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Trend analysis of crop productivity growth in Nigeria (1961-2014)

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ABSTRACT

This paper focuses on trend analysis of crop productivity growth in Nigeria between 1961 and 2014. It was therefore intended to estimate the effect of different factors of production that influence crop output and to compute their technical efficiency, technological change and total factor productivity change. Panel data was broken into land, labour, tractor, fertilizer and animal power. Descriptive statistics, Cobb-Douglas production analysis and Malmquist Productivity index were the tools employed for the analysis. The result of the trend analysis shows that time has a positive effect on crop production and also shows that there is an increase in crop output, land, labour, tractor, fertilizer and animal power over years. Land and animal power are statistically significant at 1% probability level and a unit increase in land and animal power, crop output increases by 2.176772 tons and 0.7531192 tons respectively, this implies that land and animal power have a positive effect on crop output in Nigeria. Labour and tractor have negative impact on crop output, while fertilizer has no significant effect on crop output. The efficiency change, technical change and total factor productivity change were also analyzed. According to the analysis, Nigeria experienced the highest agricultural productivity from 1992, with value of 1.166. It is therefore recommended that the use of agricultural land should be increased, relevant policies should address the constraints to technology progress, and efficiency should be promoted in order to improve productivity growth.

Key words: total factor productivity, trend analysis, Malmquist Productivity index, technical change

INTRODUCTION

Nigerian agriculture encompasses considerable regional and crop diversity. According to the Nigeria Bureau of Statistics (2014), in the 1960s, the agricultural sector was the most important in terms of contributions to domestic production, employment and foreign exchange earnings. The agricultural sector is strategic to national economic development and contributes 42.1% of the current Gross Domestic Product (Eleri et al., 2012). It remains a major source of food and raw material for agro-industrial processing and has strong links to employment, national income, market opportunities for industrial production

and strong potentials for poverty reduction and health improvement. However, Nigerian agriculture faces tremendous challenges which among others include low agricultural output.

The growth rate of a nation depends on two factors: the number of people producing and how well they are producing. This is the growth rate of the labour force and the productivity of the labour force respectively. Productivity gains could come from increase in human capital and physical capital, technological advances or the better use of resources (Ruttan, 2002). Chung et al (1997) identified some other important sources of productivity growth; these include capital accumulation, available resources, growth-compatible institutions, entrepreneurship and technological development. Improved rural infrastructure, improved inputs and transport system were identified by Boutong and Downswell (2002) to be other essential components necessary for meaningful agricultural productivity.

The trend in the share of agriculture in the GDP shows a substantial variation and long-term decline from 60% in the early 1960s to 48.8% in the 1970s and 22.2% in the 1980s. Unstable and often inappropriate economic policies (of pricing, trade and exchange rate), and the relative neglect of the sector are important factors responsible for the decline. Nigerian agriculture consists of tree and food crops, forestry, livestock and fisheries. In 1993 constant factor cost, crops (the major source of food) accounted for about 30% of the Gross Domestic Products (GDP), livestock about 5%, forestry and wildlife about 1.3% and fisheries accounted for 1.2%. Alabi (2005) stated that stagnation in agriculture is the principal explanation for poor economic performance, while rising agricultural productivity has been the most important concomitant of successful industrialization. A strong and efficient agricultural sector would enable a country to feed its growing population, generate employment, earn foreign exchange and provide raw materials for industries. The agricultural sector has a multiplier effect on any nation's socio-economic and industrial fabric because of the multifunctional nature of agriculture (Oguchi, 2004). The National Bureau of Statistics says 60.90% of Nigerians were living in absolute poverty in 2010, up from 54.7% in 2004.

Nigeria which is endowed with a strong natural resource base cannot confidently feed its population, being one of the highest importers of agricultural products. However, these resources have to be effectively utilized so as to diversify the economic base and reduce dependence on oil 18 and on imports. The economy remains vulnerable to external shocks rising from fluctuations in the world prices of crude oil and the rising prices of imports. This has resulted in a great challenge – agricultural productivity has seriously declined over the past two decades and as a result, rural poverty is rampant. World bank data shows that more than 70% of Nigerians live below the poverty line (which is less than a dollar/ day) implying that there has been an excessive growth in the levels of poverty of Nigerians most of whom are engaged in agriculture from independence till today.

Nigerian agriculture is inefficient and poor performing because a unit of input employed in the production process does not yield its highest possible level of output. This is as a result of poor past policies, civil and social unrest, burgeoning population, resource mis-management and failure to build capital and strengthen local industries. Furthermore, terms of trade, which account for 42% of export trade,

have been most unfavourable in the recent past. The loss of income arising from this situation thus jeopardizes economic development (ECA, 2002). The problem of Nigerian agriculture stems from the fact that most farmers are still engaged in peasant farming with low level of technology, which leads to poor productivity growth. This has resulted in decrease in export earnings, low capital formation, food insecurity and poor rural development. To resolve the low productivity problem, and in order to improve on their total factor productivity, Nigeria has embarked on the use of high yielding plant varieties/breeds of animals, inorganic fertilizers and farm machinery.

There is, however, a paucity of research in productivity growth at the micro level in Nigeria. Most studies have been based on production as productivity at the farm/micro level. This study intends to improve upon other studies by examining production as a function of aggregate input use. It is significant to state that Nigeria is homogenous in the system of agricultural activities practiced.

MATERIAL AND METHODS

The study was carried out in Nigeria over the period of 1961-2014. Nigeria has a population of 166.6 million people (UNDESA, 2011) with a total area of 923,769sq km and occupies about 14% of land area in West Africa.

Panel data of five inputs (land, animal power, labour, fertilizer consumption and agricultural machinery (number of tractors) on crop production in Nigeria from 1961 - 2014 were used for data analysis which were obtained from FAOSTAT and FAO Statistics Division. Statistical tools that were employed in this study are descriptive statistics, multiple regression analysis and malmquist TFP indices. In this study the measure used to analyze productivity growth of Nigeria is the DEA based on Malmquist TFP indices and the regression analysis was used to study trend and also to study the effect of the variables on the output.

(i) Cobb-Douglas production function analysis

It was used to highlight the factors affecting crop productivity and the effect of the variables on the output and the Cobb-Douglas production function model is specified as follows;

$Y = f(X1, X2, X3, X4, X5, u)$

Where:

Y = Crop output (Tonnes)

$X1$ = Agricultural land (ha) the a priori expectation is that Agricultural land coefficient will be positive because people may use more of agricultural land.

$X2$ = Labour (man day). It is expected that the coefficient of labour will be positive. This is because agriculture is the major occupation for most Nigerians.

$X3$ = Tractor (number of tractor hours) It is expected that the coefficient of the tractor used should be negative because majority of the population engage in agricultural production uses manual labour.

$X4$= Fertilizer (Kg) Coefficient of fertilizer is expected to be positive because increase fertilizer usage should increase crop output.

$X5$ = Animal power (heads).

U = Error Term

The following production functions were fitted to the model:

Linear function:

$$Yt = b_0 + b_1X_{1t} + b_2X_{2t} + b_3X_{3t} + b_4X_{4t} + b_5X_{5t} + U_t$$

Semi-log function:

$$Yt = b_0 + b_1 \log X_{1t} + b_2 \log X_{2t} + b_3 \log X_{3t} + + b_4 \log X_{4t} + b_5 \log X_{5t} + U_t$$

Double-log function:

$$Log\ Y_t = b_0 + b_1 \log X_{1t} + b_2 \log X_{2t} + + b_3 \log X_{3t} + b_4 \log X_{4t} + b_5 \log X_{5t} + U_t$$

(ii) Malmquist TFP indices

These indices were introduced by Caves et al. (1982). The innovation of Fän et al. (1994), shows that this index can be estimated using a nonparametric approach. Malmquist indices allow for the decomposition of productivity growth into technical and efficiency change components: Improvement in technical efficiency with which the inputs are used (catching up), and - The innovation in technology (technical change) (Belloumi and Matoussi, 2009).

TFP is measured in this study by the Malmquist index methods. Using the Malmquist Productivity index (MPI) as a measure of productivity change over time. The method has the advantage that it is parameter free; we do not presuppose a parametric functional form. Specifying a functional form imposes restrictions on the structure of technology, which could give rise to specification error (Nkamleu, 2004).

Using period s-technology:

$$m_o^s(q_s, q_t, x_s, x_t) = \frac{d_o^s(q_t, q_t)}{d_o^s(q_s, q_s)} \qquad \text{(i)}$$

Using period t-technology:

$$m_o^t(q_s, q_t, x_s, x_t) = \frac{d_o^t(q_t, q_t)}{d_o^t(q_s, q_s)} \qquad \text{(ii)}$$

Since there are two possible MFP measures, based on period s and t technology, the MFP is defined as the geometric average of the two:

$$m_o(q_s, q_t, x_s, x_t) = \left[m_o^s(q_s, q_t, x_s, x_t) X\, m_o^t(q_s, q_t, x_s, x_t)\right]^{0.5}$$

$$= \left[\frac{d_o^s(q_t, q_t)}{d_o^s(q_s, q_s)} X \frac{d_o^t(q_t, q_t)}{d_o^t(q_s, q_s)}\right]^{0.5} \qquad \text{(iii)}$$

It can be decomposed into efficiency change and technical change:

$$m_o(q_s, q_t, x_s, x_t) = \frac{d_o^t(q_t, q_t)}{d_o^s(q_s, q_s)}\left[\frac{d_o^s(q_t, q_t)}{d_o^s(q_s, q_s)} X \frac{d_o^t(q_t, q_t)}{d_o^t(q_s, q_s)}\right]^{0.5} \qquad \text{(iv)}$$

Efficiency change Technical change

The first term is the efficiency change component or "catching-up", which measures the change from observed output toward frontier output (i.e., maximum potential production) between period t and t+1. The second term is the technical change component or "innovation", which captures the shift in technology (the world frontier) at each country's observed input mix between period t and period t+1. Once a country reaches the frontier, further growth is limited by the rate of innovation, or movement of the frontier itself.

Table 1. Descriptive information on crop productivity in Nigeria

Variable	Mean	StdDeviation	Minimum	Maximum
CropOutput	4200585	3683975	1530839	25829680
Land	76254.97	105871.70	47219.17	837636.40
Labour	12618.31	1338.60	12301	22259
Tractor	13028.40	9012.66	500	37644.8
Fertiliser	355110.8	1154520	1394	8610000
Animalpower	1811139	2535214	500027	19450000

Source: Computed from FAO Data, 2015

RESULTS AND DISCUSSION

(a) Descriptive Statistics of Agricultural production in Nigeria (1961-2014)

Table 1 showed the maximum agricultural output was 25,829,680 tons and minimum output of 1,530, 839 with a mean of 4,200,585 tons. Average land used for cultivation in Nigeria was 76254.97 hectare, minimum of 47219.17 hectare and maximum 837636.4. The average number of labour actively involved in Agriculture is 12618.37, minimum of 12301 people and maximum of 22259 people. The average number of tractor used was 13028.4, minimum of 500 and maximum of 37644.88. The maximum fertilizer used was 8610000 tonnes, minimum of 1394 tons and average of 355110.8. Animal power average was 1811139 heads, maximum of 19450000 heads and minimum of 1394.

(b) Agricultural output and inputs trend in Nigeria

(i) Nigeria crop output trend

The graphical representation for agricultural output trend shows a positive trend in which the crop output shows that there has been an increase in agricultural crop output over time. This is contrary to the belief that crop output has decreased overtime, although it is not increasing at a constant rate since in some years it fell – however, according to the graph agricultural output increased greatly from 2005 to 2014.

(ii) Nigeria agricultural land trend

There has also been an increase overtime according to the graph shown in figure 1. Since agricultural land is directly proportional to output, it is expected for it to also be on an increase. As it is shown in the figure 1, the land used was almost constant until 1972 when it declined, indicating that so many people did not cultivate until 1977 when it went up and it was like that till 2014. This implies that the use of agricultural land has increased over the years.

(iii) Nigeria agricultural labour trend

According to the figure 1 it also showed that there have been a positive trend over time for labour. This implies that more people have been involved in Agriculture over the years.

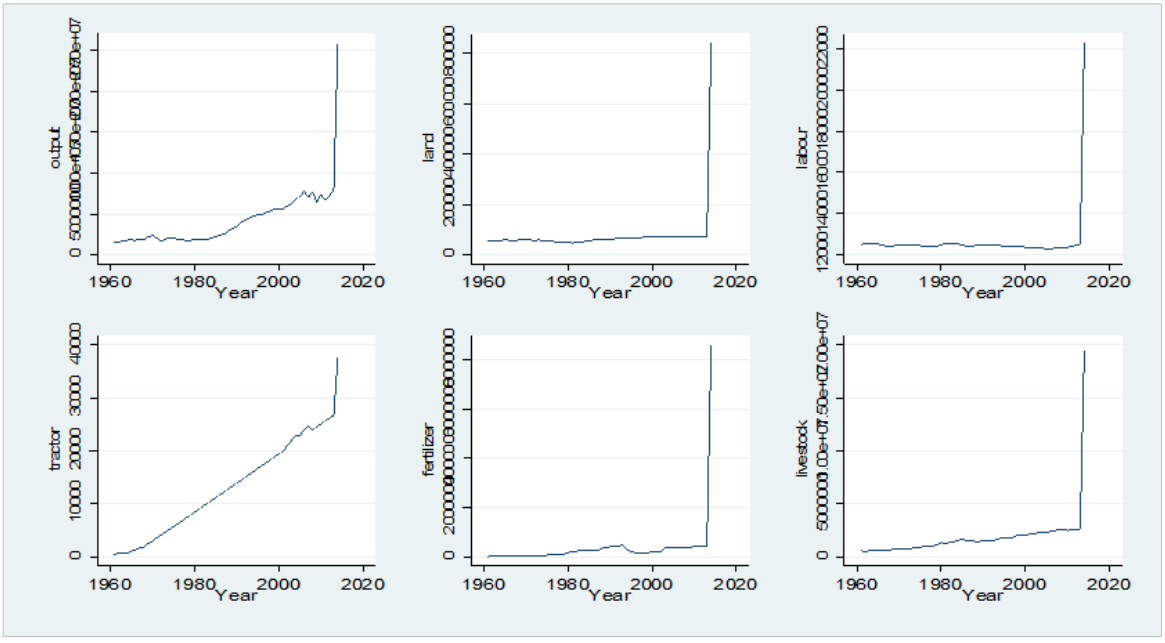
(iv)Nigeria agricultural tractor trend

According to the figure 1, it was noticed that it is also exhibiting a positive trend. This also implies that more tractors are in use now

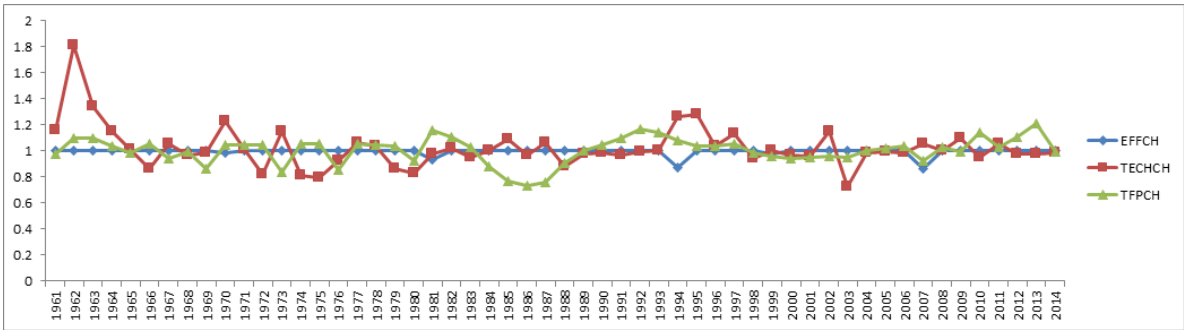
than before, in the 1960's tractors were very few. It shows that most farmers were using manual labour from 1980 up until 2014 when the number increased. Although it has been reported by National Bureau of Statistics that mechanization in Nigeria is not encouraging i.e. there is more things to be done in the area of mechanization and this is due to the expensive amount used to get the tractors.

(v) Nigeria fertilizer usage trend

Looking at fertilizer usage trend, it was fairly constant but experienced an increase by 2014, whic implies that more people are aware of fertilizer and more of it has been used.



Graph 1: Graphical Representation of Output and Inputs Trend in Nigeria (1961-2014)



Graph 2: Graphical Representation of Efficiency change, Technical change and Total factor productivity change
Source: Field survey 2016

(c) Determinants of crop output

Table 2 shows the relationship between agricultural output and selected variables. Linear functional forms were used and it has high coefficient, a high R2 and also a test of multicollinearity was taken and it indicates the absence of multicollinearity based on the fact that VIF<10. The coefficient of determination R2 is 0.97, indicating that 97% of the variation in agricultural output is explained by the explanatory variables.

$$Y= 70.3975 + 2.1767X_1 – 9.4458X_2 – 0.1192X_3 + 0.0104X_4 + 0.7531X_5 + Ut \quad (v)$$

The coefficient of land and livestock is statistically significant at 1% probability level. The result further indicates that for every unit increase in land and livestock, crop output will respond by 2.1767 tons and 0.7531 tons respectively. Labour has a relationship with crop output; this may be due to labour not being effective enough. Fertilizer has no significant effect on crop production in Nigeria. This can be explained by studying the trend; it was noticed that although the trend seems to be positive, the rate of increase is not proportional to the increase in crop output. This finding is in agreement with (Akinleye 2004). Tractor on the other hand has a negative effect on crop output which is in agreement with a priori expectation and in agreement with Akinleye (2004).

Table 2. Cobb-Douglas Production Function and VIF analysis

Variable	Coefficient	T-value	VIFvalue
CropOutput	70.39756	11.72*	
Land	2.176772	11.63*	2.16
Labour	-9.445872	-11.97*	7.24
Tractor	-0.119239	-1.65***	1.37
Fertiliser	0.010407	0.26	4.27
Animalpower	0.753119	6.17*	6.08
R2 = 0.9727			
F (5, 48) = 342.04			
Adjusted R2 = 0.9699			

Source: Computed from FAO Data, 2015
***, **, * Coefficient significant at 10%, 5%, 1% levels

Table 3: Efficiency change, Technical change and Total factor productivity change

YEAR	EFFCH	TECHCH	TFPCH
1961	1	1155	0.98188
1962	1	1815	1100188
1963	1	1344	1096262
1964	1	1152	1041156
1965	1	1.01	0.98859
1966	0.999	0.866	1056027
1967	1	1057	0.945183
1968	1	0.969	0.991436
1969	1	0.984	0.864243
1970	0.988	1229	1044027
1971	1	1008	10044
1972	1	0.823	1043382
1973	1	1152	0.840624
1974	1	0.809	1052916
1975	1	0.792	1056584
1976	0.999	0.924	0.857624
1977	1	1064	1057261
1978	1	1037	104902
1979	1	0.863	1038648
1980	1	0.828	0.926642
1981	0.933	0.98	115629
1982	1	1017	1106487
1983	1	0.95	1032726
1984	1	1006	0.877252
1985	1	1094	0.76918
1986	1	0.971	0.731842
1987	1	1.06	0.755226
1988	1	0.881	0.908518
1989	1	0.979	1002553
1990	1	0.986	1048366
1991	1	0.972	1101759
1992	1	0.991	1166731
1993	1	1003	1138105
1994	0.876	1.26	1084073
1995	1	1285	1039429
1996	1	1039	1041201
1997	1	1134	105351
1998	1	0.944	0.98749
1999	0.974	1006	0.956268
2000	1	0.97	0.943218
2001	1	0.956	0.951511
2002	1	1148	0.956213
2003	1	0.726	0.950827
2004	1	0.986	100018
2005	1	0.993	1018017
2006	1	0.985	103761
2007	0.866	1051	0.924778
2008	1	1	1027513
2009	1	1096	0.993503
2010	1	0.954	1142415
2011	1	1057	102886
2012	1	0.978	110734
2013	1	0.976	1215301
2014	1	0.988	0.990068

Sources: DEA analysis, 2016

(d) Efficiency change, Technical change and Total factor productivity

Table 3 shows the efficiency change, technical change and total factor productivity change that occurred over the years. Improvement in efficiency change component is considered to be evidence of catching up (to the frontier), while improvements in the technical change component are considered to be evidence of innovation. It was noticed that the technological efficiency change was constant throughout the years. That means the technical efficiency did not change over time, while technical change changed over the years i.e. there is evidence of innovation or no innovation. According to the table the efficiency change of most years was not changing while few years such as 1966, 1970, 1976, 1981, 1993 and 1999 experienced reduced efficiency change i.e. EF<1. This means that there is no catching up to the frontier. The technical change was fluctuating over the years, in some years Nigeria experienced an increase in technical change, in some there was no change and in some there was reduced technical change. TC>1, TC=1 and TC<1 respectively. In 1962 it experienced the highest technical change of 1.815. This implies that there was more innovation in that year than any other. Also it was noticed that in that same year the efficiency change was constant and the total factor productivity was increased. This was due to the increased technical efficiency. The total factor productivity was also changing in either a positive or negative way. This table shows that the highest TFP was in1 992 – that of1.166. Table 3 shows that total factor productivity experienced a fluctuation over years in Nigeria. Although all the variables experienced and increase, productivity decreased. Nigeria has been seen as a country that experienced increased crop production due to increase in land but decreased productivity over the years because of its efficiency change and technical change.

CONCLUSIONS

This paper focused on trend analysis of crop productivity growth in Nigeria using a panel data obtained from FAO statistics for a period of 54 years (1961-2014). Trend of agricultural productivity, effect of the variables on Agricultural output and efficiency change, technical change and total productivity change in Nigeria were examined.

The result of the trend analysis shows that time has a positive effect on Agricultural production. The positive trend shows an increase in output, land, labour, tractor, fertilizer and animal power over the years, although the increase is very minimal, the change is present. All the variables show their maximum in 2014.

It can be concluded that Nigeria experienced the highest productivity in terms of agriculture in 1992 with a value of 1.166. Also, crop production seems to be on the increase but crop productivity, which takes into consideration both efficiency change and technical change, is fluctuating over the years in Nigeria.

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Analiza kretanja rasta proizvodnje poljoprivrednih kultura u Nigeriji (1961. –2014.)

SAŽETAK

Ovaj je rad usredotočen na analizu kretanja rasta proizvodnje poljoprivrednih kultura u Nigeriji u razdoblju od 1961. do 2014. Cilj je ovog rada odrediti kako različiti faktori proizvodnje utječu na količinu proizvedenih kultura te izmjeriti njihovu tehničku učinkovitost, tehnološki razvoj i promjene u ukupnom faktoru produktivnosti. Panel podaci razdijeljeni su u sljedeće kategorije: zemljište, radna snaga, traktori, gnojivo i životinjska snaga (radne životinje). Za potrebe analize korištena je deskriptivna statistika, Cobb-Douglasova proizvodna funkcija i Malmquistov indeks produktivnosti. Dobiveni rezultati pokazuju da vrijeme ima pozitivan učinak na proizvodnju poljoprivrednih kultura te da je tijekom godina zamjetan porast u količini proizvedenih kultura, zemljištu, radnoj snazi, traktorima, gnojivu i životinjskoj snazi. Zemljište i životinjske snaga statistički su značajne kategorije, s razinom vjerojatnosti od 1 %. Porast jedinice zemljišta rezultira porastom od 2,176.772 tona u poljoprivrednim kulturama, a životinjske snage porastom od 0,7531192 tona u poljoprivrednim kulturama. Iz ovoga proizlazi da zemljište i životinjska snaga imaju pozitivan utjecaj na količinu proizvedenih poljoprivrednih kultura u Nigeriji. Kategorije radne snage i traktora imaju negativan učinak, a gnojiva nemaju nikakav značajni učinak na količinu proizvedenih poljoprivrednih kultura. Mjerena je i tehnička učinkovitost te tehnološki razvoj i promjene u ukupnom faktoru produktivnosti. Prema dobivenim rezultatima, poljoprivredna je proizvodnja u Nigeriji 1992. dosegla svoju najveću vrijednost od 1,166. S obzirom na rezultate preporučuje za povećanje poljoprivrednog zemljišta i učinkovitosti te donošenje relevantnih mjera čiji bi cilj bio rješavanje problematike razvoja tehnologije.

Ključne riječi: ukupni faktor produktivnosti, analiza kretanja rasta, Malmquistov indeks produktivnosti, tehnološki razvoj