EXPLAINING THE FAILURE OF AGRICULTURAL PRODUCTION IN SUB-SAHARAN AFRICA

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ABSTRACT

This paper examines changes in agricultural productivity in 10 Subsaharan countries. The relative performance of agricultural sector was gauged using data envelopment analysis. From a panel data set of the 10 countries which included the 28-year period 1972-1999, mathematical programming methods were used to measure Malmquist indexes of total factor productivity. It was found that, during that period, total factor productivity have experienced a negative evolution in sample countries. A decomposition of those measures suggest that, most of the weak performance of factors productivity is attributable more to technological change than technical efficiency change. French-speaking countries better succeeded to raise their productivity than English-speaking countries do. In addition, it have been found that Sahelian countries failed to rise their agricultural productivity compared to forest countries where a positive evolution have been detected.

Keywords: Data envelopment analysis, Efficiency, Productivity, Subsaharan Africa.

INTRODUCTION

Agriculture is an important sector for sustaining growth and reducing poverty in developing countries. Because the food and agricultural sector dominates most African economies in terms of contribution to GDP, employment and incomes, its growth and development are essential for the overall process of socioeconomic development in the region.

In light of the general objective of attaining regional self-sufficiency in agricultural products, governments and institutions have sought strategies that would lead to higher levels of production. A key factor of a sustained increase of agricultural production is improvement of productivity, which is carried out through technological change and efficiency change.

Many African farmers are still using low yielding agricultural technologies, which lead to low productivity and production. Also, it is always argued that, relevant question for agricultural policy makers, is whether the agricultural sector can be made more efficient, by achieving more output with the current input level, or achieving the current output with less input usage than that is currently observed. An important step in answering this question is to identify the behavior of productivity and its components.

The purpose of this study is to explore evolution of factor productivity and its components in Sub-Saharan Agricultural sector, using data envelopment analysis. The study used panel data on 10 selected countries of the region, and is intended to explain the relative performance of agricultural sector across regions and countries.

THEORETICAL FRAMEWORK: MALMQUIST DATA ENVELOPMENT ANALYSIS

Over the past two decades, much progress has been made towards refining the frontier function methodology introduced by Farell in 1957.

More recently, a non-parametric method had been developed that calculate total factor productivity index using efficiency measure. This approach, using panel data, applies DEA-like linear programs and the Malmquist total factor productivity index to measure productivity change, and to decompose this productivity change into technical change and technical efficiency change. In this paper, this method is employed.

Following Fare et al (1994), the Malmquist Index Total Factor Productivity (MI TFP) change between a base period (s) and a period t can be written as:

$$m_0\left(y_s, x_s, y_t, x_t\right) = \frac{d_0^s\left(y_t, x_t\right)}{d_0^s\left(y_s, x_s\right)}\left[\frac{d_0^s\left(y_t, x_t\right)}{d_0^t\left(y_t, x_t\right)}\frac{d_0^s\left(y_s, x_s\right)}{d_0^t\left(y_s, x_s\right)}\right]^{1/2} \tag{1}$$

In (1) the term outside the square brackets measures the Farrell efficiency change between period s and t, and that inside measures technical change, it is the geometric mean of the shift in the technology between the two period. Furthermore, the first term can be separated into a scale efficiency and pure technical efficiency. The overall index represents the productivity of the production point (y_t, x_t) relative to the point (y_s, x_s), and a value larger than one depicts positive TFP growth between periods s and t. Empirical applications require the computations of the four distance functions in (1). As suggested by Coelli (1996), the distance functions can be recovered by solving the following DEA-like linear programs.

$$\begin{aligned} &[d_0^t(x_t, y_t)]^{-1} = Max_{\phi,\lambda}\phi, \\ &subjet\ to \quad -\phi y_{it} + Y_t\lambda \geq 0 \\ &\qquad x_{it} - X_t\lambda \geq 0' \\ &\qquad \lambda \geq 0, \end{aligned}$$

$$\begin{aligned} &[d_0^{t+1}(x_{t+1}, y_{t+1})]^{-1} = Max_{\phi,\lambda}\phi, \\ &subjet\ to \quad -\phi y_{i,t+1} + Y_{t+1}\lambda \geq 0 \\ &\qquad x_{i,t+1} - X_{t+1}\lambda \geq 0' \\ &\qquad \lambda \geq 0, \end{aligned}$$

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$$\begin{aligned} &[d_0^{t+1}(x_t, y_t)]^{-1} = Max_{\phi,\lambda}\phi, \\ &subjet\ to \quad -\phi y_{it} + Y_{t+1}\lambda \geq 0 \\ &\qquad x_{it} - X_{t+1}\lambda \geq 0' \\ &\qquad \lambda \geq 0, \end{aligned}$$

Where λ is a Nx1 vector of constant and ϕ is a scalar with $\phi \geq 1$.
ϕ-1 is the proportional increase in outputs that could be achieved by the i-th unit, with input quantities held constant.

The above programs must be solved for each country in the sample in each a period, and an extra three programs for each country to construct the chained index. If we have T time periods, we must calculate (3T-2) LP's. Overall for N firms and T periods, with the decomposition of the technical efficiency N(4T-2) LP's are solved (1100 LP in our case).

DATA SPECIFICATION

To estimate the Malmquist indexes of efficiencies and total factor productivity, a panel dataset on 10 Sub-Saharan countries, from 1972 to 1999 were used. The concerned countries are listed below (Table 1). The data consist of information on agricultural production and means of production in those countries. Records of agricultural production indices (base 1989-1991), rural population, number of tractors in use, fertilizer uses, agricultural areas were obtained from FAO statistic database.

Table 1. Sample countries used in the analysis.

	Cameroon	**Cote d'Ivoire**	**Senegal**	**Mali**	**Burkina Faso**	**Nigeria**	**Ghana**	**Zimbabwe**	**Zambia**	**Uganda**
Language	French	French	French	French	French	English	English	English	English	English
Geographic description	Non-Sahelian	Non-Sahelian	Sahelian	Sahelian	Sahelian	Non-Sahelian	Non-Sahelian	Non-Sahelian	Non-Sahelian	Non-Sahelian

Specification of output and input in our analysis is as follows:

Output

Agricultural production index is the level of the aggregate volume of agricultural production for each year in comparison with the base period 1989-91.

They are based on the sum of price-weighted quantities of different agricultural commodities produced after deductions of quantities used as seed and feed weighted in a similar manner. The resulting aggregate represents, therefore, disposable production for any use except as seed and feed. These indices are calculated by the Laspeyres formula.

Input

- Labor refers to economically active population in agriculture for each year in each country. Economically active population in agriculture is defined as all persons engaged or seeking employment in agriculture, forestry, hunting or fishing sector, whether as employers, own-account workers, salaried employees or unpaid workers.
- Agricultural land. The sum of area under *Arable land* (land under temporary crops, temporary meadows for mowing or pasture, land under market and kitchen gardens and land temporarily fallow), *Permanent crops* (land cultivated with crops that occupy the land for long periods and need not be replanted after each harvest, such as cocoa, coffee and rubber), and *Permanent pastures* (land used permanently for herbaceous forage crops, either cultivated or growing wild).
- Fertilizer: The sum of nitrogen, potash and phosphate content of various fertilizers consumed, measured in thousands of metric tons in nutrient units.
- Tractors are referred to as total wheel and crawler tractors (excluding garden tractors) used for agricultural production.

In the analysis, all inputs are converted in index basis (base 1989-1991).

RESULTS

Different index was estimated using data set, which included the 28-year period 1972-1999. Mean overall technical efficiencies are shown in Table 2, indicating an overall stable trend over time for the sample countries. Yet, countries do not have same performance during the period. Some countries like Côte d'Ivoire and Senegal have experienced big increases of overall technical efficiency during the period. Recall that a value higher than one represents an improvement of efficiency and/or productivity. Turning to the component measures ('PechcY' and 'sechCY'), it appeared that, the pure technical efficiency and the scale efficiency have both been stable during the reference period.

This suggests that, in the achievement of high levels of technical performance over time, the sample countries fail in rising pure and/or scale technical efficiency component. But they do succeed in maintaining the level of these efficiencies. The stability of scale inefficiency suggests that agricultural sector failed to take advantage of the growing size of the sector. While the stability in pure technical efficiency over the period of our study, suggests that the learning process as predicted by theories of intra-firm diffusion (Kalirajan and Shand, 2001) did not work well.

Table 2. Mean technical efficiencies change.

COUNTRIES	Technical efficiency change **EffchC**	Pure technical efficiency change **PechC**	Scale efficiency change **SechC**
Cameroon	1	1.002	0.998
Burkina	0.996	0.999	0.996
Côte d'Ivoire	1.017	1	1.017
Senegal	1.01	1.004	1.006
Mali	1.008	1	1.008
Ghana	1	1	1
Nigeria	1	1	1
Zimbabwe	0.988	0.998	0.99
Uganda	0.991	0.999	0.991
Zambia	0.994	1	0.994
Mean	1	1	1

Examining the trend of efficiencies offers another important insight into performance over time. The evolutionary trend of technical efficiency and its component is exhibited in Figure 1. Scale efficiency has experienced high season by season fluctuations, inducing high fluctuation in overall technical efficiency. This situation may be due to large difference between countries in performing scale efficiency change (Table 2).

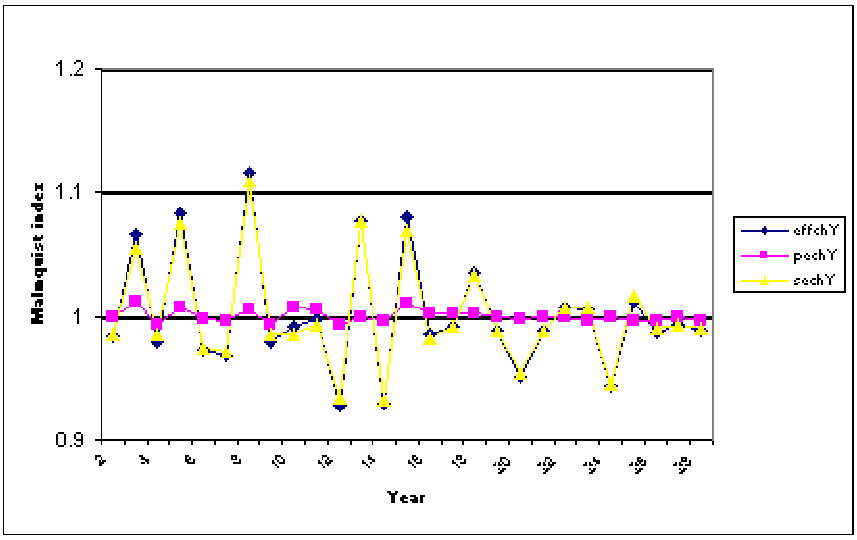

Figure 1. Evolution of technical efficiency change over time.

Turning to the Malmquist total factor productivity index, Table 3 includes means of our measures of change in total factor productivity index and its components (efficiency change and technological change). The means are given for the sample as a whole as well as by country. Looking first at the sample as a whole, the change in total factor productivity of the agricultural sector of the countries in our sample, has been negative. On average total factor productivity has decreased by 0.2% annually.

An important question is what is the main cause of that loss of productivity. Agricultural sector can improve the level of total factor productivity either by change in technical efficiency or by technological change (shift in the production frontier). The component measures of total factor productivity; 'Effchc' and 'TechchC' show that technological change has been the main cause of the failure of total factor productivity. Efficiency has been constant.

This suggests that, for the sample countries, technical change has been the main constraint of achievement of high levels of total factor productivity during the reference period.

Table 3. Mean total factor productivity change.

COUNTRIES	Technical efficiency change **EffchC**	Technological change **TechchC**	Total factor productivity change **TfpchC**
Cameroon	1	1.002	1.002
Burkina	0.996	0.956	0.952
Côte d'Ivoire	1.017	1.01	1.027
Senegal	1.01	1.013	1.024
Mali	1.008	0.991	0.999
Ghana	1	0.998	0.998
Nigeria	1	0.999	0.999
Zimbabwe	0.988	1.009	0.997
Uganda	0.991	1.001	0.991
Zambia	0.994	1.001	0.995
Mean	1	0.998	0.998

Also here, countries did not perform similarly. Some countries, which have been good or average in increasing level of technical efficiencies, have poorly experienced technical change. The most dramatic differences appear in Mali and Burkina. Contrary, in Zimbabwe, Uganda and Zambia, technical change has been crucial to avoid drastic decrease of total factor productivity. Overall half of countries have increased efficiency more than technology (Table 4). This is useful information and important in guiding efforts to increase agricultural production.

Table 4. Comparison between technical efficiency change and technological change.

COUNTRIES	EffchC > TechchC	TechchC > EffchC
Cameroon		*
Burkina	*	
Côte d'Ivoire	*	
Senegal		*
Mali	*	
Ghana	*	
Nigeria	*	
Zimbabwe		*
Uganda		*
Zambia		*
Mean	*	

* = Yes

Figure 2 shows the trend over time. This trend is characterized by important season by season variation of the two components of total factor productivity index. The technical change component has had more fluctuation, suggesting that promotion of technical change have not been constant during the period.

The results presented so far do support the notion that there is a difference between countries in performing efficiency and productivity change. It is therefore interesting to investigate the relationship between those changes and countries particularities. We will like to statistically test the difference between French and English speaking countries as well as Sahelian and non-Sahelian countries.

The distribution of the efficiency and productivity change cannot be assumed to be normal since they are calculated from a condition where distribution is not clear (Dawson and Lingard, 1989). Thus simple parametric tests can not be undertaken. We therefore use non-parametric tests. The Mann-Whitney compares the average changes of efficiency and/or productivity between groups. Kruskal-Wallis compares the groups on the basis of central tendency as defined by the median. The null hypothesis for each is that the population means and/or median are equal.

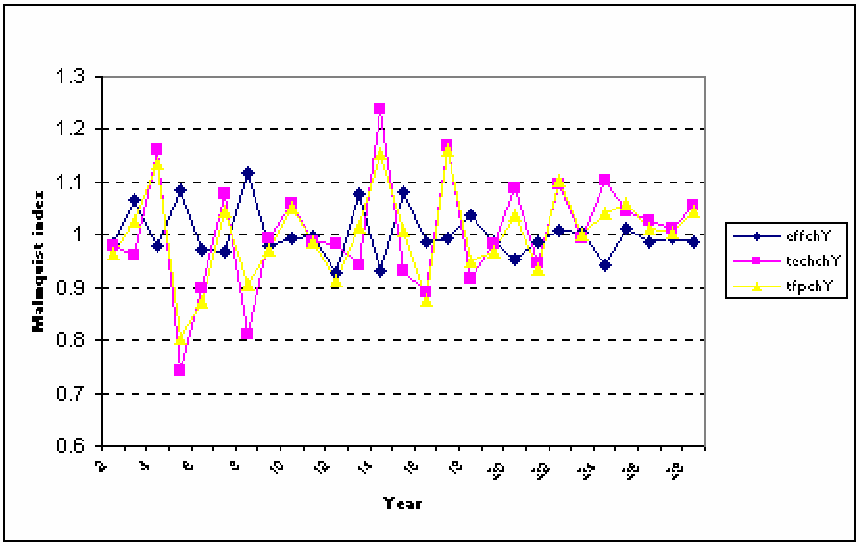

Figure 2. Evolution of total factor productivity change over time.

Table 5. Statistical test : by country's colonial language. (French/English).

	Mann Whitney Test "Z"	Kruskal-Wallis Test (Median) "χ^2"
Overall efficiency	-0.65	0.78
Change	(0.51)	(0.38)
Technological	-0.15	0.13
Change	(0.88)	(0.72)
Pure efficiency	-0.83	4.47
Change	(0.41)	(0.04)
Scale efficiency	-0.51	0.40
Change	(0.61)	(0.51)
Total factor productivity	-1.06	0.37
Change	(0.29)	(0.54)

In bracket are corresponding level of significance.

Table 6. Statistical test : by geographic situation. (Sahelian/non-Sahelian).

	Mann Whitney Test "Z"	Kruskal-Wallis Test (Median) "χ^2"
Overall efficiency	-0.36	0.037
Change	(0.72)	(0.85)
Technological	-0.03	0.018
Change	(0.98)	(0.89)
Pure efficiency	-0.50	0.077
Change	(0.62)	(0.78)
Scale efficiency	-0.48	0.037
Change	(0.63)	(0.85)
Total factor productivity	-0.37	0.16
Change	(0.71)	(0.69)

In bracket are corresponding level of significance.

The test statistics appear in Table 5 and 6. The results demonstrate that efficiency and productivity change was not significantly different between groups of countries. Although lack of significance, we found important difference in the performance of these groups. Table 7 shows that French speaking countries have had good performance as compared to English speaking countries.

Globally, French speaking countries have had a positive evolution of the total factor productivity (1.005), while the figure is negative for English speaking countries (0.996).

Table 7. Comparison of technical efficiency and technological change in French and English speaking countries.

	Technical efficiency change **EffchC**	Pure technical efficiency change **PechC**	Scale efficiency change **SechC**	Technological change **TechchC**	Total factor productivity change **TfpchC**
French Countries	1.006	1.001	1.005	0.994	1.0005
English Countries	0.994	0.999	0.995	1.001	0.996

The same kind of conclusion appears when comparing Sahelian and Forest countries (Table 8). The later have had a positive evolution, while the sahelian have had a negative evolution of TFPCH. An important fact to note is that despite their overall weak performance, sahelian countries have goodly succeeded in raising their efficiency level (EFFCH = 1.005) against 0.998 for forest countries. Their weak performance is attributed to the failure to rise the technological level of the agricultural sector. The mean technological change for sahelian countries have been negative (-1.3%) while positive for forest countries (0.3%).

Table 8. Comparison of technical efficiency change and technological change in Sahelian and forest countries.

	Technical efficiency change **EffchC**	Pure technical efficiency change **PechC**	Scale efficiency change **SechC**	Technological change **TechchC**	Total factor productivity change **TfpchC**
Sahelian countries	1.005	1.001	1.004	0.987	0.991
Forest countries	0.998	0.999	0.998	1.003	1.001

CONCLUSION

Sub-Saharan Africa's economic malaise is first and foremost a malaise of the inability of the region's agriculture to continue to contribute to the overall growth process in the region. The decline in food and agricultural production over the years has become synonymous with the region's stagnation, social decline and marginalization in the world. Unless renewed measures are taken by the governments and people of the region to dramatically increase agricultural production, there will be continued deterioration and stagnation throughout the region

Efforts are needed not only from within the region but also from the international community to ensure that the right mixture of policies is put in place to promote and sustain agricultural production.

In particular, looking for strategies that would lead to higher levels of productivity can be regarded as determinant to increase production of agriculture, and release surplus to be used in others sector.

In this paper, the relative performance of agricultural sector was gauged using data envelopment analysis. From a panel data set of 10 countries, which included the 28-year period 1972-1999, mathematical programming methods were used to measure Malmquist indexes of total factor productivity. It was found that, during that period, total factor productivity has experienced a negative evolution in sample countries. A decomposition of those measures suggests that, most of the weak performance of factors productivity is attributable rather to technological change than technical efficiency change. More, it has been showed that French-speaking countries better succeeded to raise their productivity than English-speaking countries do.

In addition, it have been found that Sahelian countries failed to rise their agricultural productivity compared to forest countries where a positive evolution have been detected.

This suggests that, in the achievement of high levels of agricultural production, the principal difficulty appear in raising technology, i.e. shift in the production frontier. This is providing support to early work of Schultz (1964) on efficiency, which demonstrated that despite constraints faced by small holder farmers, they are technically efficient in their production.

These results have important implications for policy targeting. The principal difficulty in the long run lies in the slow and/or negative rate of increase in technical change. This indicates that there is a growing urgency for sustained improvements of technology which require a more active role for the public sector and international agencies in research and extension activities in collaboration with farmers to raise technology level significantly over time. In this regards, the emphasis every where should be on the communication of the research results to farmers in a usable form and the establishment of the national, regional and international means to enhance research-extension-farmer linkages and the efficiency and relevance of technology generation and transfer.

However, a productivity and technical efficiency gap still exists between countries, and there is scope to narrow this by identifying the less competitive countries and future investigating the reasons for their relatively poor performance. A mix of physical factors and socio-cultural attributes will be responsible for constraining productivity of agricultural sector of many countries. Appropriate policy programs targeted at the less performing countries should enable the gap to be narrowed.

A final conclusion is that the pattern of performance found in this study clearly demonstrates the role of each component on the evolution of total factor productivity.

Further research effort is certainly warranted to investigate the factors affecting behavior of each component.

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