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Productivity Growth, Technical Progress, and Efficiency Change in ECOWAS Agriculture 1971-2009: A Full Cumulative (FC) Extended Malmquist Approach

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***Abstract:** This study employed the use of country-level panel data on agriculture in Economic Community of West African States (ECOWAS) to investigate Total Factor Productivity (TFP) growth in the region during 1971 - 2009. The TFP growth of ECOWAS agriculture was measured using the Full Cumulative (FC) Extended Malmquist Approach developed by Nghiem (1999) and Nghiem and Coelli (2000). The method is applied to a panel data on thirteen ECOWAS countries over a period of 39-year from 1971 to 2009. The panel data which consist of information on agricultural production and means of production were obtained from FAO AGROSTAT on thirteen selected ECOWAS member states. The panel data span over a period of 39 years (1971 -2009). The Standard Full Cumulative Method best explained the relationships of interest. Thus, a decomposition of Total Factor Productivity (TFP) measures (from Standard Full Cumulative Method) revealed that the observed increase in the TFP in ECOWAS agriculture is due to the efficiency change rather than technological change and as such is the main constrained of achieving higher level of TFP during the reference period.*

***Keywords:** Full Cumulative (FC) Extended Malmquist Approach, Productivity Growth, Technical Progress, and Efficiency Change, ECOWAS*

I. INTRODUCTION

The ECOWAS agriculture has suffered such problems as limitation of exports to few commodities, low export earnings, low capital formation, weak human assets, a high degree of economic vulnerability, increasing trend towards urbanization, food insecurity and poor rural development as well as ineffective implementation of both regional and national policies due to poor knowledge of the determinants of agricultural productivity and their degrees. Therefore, the growth and development of the agricultural sector is essential for the overall process of socioeconomic development in the ECOWAS sub-region of Africa (ECA, 2002; Ajetomobi, 2009; and Fulginiti et. al, 2004).

Based on the foregoing, for the agricultural sector in ECOWAS to take its rightful place and achieve its major goals of being the major employer of labour, largest supplier of raw materials for the agro-allied and other industries as well as being the mainstay of almost all economies in the ECOWAS sub-region, various governments and institutions at regional and national levels have to come up with excellent broad-based agricultural policy plans that will usher in higher levels of production and a sustained increase of agricultural production through improvement in the technological change and efficiency change in the region. Hence, increasing agricultural productivity in ECOWAS has received a wide spread attention in the literature on economic development and poverty alleviation. Since agricultural growth is linked to farm profit, there had been considerable research works that examined the performance of the agricultural sector in sub-Saharan Africa as well as in ECOWAS sub-region (e.g. Moock, 1973; Lipton, 1988; Nkamleu et. al., 2003; Ajetomobi, 2009; Ajetomobi, 2008; and Ajao, 2011).

Previous works like Ajetomobi (2009) employed Stochastic Frontier Analysis (SFA) and Data Envelopment Analysis (DEA), Ludena (2010) and Ajao (2011) employed the DEA Malmquist Productivity Index while Nadeem et. al., (2010) employed Index Number Approach (Tornqvist Index). A price-based index number method, such as the Tornqvist index, may not be the best approach because of the use of price information and also assume that the economic agents involved exhibit cost minimizing behaviour. Data Envelopment Analysis (DEA) does not require the explicit specification of the underlying production relationship; its key drawback like other non-parametric approaches is that it generally assumes that there is no random error owing to luck, data problems, or other measurement errors while attributing the deviation of a production unit from the frontier entirely to inefficiency. Stochastic Frontier Analysis (SFA) has an advantage over DEA and this lies in its stochastic nature, which enables it to distinguish the effects of data noise from those of inefficiency error, thereby attributing any deviation from the frontier to either or both noise components. But SFA has a major drawback as it imposes a technology structure through the specification of a functional form unlike DEA and associated behavioral assumptions that presuppose the shape of the frontier (Berger and Humphrey, 1997). Although, there is however no consensus on the preferred method for determining the best-practice frontier against which relative efficiencies are measured because of the existing tradeoff between accounting for data noise versus imposing a particular functional form. SFA thus seems the most frequently applied frontier methodologies in agricultural efficiency literature around the globe most especially for studies focusing on the developing agriculture where data generating processes are often influenced by measurement errors. Three Year Window (TYW) method, an extended DEA Malmquist Index is able to handle the degrees of freedom limitations which the methods used in the previous studies like Ajetomobi, 2009; Ludena, 2010; Ajao, 2011; and Nadeem et. al., 2010) could not handle. It is able to relieve degrees of freedom pressure when the number of inputs plus outputs is large relative to the number of firms. The Full Cumulative Extended Malmquist method does not require the explicit use of price information, nor does it require the assumption of cost minimising behaviour. The Full Cumulative Extended Malmquist method TYW method has the advantage that it permits the decomposition of the TFP growth from each region into two components: technical change (shifts in the frontier) and technical efficiency change (catching up to the frontier) (Coelli et. al., 1998). TYW method allows for the inclusion of extra observations from previous years to construct a more robust reference frontier in each year. This paper therefore addresses such questions such as: What is the status of agricultural productivity in ECOWAS? Has ECOWAS agricultural productivity declined sharply as perceived? The broad objective of the study is to analyze the productivity growth, technical progress and efficiency change in ECOWAS agriculture from 1971 to 2009.

II. MATERIALS AND METHOD

Productivity growth has been extensively described in terms of the improvement and technical change with which inputs are transferred into outputs in the production process; see e.g. Shih-Hsun *et al.*, 2003. Indexes of productivity can therefore be simply referred to as the ratio of aggregate output index to an index for total factor use. In assessing growth, sustainability, and competitiveness in the agricultural sector, proper identification and measurement of agricultural productivity growth, particularly when technical change in the sector is factor-biased rather than Hicks-neutral is very important.

TFP growth measures how much productivity grows or declines over time. When there are more outputs relative to the quantity of given inputs, then TFP has grown or increased. TFP can grow when adopting innovation, this kind of growth is due to "technological change" (TECHCH). TFP can also grow when an economic sector uses its available technology and economic inputs more efficiently; they can produce more while using the same level of inputs, or more generally, this kind of growth is due to "technical efficiency" (EFFCH). Therefore, any change in TFP from one year to another is comprised of technological change and changes in technical efficiency. Technical efficiency change (catch-up) measures the change in efficiency between current (t) and next (t+1) periods, while the technological change (innovation) captures the shift in frontier technology (Jajri, 2007).

An increase in the level of productivity reflects an increase in the efficiency of inputs. Hence, the same level of inputs can produce a higher output level, which means that the cost of production reduces. In other words, it reflects an improvement in the quality of inputs. There are several factors affecting productivity such as level of technology and socio-demographic (Bhatia, 1990). TFP does not merely mean technological improvement, but also improvement in quality of inputs due to other factors like Human Resource Development (HRD) and Human Resource Management (HRM) and has been argued by researchers like Kartz (1969) to be a contribution of technological advancement.

A large volume of works done on the empirical analyses of agricultural productivity have most of the time focused on global (e.g. Rao and Coelli, 1998), regional (e.g. Fulginiti *et. al.*, 2004; Nkamleu et. al, 2003; Ajetomobi, 2009 and Ajao, 2011) and country level performance (e.g. Bhatia, 1990; Alabi, 2005; Jajri, 2007). There are different methods for estimating the total factor productivity (TFP) growth e.g. Malmquist and Tornquist indexes. The former had gained popularity in recent years since Fare *et al.*, (1994) apply the linear programming approach to calculate the distance functions that make up the Malmquist index.

According to Shih *et al*, (2003), since Data Envelopment Analysis (DEA) type of analysis can be directly applied to calculate the index, the Malmquist index has the advantage of computational ease, does not require information on cost or revenue shares to aggregate inputs or outputs, consequently, less data demanding and it allows decomposition into changes in efficiency and technology. This method does not attract any of the stochastic assumptions restriction, however, it is susceptible to the effects of data noise, and can suffer from the problem of 'unusual' shadow prices, when degrees of freedom are limited (Coelli and Rao, 2003).

The Malmquist index measures the total factor productivity change (TFPCH), between two data points over time, by calculating the ratio of distances of each data points relative to a common technology. The Malmquist index has been used extensively in various studies that have examined total factor productivity growth (see also Sturm and Williams, 2004; Coelli and Rao, 2005; Chen and Lin, 2007; Mukherjee et. al, 2001; and Sufian, 2006). Caves et. al, (1982) had initially introduced the Malmquist productivity index as the theoretical index. Later, Fare et. al, (1992) did merged Farell's (1957) to subsequently demonstrate that the resulting Total Factor Productivity (TFP) indices could be decomposed into efficiency change and technical change components. Fare et. al, (1994) later did decomposed the efficiency change into pure technical efficiency change and changes in scale efficiency, a development which led to the Malmquist index becoming widely popular as an empirical index of productivity changes.

Technological change (TECHCH) is the development of new products or the development of new technologies that allows methods of production to improve and results in the shifting upwards of the production frontier. More specifically, technological changes include new production processes, called process innovation and the discovery of new products called product innovation. Technical efficiency change (EFFCH), on the other hand, can make use of existing economic inputs like land, labour, fertilizer and machinery and other inputs to produce more of same product. With panel data, the estimation of technical progress (the movement of the frontier established by the best- practiced firms) as well as changes in technical efficiencies over time (the distance of the inefficient firms from the best practice firm) or catching up (Jajri, 2007).

III. DATA ENVELOPMENT ANALYSIS (DEA)

The Data Envelopment Analysis (DEA) was first introduced in the work of Farrell (1957) and developed further by Charnes *et al.*, (1978). DEA is a piecewise-linear combination that connects the set of the best-practice or frontier observations, yielding a convex production possibility set. It envelopes all observations in order to identify an empirical frontier that is used to evaluate the performance of production units represented by those observations. By construction, DEA does not require the explicit specification of the underlying production relationship. However, a key drawback of DEA like other non-parametric approaches is that they generally assume that there is no random error owing to luck, data problems, or other measurement errors while attributing the deviation of a production unit from the frontier entirely to inefficiency. The implication of this is that if random errors exist, the measured efficiency may be confounded with these random deviations from the true efficiency frontier. 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). 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)
$$
\begin{aligned}
&\left[d_o^t\left(x_t, y_t\right)\right]^{-1} = Max_{\phi,\lambda}\ \phi, \\
s.t\quad & -\phi y_{it} + Y,\ \lambda \geq 0 \\
& x_{i,t} - X,\ \lambda \geq 0 \\
& \lambda \geq 0
\end{aligned}
$$

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

(iii)
$$
\begin{aligned}
&\left[d_o^{t}\left(x_{t+1}, y_{t+1}\right)\right]^{-1} = Max_{\phi,\lambda}\ \phi, \\
s.t\quad & -\phi y_{i,t+1} + Y_t \lambda \geq 0 \\
& x_{i,t+1} - X,\ \lambda \geq 0 \\
& \lambda \geq 0
\end{aligned}
$$

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

Where λ is a N X 1 vector of a constant and ϕ is a scalar with $\phi \geq 1$. Over time best practice are natural and to include frontier shifts, that is, technical change, the Malmquist productivity index is a well-established measure.

THE EXTENDED MALMQUIST DEA METHOD

The data available for this study contains only thirteen observations (corresponding to countries of ECOWAS regions) for each year. Therefore, the standard Malmquist DEA method of Fare et al (1994) may produce unstable TFP indices because the sparse data will not be able to construct approximately "smoothed-surface" frontiers in each period. To overcome this problem, the *Full Cumulative (FC) DEA Method* was developed and it is discussed extensively below.

THE FULL CUMULATIVE (FC) DEA METHOD

This method, like the window method, is designed to alleviate the degrees of freedom problem, but it also has the additional advantage that it prevents the calculation of "technical regress", which one often calculates using the standard Malmquist DEA method, when random fluctuations in climate, etc. influence the empirical results. This technique of measuring efficiency using pooled data was used in Diewert and Parkan (1983) and Färe, Grabowski and Grosskopf (1985). However, those studies did not use the full cumulative DEA to calculate the MPI.

The FC method similar to that of the window DEA method but its first sub-panel contains periods {1, 2, …, S}. One more time period is then also added to the second sub-panel, but in contrast to the window DEA method, the first time period is not discarded. Therefore, the second sub- panel contains periods {1, 2,…., S+1}; the third sub- panel contains periods {1, 2, …, S+2} and so on until the last sub- panel, which is actually the entire panel, contains periods {1, 2, …, T}.

In this study, the value of S was arbitrarily chosen at three. Thus, the first sub-panel contains periods {1971, 1972, 1973}, the second sub-panel contains periods {1971, 1972, 1973, 1974} and so on until the last sub-panel contains periods {1971, 1972,….2009}. Thus, the frontier constructed using 1971-1973 data represented 1973 frontier; the frontier constructed using the 1971-1974 data represented 1974 frontier; and the last frontier constructed using 1971-2009 data represented 2009 frontier. Otherwise, the LPs are identical to those in equations (8) to (11). These methods are clearly quite computationally intensive. There are two publicly available computer programs that can be used to readily calculate the standard Malmquist DEA TFP index. These are DEAP, written by Coelli (1996) and OnFront written by EMQ (1997). However, this study employed the DEAP software written by Coelli (1996), as there is no publicly available computer program that can readily calculate the new Malmquist Productivity Index (MPI) method adopted in this study.

IV. METHODOLOGY

The study was based on the data that were drawn from the FAO web site (AGROSTAT) and it covers a period of 39 years (1971-2009). Panel data on output and conventional agricultural inputs (land, labor, fertilizer, and machinery) for 13 ECOWAS countries for the period 1971–2009 was accessed from the FAOSTAT database (FAO, 2011). The data that were collected from FAOSTAT include: (a.) per capita value of Agricultural Production (1971-2009). (b.) Input data (1971-2009) which are: (i.) Agricultural land which include total arable land area, permanent cropland and pasture measured in '000 ha. (ii.) Fertilizer consumption measured in metric tonnes. (iii.) Agricultural machines which are number of tractors – wheel and crawler – used in agriculture as a measure of the use of modern technological tools. (iv.) Labour measured in thousands and covers the economically active population involved in agriculture.

V. RESULTS AND DISCUSSION

PANEL UNIT ROOT TEST

In order to avoid spurious regression and analysis in this study, panel unit roots tests were carried out to first examine whether the variables are stationary. If variables are non-stationary, ordinary panel techniques of estimation by least squares will be inconsistent and standard inference of the coefficient will also be impossible. In this study, four unit root tests for panel data are applied to assess stationarity. The tests are Levin Lin and Chu t-stat, IPS, ADF Fisher chi square, and Phillip Perron Fisher chi square. All the tests include individual constants and individual trends. Levin Lin and Chu (LLC) assume a common root unit root process while Phillip Perron (PP), IPS and Augmented Dickey Fuller (ADF) allow for individual unit root process so that the autoregressive coefficient can vary across units (Levin et. al., 1993, 2002). The tests are provided by the econometric software package E-view 5. Table 24 below presents the results of panel unit root test. Through the estimation, it was found that all variables are I(1) except for Rural Population (X_4) which is I(2). Under the level data sets, LLC, IPS, ADF-fisher and PP-fisher test are almost non-stationary series for all the variables (Agricultural land area, fertilizer consumption, tractorization, rural population and per capita value of agricultural production). Under the difference form, all variables reject the unit root null hypothesis (i.e. Agricultural land area, fertilizer consumption, tractorization and per capita value of agricultural production are stationary at I(1) while rural population is at I(2)). The results reported in Table 24 shows that at 1st differencing ((i.e. X_1, X_2, X_3, and Y) and 2nd differencing (i.e. X_4) respectively, all variables are stationary using LLC, IPS, ADF-fisher and PP-fisher test.

Variables	PP Fisher	LLC	ADF Fisher	I.P.S	Decision
X_1	190.70 (0.00)	-9.89 (0.00)	129.30 (0.00)	-	Stationary at I(1) (No intercept and trend).
X_1	184.20 (0.00)	-10.21 (0.00)	151.24 (0.00)	-11.19 (0.00)	Stationary at I(1) (With intercept).
X_2	670.26 (0.00)	-15.96 (0.00)	281.61 (0.00)	-	Stationary at I(1) (No intercept and trend).
X_2	237.16 (0.00)	-10.13 (0.00)	138.23 (0.00)	-8.74 (0.00)	Stationary at I(1) (With intercept)
X_3	206.39 (0.00)	-10.95 (0.00)	158.35 (0.00)	-	Stationary at I(1) (No intercept and trend).
X_3	151.05 (0.00)	-12.31 (0.00)	130.37 (0.00)	-8.75 (0.00)	Stationary at I(1) (With i ntercept).
X_4	76.31 (0.00)	-8.19 (0.00)	107.68 (0.00)	-	Stationary at I(2) (No intercept and trend).
X_4	38.20 (0.00)	-2.05 (0.00)	69.14 (0.00)	-5.42 (0.00)	Stationary at I(2) (With intercept)
Y	824.03	-18.86	374.31	-	Stationary at

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	(0.00)	(0.00)	(0.00)		I(1) (No intercept and trend)
Y	281.97 (0.00)	-14.05 (0.00)	201.41 (0.00)	-14.84 (0.00)	Stationary at I(1) (With intercept)

Source: Data Analysis, 2014

Table 1: Panel Unit Root Test Results

This study is benchmarking the works by Nghiem (1999) and Nghiem and Coelli (2000) which pioneered the application of the window DEA method to calculating the Malmquist Productivity Index (MPI). This study therefore used an Extended Malmquist Productivity Index to measure the productivity growth of agricultural sector of thirteen out of fifteen countries in ECOWAS sub-region of Africa during 1971 - 2009. This method allowed for the construction of the best-practice frontier in agricultural production sector in the sampled ECOWAS countries and then compared with the overall status of the ECOWAS sub-region. Extended Malmquist productivity indexes as well as efficiency change and technological change components for each country of ECOWAS sampled were calculated. Since this index is based on discrete time, each country has an index for every pair of years.

The results of TFP decomposition based on Standard DEA Full Cumulative (FC) Method for the performance of agriculture in ECOWAS between 1971 and 2009, in terms of a simple average of TFP measures at the country level for a sample of 13 ECOWAS countries shows a positive annual productivity growth of 7.97 percent per annum (i.e. the TFP index value for the period was 1.0797) as a result of a 0.09 percent increase in the efficiency change and a 7.97 percent increase in the technological progress (TECHCH) over the period considered. The pre-ECOWAS period (1971-1978) was characterized by better performance and productivity growth (1.03 percent per annum), due largely to a 1.03 percent increase in the technological change (TECHCH). The ECOWAS period (1979-2009) was also characterized by a better performance and productivity growth (1.60 percent per annum), and it was due largely to a 1.60 percent increase in the technological progress (TECHCH). The ECOWAS period (1979 - 2009) had an outstandingly significant improvement over the pre-ECOWAS period (1971-1978) largely due to the impact of the technological changes and on the overall there is an excellent performance and a very encouraging productivity growth in ECOWAS agriculture over the entire period (1971-2009). The major finding from the above discussion on the decomposition of ECOWAS's agricultural TFP growth into efficiency and technical change shows that the improvements in its agricultural TFP growth during the ECOWAS period and entire period are due to ECOWAS agricultural sector catching up to the technology frontier after falling behind between the pre-ECOWAS period (1971 - 1978) as shown in Table and Figure below. Thus, based on previous literature on agricultural TFP growth in the sub-Saharan Africa and ECOWAS alike, the above behaviour and the various upturns and downturns (fluctuations) in TFP of ECOWAS agriculture (due to the variations in the technological progress) which may be due to the following: the number of people producing and how well they are producing in those countries; prevalence of low per capita production of food and cash crops; weak human assets; a high degree of economic vulnerability; unstable climatic conditions in the sub-region like recurrent droughts and a general trend towards desertification; high cost of production factors; institutional weaknesses; ecological and land tenure constraints; weak use of innovative technologies; increasing trend towards urbanization, consumption of imported food grains and demand for diversified foodstuffs; decrease in export earnings, low capital formation, food insecurity and poor rural development; recurrent drought and adverse terms of trade movements (Repello et. al., 1996; Colander,2001; Boutong and Downswell,2002; ECA, 2002; Fulginiti et. al., 2004; Njikam et. al., 2006; Fuglie, 2010; Nin-Pratt and Yu, 2008; Ajetomobi, 2009; Seka, 2009).

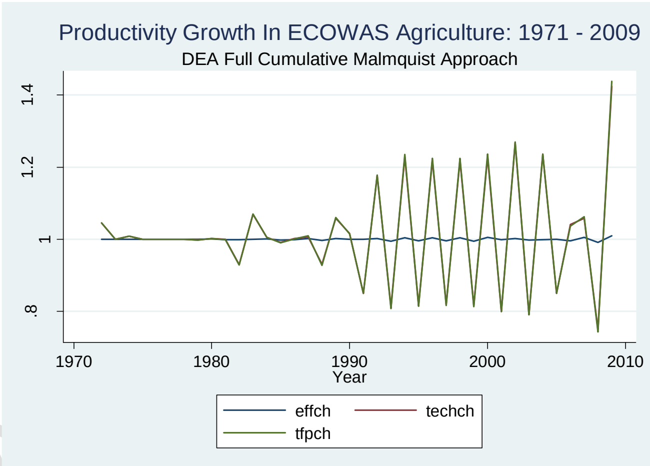

Figure 1: Graph of Productivity Growth in ECOWAS Agriculture: 1971 -2009

AGRICULTURAL TFP GROWTH AND PERFORMANCE OF ECOWAS MEMBER STATES: 1971 – 2009

The results of the agricultural total factor productivity growth and performance of ECOWAS member states as shown in the Table below are discussed below as:

In ECOWAS member states like Benin, Burkina Faso, Cote D'Ivoire, Gambia, Ghana, Guinea, Liberia and Senegal, there were indications of agricultural TFP growth during the pre-ECOWAS (1971-1978), ECOWAS (1979 - 2009) and the entire (1971 - 2009) periods due majorly to the technological progress in such member states. Member states like Mali, Niger and Nigeria experienced a negative agricultural TFP growth during the pre-ECOWAS, a positive agricultural TFP growth in ECOWAS with resultant positive agricultural TFP growth in the entire period due majorly to the technological progress in such member states. Other member states like Sierra Leone and Togo which experienced a negative agricultural TFP over the entire period (1971 - 2009) as a result of a negative agricultural TFP over a prolong ECOWAS period (1979 - 2009) as shown in Table 30.

AGRICULTURAL TFP GROWTH AND PERFORMANCE OF ECOWAS MEMBER STATES: 1971 – 2009

Time Reference	Country	Effch	Techch	Tfpch	TFP growth
Pre-ECOWAS	Benin	1	1	1	0.00%
ECOWAS	Benin	0.9999	1.0232	1.0232	2.32%
Entire Period	Benin	0.9999	1.0189	1.0193	1.93%

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Pre-ECOWAS	Burkina Faso	1	1	1.001	0.10%
ECOWAS	Burkina Faso	0.9999	1.0052	1.0052	0.52%
Entire Period	Burkina Faso	0.9999	1.0043	1.0043	0.43%
Pre-ECOWAS	Cote D'Ivoire	1	1.0041	1.0041	0.41%
ECOWAS	Cote D'Ivoire	1	1.0253	1.0253	2.53%
Entire Period	Cote D'Ivoire	1	1.0214	1.0214	2.14%
Pre-ECOWAS	Gambia	1	1	1	0.00%
ECOWAS	Gambia	1	1.0806	1.0806	8.06%
Entire Period	Gambia	1	1.0657	1.0657	6.57%
Pre-ECOWAS	Ghana	0.9999	1.0226	1.0226	2.26%
ECOWAS	Ghana	1	1.0383	1.0383	3.83%
Entire Period	Ghana	0.9999	1.0352	1.0352	3.52%
Pre-ECOWAS	Guinea	1	1	1	0.00%
ECOWAS	Guinea	1	1.0466	1.0466	4.66%
Entire Period	Guinea	1	1.038	1.038	3.80%
Pre-ECOWAS	Liberia	1	1.0001	1.0001	0.01%
ECOWAS	Liberia	0.9999	1.0779	1.0779	7.79%
Entire Period	Liberia	0.9999	1.0635	1.0653	6.53%
Pre-ECOWAS	Mali	0.9996	1	0.9996	-0.04%
ECOWAS	Mali	0.9999	1.0779	1.0779	7.79%
Entire Period	Mali	1.0001	1.0513	1.0525	5.25%
Pre-ECOWAS	Niger	0.9994	1	0.9994	-0.06%
ECOWAS	Niger	1.0002	1.0629	1.0629	6.29%
Entire Period	Niger	1	1.035	1.0358	3.58%
Pre-ECOWAS	Nigeria	0.9993	1	0.9993	-0.07%
ECOWAS	Nigeria	1	1.0284	1.0284	2.84%
Entire Period	Nigeria	0.9999	1.0231	1.0231	2.31%
Pre-ECOWAS	Senegal	0.999	1.0226	1.0226	2.26%
ECOWAS	Senegal	1.0001	1.001	1.001	0.10%
Entire Period	Senegal	0.9999	1.0045	1.0045	4.50%
Pre-ECOWAS	Sierra Leone	1	1.0796	1.0796	7.96%
ECOWAS	Sierra Leone	0.9999	0.9856	0.9858	-1.42%
Entire Period	Sierra Leone	0.9999	1.003	1.003	0.30%
Pre-ECOWAS	Togo	1	1.0201	1.0201	2.01%
ECOWAS	Togo	0.9998	0.9857	0.9858	-1.42%
Entire Period	Togo	0.9998	0.992	0.9921	-0.79%

Source; Data Analysis, 2014

Methodology	Period	Effch	Techch	Tfpch
Standard DEA Full Cumulative Method	Pre-ECOWAS: 1971 – 1978	1.0000	1.0103	1.0103
	ECOWAS: 1979 – 2009	1.0000	1.0158	1.016
	ENTIRE: 1971 – 2009	1.0009	1.0890	1.0797

	Standard DEA Full Cumulative		
Year	**EFFCH**	**TECHCH**	**TFPCH**
1972	1	1.046	1.046
1973	1	1	1
1974	1	1.009	1.009
1975	1	1	1
1976	1	1	1
1977	1	1	1
1978	1	1	1
1979	1	0.998	0.998
1980	1.001	1.002	1.002
1981	0.999	1	0.999
1982	0.999	0.93	0.929
1983	1	1.069	1.07
1984	1.001	1.005	1.006
1985	0.998	0.992	0.99
1986	0.999	1.002	1.001
1987	1.002	1.007	1.01
1988	0.997	0.931	0.928
1989	1.002	1.058	1.061
1990	1	1.016	1.015
1991	1	0.85	0.85
1992	1.002	1.176	1.178
1993	0.995	0.812	0.808
1994	1.004	1.229	1.235
1995	0.996	0.818	0.815
1996	1.004	1.219	1.225
1997	0.996	0.82	0.817
1998	1.004	1.219	1.225
1999	0.995	0.817	0.813
2000	1.006	1.229	1.236
2001	0.999	0.8	0.799
2002	1.002	1.267	1.27
2003	0.998	0.792	0.791
2004	0.999	1.236	1.235
2005	1	0.85	0.851
2006	0.996	1.041	1.037
2007	1.005	1.058	1.063
2008	0.991	0.75	0.743
2009	1.01	1.424	1.438
mean	1.0009	1.0890	1.0797

**Results in this table are the geometric means of the annual results.*

Table 1: Full Cumulative Estimates of Annual Average Malmquist Catch-up, Technical Change and TFP Change

[Note that all Malmquist index averages are geometric means]

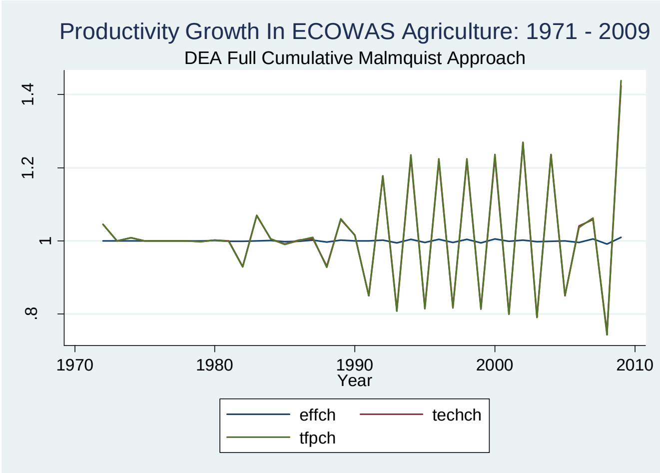

Figure 1: Graph of Productivity Growth in ECOWAS Agriculture: 1971 -2009

VI. CONCLUSIONS

This study has made two significant contributions. The first is the application of an extended Malmquist DEA method which caters for the problem of a limited number of cross-sectional observations in the calculation of productivity change. The Full Cumulative Extended Malmquist method developed by Nghiem and Coelli (2000) was applied in this study. This approach deals with the degrees of freedom problem by pooling observations from previous years to obtain improved estimates of the frontier in each year of the analysis. This avoids the danger of obtaining unstable results derived from frontiers constructed using only a few observations. The second significant contribution of this study is the provision of valuable information on productivity growth in ECOWAS agriculture.

The results of TFP decomposition using the Full Cumulative method (an extended Malmquist DEA method) for the performance of agriculture in ECOWAS between 1971 and 2009, in terms of a simple average of TFP measures at the country level for a sample of 13 ECOWAS countries shows a positive annual productivity growth of 7.97 percent per annum (i.e. the TFP index value for the period was 1.0797) as a result of a 0.09 percent increase in the efficiency change and a 7.97 percent increase in the technological progress (TECHCH) over the period considered. Thus, in ECOWAS, there is yet to be a significant catching-up growth (that is, the agricultural sector of ECOWAS is yet maximize to use of its available technology and production inputs more efficiently and hence the region has not been able to produce more from its available input base). Thus, the source of the growth of TFP is

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the technological progress over the entire period. The TFP of the members of ECOWAS agriculture reveal that it is characterized by low productivity as the agricultural yields among its member states are extremely low and the region's economic growth is still grossly below the minimum 7% required to attain the Millennium development Goals (MDGs) (see Akinleye, 2008; Ajetomobi, 2008; Ajetomobi, 2009; Nkamleu et. al, 2003; ECOWAS Online, 2011; World Bank, 2011).

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