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The Analysis of Productivity Growth of Tuber Crops in Nigeria (1995-2006)

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The Analysis of Productivity Growth of Tuber Crops in Nigeria (1995-2006)

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Abstract

This study analyzed the productivity of Tuber crops in Nigeria from twenty states between the periods of 1995 -2006 using Data Envelopment Analysis (DEA) to estimate the total factor productivity (TFP) which was further decomposed to reveal the source of productivity growth over the reference period. Negative TFP growth was observed for all the tuber crops considered in the study on the average but an evidence of convergence in productivity level was observed when considering the starting TFP, majority of the states had low TFP (<0.6) but grew over the years by about 0.2 with Kaduna and Adamawa having the highest TFP for cocoyam and cassava respectively.

Keywords: Malmquist index, tuber, Nigeria, total factor productivity

Introduction

Agriculture provides primary means of employment for Nigerians and contributed 43.64% to the GDP in Q3, 2011 contrary to its share of the GDP which stood at about 90% before independence in I960, about 56% between 1960-1969 and more than 40% since 1986 (CBN, 2003). The decline in the contribution of agriculture to the country's GDP overtime is due to the slower growth of the sector relative to other sectors of the economy and most especially commercial exploration of petroleum (CBN, 1997). The national strategic importance of food is evident in its consideration as a key variable in matter relating to national security and in planning against disaster and other emergencies. However, a major indicator of depressed performance of the Nigeria agricultural sector is the food crisis experienced in the country in the past years.

Nigeria as a country is endowed with a large expanse of land with tremendous potential resources and favorable climate for producing food and other raw materials for export and domestic industries has not been self-sufficient in food production (Spore, 1993). The rate of growth of Nigeria food production has been very low; food production grows at the rate of 2.5% annum in recent years while food demand has been growing at the rate of more than 3.5% annum due to high rate of population growth of 2.83% (FOS, 1996). The apparent disparity between the rate of food production and demand for food in Nigeria has led to:

- a food demand- supply gap thus leading to a widening gap between domestic food supply and the total food requirement;
- an increased food importation
- high rates of increase in food due to a growing food supply deficit despite food importation (FMAWRRD, 1988).

Root and tuber crops are second only in importance to cereals as a global source of carbohydrates. They also provide some minerals and essential vitamins. Roots and tubers belong to the class of foods that basically provide energy in the human diet in the form of carbohydrates. The terms refer to any growing plant that stores edible material in subterranean root, corm or tuber. The principal root and tuber crops of the tropics are cassava (Manihot esculenta Crantz), yam (Dioscorea spp.), sweet potato (Ipomoea batatas L.), potato (Solarium spp.) and edible aroids (Colocasia spp. and Xanthosoma sagittifolium). They are widely grown and consumed as subsistence staples in many parts of Africa, Latin America, the Pacific Island and Asia. The potential of these crops is particularly high in the humid tropics and those sub-humid tropics, which are not suitable for cereal production (Onwueme, 1978). Considering the importance of tuber as a strategic crop and its perceived role in food security and wellbeing of the teeming population, this study therefore examined the productivity growth of tuber crops in Nigeria.

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Materials and methods

Productivity growth is generally defined in terms of the improvement and technical change with which inputs are transferred into outputs in the production process (Shih-Hsun *et al.* 2003). Indexes of productivity can therefore be simply referred to as the ratio of aggregate output index to an index for total factor use. In assessing growth, sustainability and competitiveness in the agricultural sector, proper identification and measurement of agricultural productivity growth, particularly when technical change in the sector is factor-based rather than Hicks-neutral is very important. There are different methods for estimating the TFP e.g.. Malmquistand Tornquist indexes. The former had gained popularity in recent years since Fare *et al.* (1994) apply the linear programming approach to calculate the distance functions that make up the Malmquist index. Malmquist Productivity Index (MPI) was first introduced by Caves *et al.* (1982). Unlike the Tornquist index, the Malmquist index has the advantage of computational ease, does not require information on cost or revenue shares to aggregate inputs, consequently, less data demanding and it allows decomposition into changes in efficiency and technology. This method does not attract any of the stochastic assumptions restriction, however, it is susceptible to the effects of data noise, and can suffer from problem of 'unusual' shadow prices, when degrees of freedom are limited (Coelli and Rao, 2003).

Agricultural productivity growth determines the efficiency and effectiveness with which human and materials resources are utilized in agriculture. Increase in Agricultural productivity which hence increase the production of food supplied to the populace which excess can then be exported and shortage or scarcity will be a thing of the past. Many things have to be taken into consideration through application of science and technology towards increasing the production of agricultural products (tuber crops to be precise). Some of the methods include the use of improved crops and stock, application of fertilizer and use of good fertile soil, proper cultural practices and provision of good water as a medium for metabolic activities to increase production of tuber crops.

The Malmquist productivity index, as proposed by Caves *et al.*, (1982), allows one to describe multi-input, multi-output production without involving explicit data and behavioral assumptions. The Malmquist Productivity Index identifies TFP growth respect to two time periods through native ratio of distance functions (Malmquist). Distance functions can be classified into input distance functions and output distance functions. Input distance functions took for a minimal proportional contraction of an input vector, given an output vector, while output distance functions look for maximal proportional expansion of an output vector, given an input vector. By using distance functions, the Malmquist Productivity Index can measure TFP growth without cost data, only with quantity data from multi-input and multi-output representations of technology. In this study, we use output distance functions. According to Hjalmarson and Veiderpass (1992), The Malmquist (quantity) index was originally introduced in a consumer theory context as a ratio between two deflation and proportional scaling factor deflating two quantity vectors onto the boundary of a utility possibility set. This deflation or distance function approach was later applied to the measurement of productivity in Caves *et al.* (1982) in a general production function framework and in a non-parametric setting by Fare *et al.* (1992). The productivity change, that is TFP change (TFPCH) using technology of period t as reference is as follows:

$$M_0^t\,(x_t, y_t, x_{t+1}, y_{t+1}) = \frac{d^{\,t}_0\,(x_t, y_t, x_{t+1}, y_{t+1})}{d^t_0(x_t, y_t)} \qquad \text{(i)}$$

Similarly, we can measure Malmquist productivity index with period t+1 as reference as follows:

$$M_0^{t+1}\,(x_t, y_t, x_{t+1}, y_{t+1}) = \left(\frac{d^{\,t}_0\,(x_t, y_t, x_{t+1}, y_{t+1})}{d^{\,t+t}_0(x_t, y_t)}\right) \qquad \text{(ii)}$$

In order to avoid choosing arbitrary period as reference, Fare *et al.* (1994) specifies the Malmquist productivity index as the geometric mean of the above two indices

$$M_0\,(x_t, y_t, x_{t+1}, y_{t+1}) = \left(\frac{d^{\,t}_0\,(x_t, y_t, x_{t+1}, y_{t+1})}{d^{\,t+t}_0(x_t, y_t)}\; \frac{d^{\,t+1}_0\,(x_t, y_t, x_{t+1}, y_{t+1})}{d^{\,t+t}_0(x_t, y_t)}\right)^{½} \qquad \text{(iii)}$$

equation (ii) can be decomposed into the following two components namely efficiency change index (EFFCH) which measures the catching up components measuring efficiency change in relation to the frontier at different time. The second component is the geometric average of both components and measures technical change (TECHCH) which measure the technology shift between period t and *t+1*. The first component in TECHCH measures the position of unit *t+1* with respect to the technologies in both periods. The second component also estimates this for unit t. If the TECHCH is greater (or less) than one, then technological progress (or regress) exists.

$$EFFCH = \frac{d^{\,t+1}_0\,(x_{t+1}, y_{t+1})}{d^t_0(x_t, y_t)} \qquad \text{(iv)}$$

and

$$TECHCH = \left(\frac{d^{t}_{0}(x_{t+1}, y_{t+1})}{d^{t+t}_{0}(x_{t+1}, y_{t+1})} \quad \frac{d^{t}_{0}(x_{t}, y_{t})}{d^{t+t}_{0}(x_{t}, y_{t})} \right)^{½} \quad (v)$$

Nigeria ,the study area of this research work, is located on the southern coast of west Africa between 2020' E and 140301 E longitude and 4030`N and 14017` latitude. It is bounded on the north by Niger Republic, on the south by the gulf of Guinea, on the east by Chad and Cameroon and on the west, Benin Republic. It has a land area of 923,773 square kilometer with about 75% suitable for cultivation of almost all typical crops, out of which only about 14% is under cultivation of any form.

Nigeria has five main vegetation belts. These are the Mangrove forest around the estuaries along the southern coastline, followed by equatorial deciduous forests, savannah grasslands and semi-desert scrublands are extreme north of the country. The Country has a wide range of climate condition but as a tropical country. It is generally hot and humid. Two seasons are discernible, the wet season and also dry season. The wet season falls between April or May to November when the prevailing monsoon winds blows from south west and dry season is between December to March when harmattan blows from 4000mm in the south-eastern parts of the country to 500mm in the north- eastern part of the country giving Nigeria diversity, which reflected in large variety of crops produced.

The Average temperature for most of the country is between 240C and 270C in the eastern highlands and on the Jos Plateau, the average annual temperature is around 210C in extern north, the average high and average low annual temperature are about 430C and 100C respectively. Nigeria has an estimated population of about 140 million with growing rate of about 2.5 percent year with nearly three quarter of its workforce employed in agriculture (FOS 1996).

This study covers the period of 1995-2006. The information and data are drawn from FAO, WARDA, FOS Websites and International food policy research Institute. The data consists the information on tuber crop production, labour, fertilizers use, land use.

Descriptive statistics and inferential statistic was used. Descriptive statistics involve the use of tables and mean. Inferential statistics involve the use of Malmquist index to analyze the efficiency change and technical change in tuber production in the country.

The dependent variable is Tuber yield index while the independent variables are:

(a) Total agricultural area (l000ha)
(b) Total rural population ('000)
(c) Fertilizer in metric tons
(d) Seedlings in metric tons

Variation in the institutional yield Index and TFP may be explained by variations in the quality of land. Since comparison of agricultural productivity among states, nations would not be meaningful unless differences in land quality are taken into account.

Results and discussions

This study used Malmquist index to measure the productivity of tuber crops for twenty states, serving as the decision making units (DMU), representing the whole country between 1995 and 2006. In this study, the Malmquist productivity index is decomposed into the technical change indexes (TECHCH) and efficiency change (EFFCH) index. In order to identify change in scale efficiency, EFFCH was further decomposed into PECH (Pure efficiency change) and SECH (Scale efficiency change). The method used constructed the best - practice frontiers in tuber production for each of the sampled states. If states' index is equal to one, the production of that particular country is on the best - practice frontier; that is, technically efficient and otherwise if less than one.

Malmquist index summary for cocoyam production

Table 1 and 2 shows the mean Malmquist index summary of the selected states over the period of study and malmquist index summary of annual means. It is to be noted that any value greater than one implies increasing productivity while less than one implies productivity decrease from period *t* (the present year) to period *t+1* (the following year). The table revealed that Kaduna is the only state that has increasing productivity with a value of 1.013 (greater than 1). It has about 1.3 percent average growth in TFP; the observed growth is entirely due to technological change and this implies that further growth can only be experienced by introducing new technology. The findings further revealed that the remaining states all have a decrease in their productivity. Edo state has the highest negative TPF growth. Recall that the value greater than one implies increasing productivity and less than one means productivity decrease from period t to period *t+1*. The mean value of TFP change for the whole period ranged from 0.801 to 1.013. A negative TFP growth was observed in all the years ranging from 1996-2006 with 2003 being the year with the highest negative TFP value; this is due to a decline in the technological change increase 5 percent.

It is important to examine the main cause of improved productivity for cocoyam production. The level of TFP of agricultural sector can be improved either by change in technical efficiency or a shift in production frontier (technological change). Since efficiency change and technological change are the components measure of TFP, these two mean values were then compared to know the source of TFP growth in the sample period. On the average, the efficiency change increase by 0.2 percent while the technological change decreased on the average by 16.1 percent. This suggest that the observed decrease in TFP in cocoyam production in Nigeria is due to technological change rather than Efficiency change. It was observed that the technological change been positive was responsible for the only TFP growth that we have in Kaduna State, other states like Kaduna with increased efficiency change such as Adamawa, Bayelsa, Ekiti, Ermgu, Lagos, Ondo, Oyo and Rivers tend to still have a negative TFP growth , This shows how Important is it to have the efficiency and technological change in increased form to be able to have a high TFP as clearly demonstrated in Kaduna . This has shown also that the production frontier (technological change) is a vital measure in cocoyam production in Nigeria.

Table 1: Malmquist index summary of annual means

Year	effch	techch	pech	sech	tfpch
1996	1.001	0.576	0.927	1.079	0.576
1997	1.012	0.712	1.009	1.003	0.720
1998	1.101	0.663	1.140	0.965	0.730
1999	0.952	0.995	1.019	0.934	0.947
2000	0.981	0.886	0.947	1.036	0.870
2001	0.975	0.941	0.916	1.064	0.917
2002	0.983	0.863	1.048	0.938	0.848
2003	1.012	0.659	1.001	1.011	0.961
2004	1.028	0.895	1.064	0.967	0.920
2005	0.975	0.946	0.990	0.985	0.923
2006	1.007	0.921	0.950	1.060	0.928
Mean	1.002	0.839	0.999	1.003	0.928

Table 2: Malmquist index summary of firm means

Firm	Effech	techch	Pech	sech	tfpch
Abia	0.997	0.807	0.997	1	0.804
Adamawa	1.064	0.904	1	1.064	0.962
Akwa ibom	0.997	0.805	0.997	1	0.802
Anambra	0.996	0.804	0.996	1	0.801
Bayelsa	1.005	0.851	1.01	1.994	0.855
Cross River	0.995	0.821	0.995	1	0.817
Delta	0.997	0.856	0.997	1	0.854
Ebonyi	0.999	0.804	0.999	1	0.804
Edo	0.996	0.897	1	0.996	0.894
Ekiti	1	0.817	1	1	0.817
Enugu	1	0.802	1	1	0.802
Imo	0.997	0.81	0.997	1	0.807
Kaduna	1	1.013	1	1	1.013
Kogi	0.999	0.814	0.999	1	0.813
Lagos	1	0.841	1	1	0.841
Ogun	0.999	0.819	0.999	1	0.819
Ondo	1	0.823	1	1	0.823
Osun	0.999	0.844	0.997	1	0.841
Oyo	1	0.824	1	1	0.842
Rivers	1	0.821	1	1	0.821
Mean	1.002	0.839	0.999	1.003	0.84

[Note that all Malmquist index averages are geometric means]
effch - Technical efficiency change
techch - Technological or technical change
pech - Pure technical efficiency change
sech - Scale efficiency change
tfpch - Total factor productivity change

Malmquist index summary for cassava production

Table 3 and 4 shows the mean Malmquist index summary of the selected states over the period of study and malmquist index summary of annual means.). The table revealed that all the states have a negative TFP with Bayelsa having the highest negative TFP with increased efficiency change of 3.8 percent and decreased technological change of 7.5percent.

The mean of TFP change of each state considered for the whole period ranged from 0.766 to 0.960. A negative TFP growth was observed in all the years ranging from 1996-2006 with 2005 being the year with the highest negative TFP Value, this is due to a decline in the technological change by 2.8 percent. Since efficiency change and technological change are the components measure of TFP, these two mean values were compared to know the source of TFP growth in the sample period. On the average, the efficiency change Increase by 0.1 percent while the technological change decreased on the average by 17.5 percent.

Table 3: Malmquist index summary of annual means

Year	effch	techch	pech	sech	tfpch
1996	1.034	0.534	1.013	1.021	0.553
1997	1.002	0.706	1.002	1	0.708
1998	0.985	0.804	0.985	1	0.792
1999	0.995	0.78	1.005	0.99	0.776
2000	1.011	0.865	1.005	1.006	0.874
2001	1.021	0.891	1.021	1	0.909
2002	0.972	0.887	0.969	1.004	0.862
2003	1.005	0.903	1.005	1	0.907
2004	1.004	0.916	1.004	1	0.919
2005	1.017	0.972	1.021	0.996	0.989
2006	0.966	0.924	0.962	1.004	0.893
Mean	1.001	0.8255	0.999	1.002	0.825

Table 4: Malmquist index summary of firm means

Firm	Effech	Techch	Pech	Sech	Tfpch
Abia	1.019	0.825	1.019	1	0.844
Adamawa	1	0.766	1.002	1	0.766
Akwa ibom	0.994	0.825	0.994	1	0.82
Anambra	0.987	0.821	0.987	1	0.81
Bayelsa	1.038	0.925	1	1.038	0.96
Cross River	1	0.821	1	1	0.821
Delta	0.998	0.822	1.002	1	0.828
Ebonyi	1.002	0.822	1.002	1	0.834
Edo	1.014	0.823	1.014	1	0.834
Ekiti	1.004	0.823	1.004	1	0.826
Enugu	0.999	0.802	0.997	1	0.801
Imo	0.997	0.808	0.976	1	0.806
Kaduna	0.976	0.807	0.976	1	0.787
Kogi	0.995	0.815	0.995	1	0.812
Lagos	1	0.869	1	1	0.869
Ogun	1	0.827	1	1	0.82
Ondo	1	0.828	1	1	0.827
Osun	1	0.828	1	1	0.828
Oyo	0.995	0.824	0.995	1	0.82
Rivers	1	0.82	1	1	0.82
Mean	1.001	0.825	0.999	1.002	0.825

[Note that all Malmquist index averages are geometric means]
effch - Technical efficiency change
techch - Technological or technical change
pech - Pure technical efficiency change
sech - Scale efficiency change
tfpch - Total factor productivity change

Malmquist index summary for yam production
Table 5 and 6 shows the mean Malmquist index summary of the selected states over the period of study and malmquist index summary of annual means. The table revealed that all the states have a negative with Adamawa having the highest negative TFP with increased efficiency change of 15.6 percent and decreased technological change of 22 percent.

The mean value of TFP change for the whole period ranged from 0.794 to 0.901. A negative TFP growth was observed in all the years ranging from 1996-2006 with 2005 being the year with the highest negative TFP value; this is due to a decline in the technological change by 6.6 percent.

It is important to examine the main cause of improved productivity for Yam production. The level of TFP of agricultural sector can be improved either by change in technical efficiency or a shift in production frontier (technological change). Since efficiency change and technological change are the components measure of TFP, these two mean values were then compared to know the source of TFP growth in the sample period. On the average, the efficiency change Increase by 0.5 percent while the technological change decreased on the average by 18.8 percent.

Table 5: Malmquist index summary of annual means

Year	effch	techch	pech	sech	tfpch
1996	0.994	0.512	0.994	1	0.509
1997	1.049	0.666	1.115	0.941	0.699
1998	1	0.737	0.989	1.011	0.737
1999	0.953	0.855	0.907	1.051	0.815
2000	1.057	0.841	1.105	0.957	0.889
2001	1.033	0.873	1.001	1.002	0.876
2002	0.991	0.904	0.992	1	0.896
2003	1.002	0.9	1.002	1	0.902
2004	1.021	0.907	1.007	1.015	0.926
2005	1	0.934	1.984	1.016	0.934
2006	0.966	0.924	0.962	1.004	0.893
Mean	1.005	0.812	0.007	1.998	0.816

Table 6: Malmquist index summary of firms means

Firm	Effech	Techch	Pech	Sech	Tfpch
Abia	1.999	0.811	0.999	1	0.810
Adamawa	1.159	0.780	1.201	0.962	0.901
Akwa ibom	0.990	0.819	0.990	1	0.811
Anambra	0.990	0.812	0.990	1	0.804
Bayelsa	1	0.815	1	1	0.814
Cross River	1	0.821	1	1	0.821
Delta	0.996	0.820	0.996	1	0.817
Ebonyi	0.997	0.811	0.997	1	0.809
Edo	0.998	0.812	0.998	1	0.811
Ekiti	1	0.818	1	1	0.818
Enugu	1	0.799	1	1	0.799
Imo	0.998	0.810	0.998	1	0.809
Kaduna	0.997	0.803	0.997	1	0.800
Kogi	0.997	0.816	0.997	1	0.813
Lagos	1	0.794	1	1	0.794
Ogun	0.997	0.814	0.997	1	0.821
Ondo	1	0.825	1	1	0.825
Osun	1	0.820	1	1	0.820
Oyo	0.995	0.816	0.995	1	0.812
Rivers	1	0.818	1	1	0.818
Mean	1.005	0.812	1.007	0.998	0.816

[Note that all Malmquist index averages are geometric means]
effch - Technical efficiency change, techch - Technological or technical change, pech - Pure technical efficiency change
sech - Scale efficiency change, tfpch - Total factor productivity change

Conclusion

Productivity growth of staple food like tubers has tremendous implications if government wants to meet up with its objective of food security and improve quality of life. The study investigated the productivity growth of tuber crops but did not make effort to examine its determinants due to lack of state wide data. The finding emerged that all the major crops examined had negative productivity growth with technological change accounted for the negative growth observed. The finding is not surprising due to the fact that state agricultural development programmes which are saddled with the responsibilities of transferring technologies and innovations experienced various challenges within the reference periods.

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