# 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.

## 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;

$Y = f(X_1, X_2, X_3, X_4, X_5, u)$
Where:

$Y$ = Crop output (Tonnes)

$X_1$ = Agricultural land (ha) the a priori expectation is that Agricultural land coefficient will be positive because people may use more of agricultural land.

$X_2$ = 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.

$X_3$ = 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.

$X_4$= Fertilizer (Kg) Coefficient of fertilizer is expected to be positive because increase fertilizer usage should increase crop output.

$X_5$ = Animal power (heads).

$U$ = Error Term

The following production functions were fitted to the model:

Linear function:

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

*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:

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

Using period t-technology:

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

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:

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

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

It can be decomposed into efficiency change and technical change:

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

## *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.

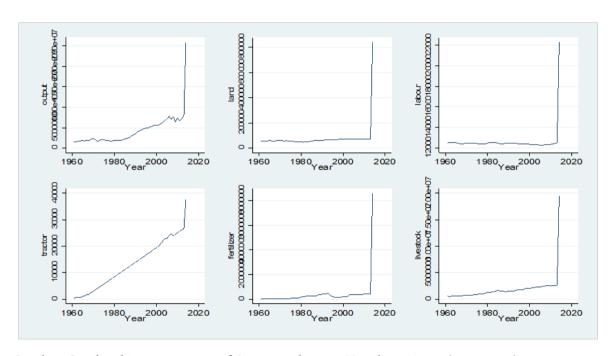#### (iii) Nigeria agricultural labour trend

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.
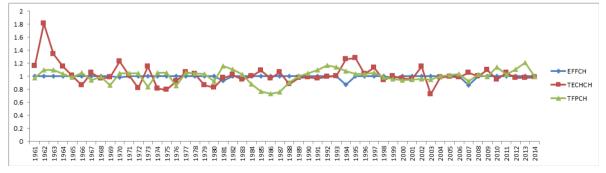
#### (iv)Nigeria agricultural tractor trend

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.

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

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.

# REFERENCES

Akinleye S.O. (2004). Agricultural productivity growth in West African agriculture: A frontier function analysis. Department of Agricultural Economics Olabisi Onabanjo University, Ogun State Nigeria.

Alabi, I. (2005). The determinants of agricultural productivity in Nigeria. Food, Agriculture and Environment Journal 3(2): 78 - 82.

Belloumi, M., and Matoussi, M.S (2009). Agricultural productivity growth in MENA countries J. Dev. Agric. Econ. 1(4): 103-113, July, 2009.

Boutong, N.E., and Downswell, C.R. (2002). Prospect for world agriculture in the 21st century. ManejoIntegrado de Plagasy. Agroecologic. No 65: 4-20.

Cavel, S., Jitsuchon, S. and Methakunnavut, N. (1982). The Importance of Public Investment for Reducing Rural Poverty in Middle-Income Countries: The Case of Thailand. DSGD Discussion Paper No.7. Washinton, D.C., International Food Policy Research Institute.

Chung, Y.H., Färe, R. and Grosskopf, S. (1997). Productivity and undesirable outputs: A directional distance function approach. Journal of Environmental Management 51: 229-40.

Economic Commission for Africa (2002). Transition from low to high productivity is Ababa.

Eleri, O. E, Uduka, I. K., Akuto, N., Onuvae, P, and Anwara, O. (2012). Towards a climate-based agricultural insurance reform in Nigeria. Presented at the workshop on legal and regulatory frameworks for agricultural insurance reform in Nigeria-Protecting Nigeria's farmers from climate change Kano Hall, Transcorp Hilton Hotel, February 27, 2012. pp. 1-53.

Nigerian Bureau of statistics (2010). Nigeria poverty profile report. Abuja.

Nkamleu, G.B (2004). Productivity growth, technical progress and efficiency change in African agriculture. Afr. Dev. Rev. 16: 203-222.

Oguchi, N. (2004). Integrated Report. Total Factor Productivity Growth: Survey Report. Tokyo, Asian Productivity Organization.

Ruttan, V. W. (2002). Productivity Growth in World Agriculture: Sources and Constraints. Journal of Economic Perspectives 16: 161-184.

United Nations Department of Economic and Social Affairs (2011). World population prospects: The 2010 revision. United Nations Department of Economic and Social Affairs, Population Division, New York.

# 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