0.926	-0.074	0.977
2009	0.918	-0.082	0.984
2010	1.083	0.083	0.984
2011	1.043	0.043	0.900
2012	0.912	-0.082	0.980
2013	0.957	-0.043	0.955
2014	1.137	0.137	0.915
2015	0.982	-0.018	0.979
2016	1.168	0.168	1.139
Mean	0.982	0.018	0.998

Source: Field survey, 2017

Table 4. Comparison between technical efficiency change (TEFFCH) and technological change (TECHCH) in the production of yam in North-Central Nigeria

State	TEFFCH	TECHCH	TEFFCH>TECHCH	TECHCH>TEFFCH
Benue	1.000	0.996	*	
Kogi	0.989	0.994		*
Kwara	0.953	1.002		*
Niger	0.991	0.996		*
Plateau	0.996	0.952	*	
Mean	0.986	0.988		*

Source: Field survey, 2017; TEFFCH= Technical efficiency change; TECHCH= Technological change; > = Greater than;
*= Yes, the change is greater or contributes more to productivity growth (growth in total factor productivity- TFP) than the other one.

Determinants of Total Factor Productivity Change (TFPCH) in yam production

The results of the factors that determined the total factor productivity change in the study area are as presented in Table 5. The results indicate that institutional factor (amount of credit borrowed), government policy (ATA), capital and labour had positive and significant relationship with yam productivity growth at $p\leq0.05$, $p\leq0.05$, $p\leq0.05$ and $p\leq0.01$, respectively, over the period studied. These imply that increase in the farmers' utilization of these factors led to increase in the yam's productivity growth. Capital-labour was significant at $p\leq0.01$ but was negatively related to the crop's productivity growth in the study area.

Table 5. Tobit model of the determinants of total factor productivity change in yam in North-Central Nigeria

Variables	Coefficient
Amount of Credit (₦/K)	3.00e-06** (2.58)
Rainfall (mm^3)	0.035 (0.68)
Government Policy: ATA	
(Before = 0; During = 1)	0.22** (2.56)
Capital (₦/K)	0.03** (2.54)
Labour (Man-day)	0.02* (1.87)
Capital-labour (Ratio)	0.41* (-1.80)
Constant	-0.31
Chi2	3.25
PseudoR^2	0.85
Log Likelihood	-25.26

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

Conclusion

Analysis of non-parametric decomposition of total factor productivity growth in yam production in North Central Nigeria was carried out with the use of secondary data obtained from the field survey. Generally, productivity regress was observed in the yam production in North-Central Nigeria over the period studied (1992-2016). The study: (i) indicated technological change to be the major contributor to the productivity growths of yam; (ii) revealed that to increase the yam productivity in the area, the following recommendations needed to be undertaken: a) by yam farmers: to build on self-capacity development, through trainings on how to allocate their production resources to increase productivity growth; to form cooperatives to pool resources together to acquire quality and low-cost machineries, which will enable them to improve their farming techniques and increase output; to acquire more credit to invest in yam production to boost their crop productivity; to take insurance cover against unforeseen risks of all kind for increased productive economic activities; b) by government: to reform agricultural policies to provide farmers with conducive environment to increase farm productivities.

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Conflict of interest

The authors declare no conflict of interest.

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