Journal of Economics and Sustainable Development
ISSN 2222-1700 (Paper) ISSN 2222-2855 (Online)
Vol.4, No.5, 2013

Agricultural Productivity Growth and Incidence of Poverty: An Experience from Africa

[1]AJAO, A. O; [1]OGUNNIYI, L.T and [2]OYEDELE, G. A.

[1]Agricultural Economics Department, Ladoke Akintola Univeristy of Technology

Ogbomoso-Nigeria.

e-mail: oaajao57@lautech.edu.ng

[2]Oyo State Agricultural Development Programme, Oyo State, Nigeria.

e-mail: oyeed@yahoo.com

Abstract

This study investigates the effects of agricultural productivity growth on poverty. Using Food and Agriculture Organisation (FAO) data covering two decades (1971-2009) we determined the relationship between agricultural productivity and poverty. Malmquist Index Total Factor Productivity (TFP) was used as indicator of agricultural productivity while Human Development Index (HDI) was adopted as proxy for poverty. Further analysis was carried out to determine whether the performance of factor productivity is due to change in technology or technical efficiency.

The result of Malmquist TFP index analysis showed that the average TFP growth over the period was found to be 0.2 percent per annum with large variation in growth rate across the sampled countries. Twenty-two countries representing about 52% of the total sample experienced productivity growth and this is largely due to technological change. Congo and Somalia experienced decline in growth and this may be attributed to the incidence of war and civil unrest which have adverse effect on growth. Overall, the continent experienced improvement in technology with 2.1 percent upward shift in the production frontier and 1.8 percent decline in efficiency. Regional comparison of agricultural productivity growth reveals that East, South and North Africa experienced growth of 3.3, 2.6 and 3.6 percent respectively. There were declines in agricultural productivity in West and Southern Africa regions as a result of reduction in efficiency.

The analysis of agricultural productivity growth on poverty shows a positive and significant relationship between indicators of the two variables. Specifically, the result indicates that a unit increase in productivity growth will lead to 0.69 percent change in human development index and conversely poverty. Further analysis revealed that the unit improvement in technological change will cause about 1.3 percent improvement in human development index.

The study concludes that agricultural productivity growth is pro-poor and effective strategy to reduce poverty in Africa. It is recommended that relevant policies to address the constraints to technology progress and efficiency should be promoted to improve productivity growth and reduce poverty.

Key Words: Malmquist index, Total Factor Productivity, Technology, Efficiency, Agricultural Productivity, Poverty, Africa.

Introduction

Agriculture has for many years been the backbone of Africa economy and the potential sources of economic growth despite all its weaknesses. Agriculture accounts for about 30 percent of GDP; 40 percent of export value and about 80 percent of employment generation (FAO, 2006; World Bank 2000), also more than two-third of the total population live in the rural area where majority of the households are involved in agricultural activities (FAO, 2006).

In view of the above, agricultural sector holds the key to economic growth as well as addressing the problem of poverty and income inequality in the African continent. It is widely acknowledged in literature that agricultural productivity growth is required for a meaningful industrialization to take place. Despite the potentials that remained untapped in this sector, agriculture has been highly neglected and remained underfunded.

In order to meet one of the objectives of Millennium Development Goal (MDG) by halving poverty, African heads of state recognize the agricultural sector as key to achieving this objective by establishing several initiatives that can promote growth in this sector. This and others led to the establishment of New Partnership for African Development (NEPAD) as an indigenous economic outlook that recognizes the importance of agriculture for the desired development and poverty reduction in the continent, also Comprehensive Africa Agricultural Development Program (CAADP) was established to improve agricultural policies in the continent. The ultimate goals of these special initiatives are to achieve sustainable agricultural growth which will in the long term leads to poverty reduction. Though Africa Peer Review Mechanism (APRM) is not specifically established for agricultural sector, but could have potential impact on the sector since it is assumed that an improvement in government policy making process will reflect in a good policy environment which the sector needs to thrive.

Growth in agricultural sector is essential for poverty reduction because of the size of population that depends on it for their livelihood and the relative incidence of poverty among the African rural dweller. This study therefore attempts to estimate the direct effect of agricultural productivity growth on poverty

MATERIALS AND METHOD

DEA is linear-programming methodology, which uses data on input and output quantities of a Decision Making Units (DMU) such as individual firms of a specific sectors to construct a piece-wise linear surface over data points. In this study, the countries were used as the DMU. The DEA method is closely related to Farrell's original approach (1957) and it is widely being regarded in the literature as an extension of that approach. This approach was initiated by Charnes et al.; (1978) and related work by Fare, et al,. (1985). The frontier surface is constructed by the solution of a sequence of linear programming problems. The degree of technical inefficiency of each country, which represents the distance between the observed data point and the frontier, is produced as a by-product of the frontier construction method.

DEA can either be input or output oriented depending on the objectives. The input-oriented method, defines the frontier by seeking the maximum possible proportional reduction in input usage while the output is held constant for each country. The output-oriented method seeks the maximum proportional increase in output production with input level held fixed. These two methods, that is, input-output oriented methods provide the same technical efficiency score when a constant return to scale (CRS) technology applies but are unequal when variable returns to scale (VRS) is assumed (Coelli and Rao, 2001). In this study, the output-oriented method will be used by assuming that in agriculture, it is common to assume output maximization from a given sets of inputs. The interpretation of CRS assumption has attracted a lot of critical discussion e.g. Ray and Desli, 1997, Lovell, 2001, but also monotonicity and convexity are debatable e.g. Cherchye, *et al.*, 2000.

Fare *et al.*, (1994) used Data Envelopment Analysis (DEA) methods to estimate and decompose the Malmquist productivity index. The DEA method is a non-parametric approach in which the envelopment of decision-making units (DMU) can be estimated through linear programming methods to identify the “best practice” for each DMU. The efficient units are located on the frontier and the inefficient ones are enveloped by it. Four linear programs (LPs) must be solved for each DMU in this study (Country) to obtain the distances defined in equation (iii) and they are:

(i)
$$\left[d_o^t(x_t, y_t)\right]^{-1} = \mathrm{Max}_{\phi,\lambda}\phi,$$
$$s.t \quad -\phi y_{it} + Y_t\lambda \geq 0, \quad x_{i,t} - X_t\lambda \geq 0, \quad \lambda \geq 0$$

(ii)
$$\left[d_o^{t+1}(x_{t+1}, y_{t+1})\right]^{-1} = Max_{\phi,\lambda}\phi,$$
$$st \quad -\phi y_{i,t+1} + Y_{t+1}\lambda \geq 0, \quad x_{i,t+1} - X_{t+1}\lambda \geq 0, \quad \lambda \geq 0$$

(iii)
$$\left[d_o^t(x_{t+1}, y_{t+1})\right]^{-1} = \mathrm{Max}_{\phi,\lambda}\phi,$$
$$st \quad -\phi y_{i,t+1} + Y_t\lambda \geq 0, \quad x_{i,t+1} - X_t\lambda \geq 0, \quad \lambda \geq 0$$

(iv)
$$\left[d_o^{t+1}(x_t, y_t)\right]^{-1} = Max_{\phi,\lambda}\phi,$$
$$st \quad -\phi y_{i,t} + Y_{t+1}\lambda \geq 0, \quad x_{i,t} - X_{t+1}\lambda \geq 0, \quad \lambda \geq 0$$

Where λ is a N X 1 vector of a constant and ϕ is a scalar with $\phi \geq 1$

Over time best practices are natural and to include frontier shifts, that is, technical change, the Malmquist productivity index is a well-established measure.

The Malmquist productivity index, as proposed by Caves, et al., (1982), allows one to describe multi-input, multi-output production without involving explicit price data and behavioral assumptions. The Malmquist Productivity Iindex identifies TFP growth with respect to two time periods through a quantitative ratio of distance functions (Malmquist, 1953). Distance functions can be classified into input distance functions and output distance functions. Input distance functions look 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 or 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., (1992) 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:

$$M_o^t(x_t, y_t, x_{t+1}, y_{t+1}) = \left[\frac{d_o^t(x_{t+1}, y_{t+1})}{d_o^t(x_t, y_t)}\right] \quad \text{(v)}$$

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

$$M_o^{t+1}(x_t, y_t, x_{t+1}, y_{t+1}) = \left[\frac{d_o^{t+1}(x_{t+1}, y_{t+1})}{d_o^{t+1}(x_t, y_t)}\right] \quad \text{(vi)}$$

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

$$M_o(x_t, y_t, x_{t+1}, y_{t+1}) = \left[\frac{d_o^t(x_{t+1}, y_{t+1})}{d_o^t(x_t, y_t)} \frac{d_o^{t+1}(x_{t+1}, y_{t+1})}{d_o^{t+1}(x_t, y_t)}\right]^{1/2} \quad \text{(vii)}$$

equation (vi) 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.

$$EFFCH = \frac{d_o^{t+1}(x_{t+1}, y_{t+1})}{d_o^t(x_t, y_t)} \quad \text{(viii)}$$

and

$$TECHCH = \left[\frac{d_0^t(x_{t+1},, y_{t+1})}{d_o^{t+1}(x_{t+1}, y_{t+1})} X \frac{d_o^t(x_t, y_t)}{d_o^{t+1}(x_t, y_t)}\right]^{1/2} \quad \text{(ix)}$$

DATA AND ITS SOURCE

The study was based on the data that were drawn from the FAO web site (AGROSTAT) which covers the period 1971-2009 to estimate the TFP using Malmquist index. The following are some of the main features of the data series that were used for the study. The data consists of information on agricultural production (Crop and Livestock index) and means of production such as total rural population; land area; fertilizer; herbicide and irrigation for each of the selected countries were drawn from FAO statistic database. To investigate the link between agricultural productivity and poverty, we modeled relationship between the earlier calculated TFP and

Human Development Index (HDI) from UNDP which is a composite index of development measuring the average achievement in three basic dimensions of human development. The components of HDI are Gross National income per capita, education and life expectancy which are used as proxy for poverty.

Econometric model and variable definition

The first objective to obtain the TFP was achieved by solving equation (iv)-(vi) and to examine its effect on poverty an Ordinary Least Square (OLS) estimation techniques was used to examine the effect of the above selected variables on agricultural productivity growth.

Y = f(X, e)………………………………………………………………… …(x)

Where Y is the TFPCH index, that is, Malmquist Productivity Index and X is the HDI

RESULTS AND DISCUSSION

The Malmquist index of TFP was constructed for 42 countries for a period of 39 years. The obtained index was decomposed into technological change and efficiency change over the sample period using DEA.

The Malmquist TFP indices

The productivity growth and its components over the sample period are presented in table 1. The average TFP growth over the period was found to be 0.2 percent per annum with large variation in growth rate observed for various countries.

Recall that the value greater than one indicates an improvement in the productivity, pure efficiency and technology while less than one implies decline. It was observed from table 2 that twenty two countries which represents about 52 percent of the total sample experienced productivity growth within the reference period. The observed growth is accounted for largely by technological change with the exception of Mali, Senegal and Liberia in which efficiency change accounts for the observed growth rather than technological progress. Other countries including Congo and Somalia experienced on the average a decline in growth.

Overall, the results showed there have been evidence of technological improvement over the reference period; this indicates advances in technology as represented by an upward shift in the production frontier (2.1percent) which have not been fully exploited by African farmers and further suggests that technology is an important driver of African agricultural growth while 1.8 percent decline in efficiency was observed. The obtained technical efficiency was further decomposed into scale and pure technical efficiencies; it was observed as shown in Table 2 that there is a decline in pure efficiency change and scale efficiency change with a value of 0.987 and 0.995 respectively, this contributes to decline of overall efficiency change. This finding support the earlier findings by Nkamleu et al., 2008; Allen, 2010, Block 2010 and Ni-Pratt and Yu 2011.

Table 1: Malmquist Index Summary of Country Means

Firm	Effch	techch	pech	sech	Tfpch
Algeria	1.019	1.055	1.019	1.000	1.075
Angola	0.927	1.028	0.927	1.000	0.953
Benin	0.959	1.105	0.959	1.000	1.060
Botswana	0.973	1.106	0.973	1.000	1.076
Burkina Faso	1.004	1.043	1.004	1.000	1.047
Burundi	0.989	1.002	0.989	1.000	0.991
Cape Verde	1.001	1.071	1.001	1.000	1.072
Central African Republic	0.994	1.098	0.994	1.000	1.091
Chad	0.997	1.113	0.997	1.000	1.110
Comoros	0.998	1.042	0.998	1.000	1.039
Congo	0.945	1.044	0.945	1.000	0.986
Côte d'Ivoire	0.998	0.995	1.000	0.998	0.993
Djibouti	0.996	1.026	0.996	1.000	1.022
Egypt	0.989	1.025	0.989	1.000	1.014
Gabon	1.006	1.001	1.006	1.000	1.006
Ghana	0.918	1.083	0.918	1.000	0.995
Guinea	0.922	0.972	0.922	1.000	0.896
Kenya	0.938	0.974	0.938	1.000	0.914
Lesotho	0.969	1.011	0.963	1.007	0.980
Liberia	1.017	0.987	1.017	1.000	1.004
Libya	1.000	0.983	1.000	1.000	0.983
Madagascar	1.018	1.010	1.018	1.000	1.028
Malawi	0.896	0.950	0.901	0.995	0.851
Mali	1.024	0.996	1.024	1.000	1.019
Mauritius	0.967	1.020	0.965	1.002	0.986
Morocco	1.000	0.993	1.000	1.000	0.993
Mozambique	1.005	1.007	1.029	0.977	1.012
Namibia	1.030	1.005	1.022	1.007	1.035
Niger	0.952	1.048	0.984	0.967	0.997
Nigeria	0.897	0.980	0.932	0.962	0.879
Rwanda	1.000	0.999	1.000	1.000	0.999
Sao Tome and Principe	0.960	0.995	1.000	0.960	0.955
Senegal	1.031	0.980	1.001	1.030	1.011
Seychelles	1.011	0.991	1.000	1.011	1.002
Sierra Leone	1.004	0.958	1.001	1.003	0.963

Somalia	0.920	0.991	1.000	0.920	0.911
South Africa	0.947	0.949	1.000	0.947	0.898
Swaziland	1.026	1.019	1.026	1.000	1.046
Tunisia	1.018	1.046	1.019	0.999	1.065
united republic of Tanzania	0.998	1.085	0.998	1.000	1.083
Zambia	0.889	1.108	0.889	1.000	0.984
Zimbabwe	1.097	0.984	1.097	1.000	1.079
Mean	**0.982**	**1.021**	**0.987**	**0.995**	**1.002**

The mean productivity growth was computed for each region namely Southern Africa, East Africa, West Africa, Central Africa and Northern Africa. The East, South and North Africa experienced growth of 3.3 percent, 2.6 percent and 3.6 percent respectively with 0.5 percent and 2 percent growth in efficiency change and technological change accounted for the observed growth in North Africa. Meanwhile, the observed growth observed in other two regions is accounted for by a decline in efficiency and improvement in the technology. It should be noted here that though productivity decline was experienced in West and southern Africa region which is largely accounted for poor efficiency change, the region still enjoy a modest technological growth of 1.8 percent and 1.6 percent respectively. This finding further support the opinion that improves performance with expenditure on R and D enhanced agricultural productivity growth.

IMPLICATION OF AGRICULTURAL PRODUCTIVITY GROWTH ON POVERTY

The proposition that agricultural productivity growth has a direct impact on poverty was examined using the mean TFP and HDI also technological change and HDI. We chose HDI as a proxy for poverty due to lack of complete data set for headcount index for the country selected.

The result from table 2 shows a positive and significant relationship between the TFP and HDI also technological progress and HDI is significant at 5 percent probability level. For model 1, the elasticity was found to be 0.69 suggesting that 1 percent increase in the productivity growth will likely lead to 0.69 percent change in the HDI. Since TFP can be broken down into efficiency change and technological change and was earlier found that technological change contributes more to the productivity growth than the efficiency change, we further looked at the influence of technological change and HDI (model 2), the elasticity was found to be 1.29, suggesting that about 1 percent improvement in the technological change will improve the HDI by about 1.3 percent. This finding is similar to Colin et al. 2001 and further proved agricultural productivity growth to be both pro-poor and pro-growth

Table 2: Dependent variable HDI

Variable	Model 1	Model 2
TFP index	0.69 (2.13)**	
+Technological change index		1.29 (2.85)**
Constant	0.23	0.85
R square	0.10	0.20
F statistic	4.52	8.13

** indicates significance at 5 %

Conclusion and recommendations:

The study confirms that the continent recorded improvement in agricultural productivity and this was due to technological progress in most of the countries. However, there were cases of decline in growth in some countries due to decline in efficiency and incidence of war and civil unrest. There was a positive and significant relationship between indicators of agricultural productivity growth and human development index (poverty indicator) implying that increase in productivity growth will result in improvement in human development index and consequently reduction in poverty. The trend is the same for improvement in technological change and improvement in human development index. This is not unexpected since technological change is the major driver of productivity growth in the continent. The study concludes that agricultural productivity growth is pro-poor and a major driver of poverty reduction in Africa. It is recommended that relevant policies to address the constraints to technology progress and efficiency should be promoted to improve productivity growth and reduce poverty.

REFERENCES

Alene, A.D (2010): 'Productivity Growth and effects of R and D in African Agriculture' Agricultural Economics 41:223-238

Block, S (2010): 'The Decline and Rise of Agricultural Productivity in Sub-Saharan African Countries Since 1961. Working Paper 16481. Cambridge MA: National Bureau of Economic Research

Caves, D. W., L. R. Christensen and W. E. Diewert. (1982), "The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity." Econometrica 50: 1393–1414.

Charnes, A ., W.W. Cooper and E. Rhodes (1978), "Measuring the Efficiency of Decision-Making Units". European Journal of Operation Research, 2,429-444

Cherchye, L., T. Kuosmanen and G. T. Post. (2000), ''What is the Economic Meaning of FDH, A Reply to Thrall.'' Journal of Productivity Analysis 13(3:, 259–263.

Collin T; I, Xavier; V, Mckenzie-Hill and S, Wiggins (2001): Relationship Between Changes in Agricultural Productivity and Incidence of Poverty in Developing Countries. DFID Report No. 7946

Fare, R, S. Grosskopf and C.K. Lovell (1985), The measurement of efficiency of production. Boston: Kluwer-Nijhoff

Fare, R., S. Grosskopf,. B. Lindgren and P. Roos (1992), "Productivity Changes in Swedish Pharmacies 1980-1989: A Non-parametric Approach", Journal of Productivity Analysis, 3: 85-101.

Fare, R; S. Grosskopf and C.K. Lovell (1994), Production Frontier. Cambridge University Press, Cambridge

Hjalmarsson, L and A. Veiderpass (1992), Productivity in Swedish Electricity Retail Distribution. Scandinavian Journal of Economics, 94(S): 193-205

Lovell, C. A. K. (2001), ‘‘The Decomposition of Malmquist Productivity Indexes.’’ Journal of Productivity Analysis 20(3): 437–458.

Malmquist, S. (1953), ‘‘Index Numbers and Indifference Surfaces.’’ Trabajos de Estadistica 4: 209–242.

Nin-Pratt, A and B, Yu (2011):’ Agricultural Productivity and Policies in Sub-Sahara Africa IFPRI Discussion Paper 01150

Nkamleu, G.B., S. Kalilou and Z. Abdoulaye (2008), What Accounts for Growth in African Agriculture, American Journal of Agricultural and Biological Science, 3(1):379-388.

Ray, S. C. and E. Desli (1997). ‘‘Productivity Growth, Technical Progress and Efficiency Change in Industrialized Countries: Comment.’’ American Economic Review 87(5): 1033–1039.

World Bank (2000): Can Development Report 2000/01 Attacking Poverty World Bank/Oxford University Press