Total Factor Productivity of Agricultural Commodities in Economic Community of West African States (ECOWAS): 1961 - 2005

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Abstract

This study seeks to understand the extent of productivity growth in crops relevant to food security and which have high potential for intra-ECOWAS trade. This paper do so by obtaining measures of Total Factor Productivity (TFP) for rice, cotton and millet over a 45 year period from 1961-2005 using a panel of major ECOWAS countries producing the crops. Calculations are based on data collected from FAOSTAT database, IRRI world rice statistics, international cotton advisory committee database, and individual country statistical database and studies. The data include output of each crop (rice, cotton and millet) and six input variables comprising land area, labour, seed fertilizer, irrigation and country dummies. The TFP measures are calculated using stochastic frontier approach. The 45 year period is divided into two sub periods; 1961-1978 and 1979-2005 in order to study the effects of ECOWAS reforms on productivity growth of the selected crops. The results show evidence of phenomenal growth in the TFP of all the selected crops. Cotton however has the most impressive results followed by rice. A closer look at the TFP in ECOWAS and pre-ECOWAS sub-period shows larger TFP in ECOWAS period (1979-2005) for rice, and millet but larger TFP in pre-ECOWAS period for cotton. In both periods, productivity growth in rice and cotton is sustained through technological progress while it is sustained through more efficient use of inputs in millet.

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1. Introduction

In ECOWAS, the central role of Agriculture in the economy can not be over-emphasized. At present, the sector still contributes between 30-50% of the GDP and provides employment for between 50 -80% of the population in the region. The sector is characterized by millions of small family-run farms of between 2-10ha that derive their income and livelihood from producing primary agricultural products for consumption, domestic markets and exports.

Nevertheless all the 15 countries in the region are net-importers of food and agricultural commodities, particularly rice while the major export crops are limited to a few crops such as coffee, cotton, cocoa and rubber. The prevalent low per capita production of food and cash crops coupled with weak human assets and high degree of economic vulnerability made the United Nations to classify all the countries in ECOWAS as Least Developed Countries (LDCs). The problems are made worse because the region is characterized by increasing trend towards urbanization, consumption of imported food grains and demand for diversified foodstuffs. This secular trend has led to the differences in food grain consumption between rural and urban areas. The rural populace were consuming mainly locally produced grains such as millet, sorghum and maize and certain varieties of rice while the urban population are used to substituting local grains by imported rice and wheat.

In spite of the inherent food security problems, none of the ECOWAS countries are self-sufficient in any agricultural commodity apart from maize. The farm households in the region therefore often depend heavily on a narrow range of agricultural products for food security and quite vulnerable to large fluctuations in commodity prices and international competition. Nevertheless, as an engine for economic growth, agriculture continues to have the highest potential provided the regional and country specific productivity constraints are addressed.

Over the last decade, the growth in agricultural output and productivity in ECOWAS has been very mixed across the member nations. In countries such as Cote d'Ivoire, Ghana and Mali, there has been a strong increase in crop productivity while others such as Senegal and Niger have been less successful in increasing output SWAC 2006). The differences in performance can be attributed to climatic conditions, the extent of economic integration into upstream and downstream markets and domestic policy measures. When compared with developed economy however, ECOWAS has lower per capital productivity of food crops across the region (SWAC, 2006). Studies on TFP growth in African crop agriculture which include ECOWAS member nations are not few but limited to national aggregates when compared to ASEAN. This paper perhaps might be the first paper to look at crop specific TFP growth in ECOWAS countries. Few of the major studies that examine TFP in African agriculture are Thirstle and Townsend 1995 and Coelli and Rao, 2003, Nkamleu 2004, Lusigi 1997, and Nkamleu et al 2008. Lusigi and Thirtle 1997 calculate multilateral Malmquist indices of total factor productivity (TFP) for agriculture in 47 African countries, including all ECOWAS countries, for the period 1961-91. The average rate of TFP growth was found to be 1.27 per cent, which is higher than expected, given the pessimistic nature of much of the literature. They found some evidence of convergence in productivity levels, as the countries with low starting levels grew more rapidly. Nkamleu, 2004 uses data of 16 African countries including six ECOWAS countries over the period 1970–2001 to examine growth in total factor productivity and its decomposition into technical change and efficiency change components. The analysis used data envelopment analysis (DEA). The results of the study show that good performance of the agricultural sector was due to good progress in technical efficiency rather than technical progress.

Coelli and Rao (2003) study Total Factor Productivity (TFP) in agriculture on a global scale from 1970 – 2000. They cover 111 countries that account for 95% of global agricultural output and 98% of the world population. Their average TFP levels in selected developed countries compared to ECOWAS countries indicates that, ECOWAS has lower per capital productivity of food crops across the region. Nkamleu et al. 2008 investigates empirical relationships between the rates of growth and total factor productivity growth, physical input accumulation, as well as institutional and agro-ecological change using an international panel data set on 26 African countries and covering the period 1970-2000. The analysis employs the DEA approach to calculate the TFP indices. Their results suggest a positive evolution of the total factor productivity during the study period. The positive performance of the productivity of the agricultural sector is due to positive technological progress rather than technology absorption. Thirtle, Hadley, and Townsend

(1995) decompose the low but positive TFP growth rate they find for 1971-86 in most of the 22 SSA countries they studied into technical progress (from the time series for this panel of countries) and efficiency change (from the cross-section). Investments in infrastructure, extension, and the level of real protection on international agricultural markets are shown to be significant in explaining efficiency change, while tractors, the labor/land ratio, research and development (R&D), and secondary education are found to explain the variation in technical progress. They find the labor/land ratio, or population density, to be the single most important explanatory variable, again suggesting that productivity growth will accelerate in land-abundant countries as population density increases.

All the past studies on African agriculture pay attention to overall growth pattern and hardly highlight the specificity of the sub-regions and their major agricultural commodities which is germane to differences in regional and country level agricultural policy reforms. In recognition of the inherent twin problems of lack of self sufficiency and relatively low per capita agricultural productivity in ECOWAS for instance, the organization decided to create a common agricultural policy termed Economic community of West Africa states' Common Agricultural Policy (ECOWAP) in 2005 like her European Union (EU) counterpart. The main aims of ECOWAP are to ensure food sovereignty and promote efficient family farms among member nations. Although ECOWAP was created in 2005, government intervention was not new to the member states. All countries within ECOWAS had already been formulating agricultural policies for a long time before that. The common agricultural policy of the ECOWAS like its EU counterpart is expected to be an integration of the patchwork of national policies. The EU adopted a number of guiding principles from which ECOWAS farmers and policy makers can draw some conclusions. The first one was that of a unified market to ensure free movement of farm products from one country to another. The second principle was that of communitarian preference which closely resembles the objective of food sovereignty that ECOWAS is pursuing. This means that farm products consumed by EU that could be efficiently produced in the region should come from the region rather than from the world market. The third principle was that of parity and productivity. Parity implies that farm incomes should be equal to those in other sectors. This calls for the use of appropriate pricing policies or policy combinations to ensure that prices are high enough to improve the income of the farmers but not too high to be affordable by consumers. Therefore the productivity of farmers need be stimulated so that farmers would be able to produce at lower cost.

Hitherto, the structure and instruments of the ECOWAP need to be elaborated for such exercise to achieve its basic aim of promoting efficient family farms and food sovereignty. It is essential therefore to trace agricultural productivity growth and its decomposition in the region since the inception of ECOWAS. Such Knowledge of the productivity growth can not be based only on TFP for aggregate crops or the aggregate agricultural sectors which is the most widely available on the region at present. For effectiveness of ECOWAP, specific policy needs to focus on specific crops. To borrow a leave from EU, the EU focused her policy first on four products – cereals, milk, beef and sugar beet. She applied a system of intervention storage for the first three but somewhat different system for sugar beet. To this end, the research problems of this study are: what are the level of technical efficiency (TE) change and technological change (TC) and hence Total Factor Productivity in ECOWAS crops relevant to food security and intra trade in ECOWAS.

2. Importance of Rice, Cotton and Millet in ECOWAS

West African rice production represents only 50% of consumers' needs in the sub-region. In terms of per capita apparent consumption rice is the core staple in Senegal (93 kg per head per year) while it is only one staple in a more diversified diet in Ghana and Nigeria with yearly per capita consumption of 25 kg and 29 kg respectively. The shift to rice consumption in Senegal started as early as the colonial period. Production efforts were then driven towards production of groundnuts to the detriment of millet and broken rice was imported from Indochina as cheap staple food. Nigeria has experienced its rice diet transition in the seventies (with a rice per capita consumption annual growth rate of 11%) induced by income growth triggered by the oil industry boom. Ghanaian consumers started to shift to rice only recently compared to the two other countries and experienced a faster growth of rice per capita since 2000 (Lancon and Benz 2007). Most of these countries have adopted enhanced food security as a common policy goal. Generally, dramatic changes in consumption patterns during the past two decades have led to a large increase in the demand for rice from African consumers. Rice has therefore become a staple of considerable strategic importance. At present rice imports is still substantial perhaps because the region is not self sufficient in rice production. Figure 1 shows that both production and imports are moving in the same direction. Exports of rice in the region however are still very negligible. Even though rice is produced in almost all the countries in ECOWAS but the six countries which accounted for more than 80% production are Cote d'Ivoire, Ghana, Guinea, Mali, Nigeria and Senegal.

Cotton plays an important part in ECOWAS development. At present in ECOWAS, up to 16 million people are involved in cotton production in some way and West and Central Africa taken together are the world's 2nd largest exporters of cotton after the United States. Since 2003 and the stalemate at the World Trade Organization (WTO) Cancun Ministerial meeting, West African cotton has become a priority issue in the "Doha Round" of international trade negotiations. At the Cancun Ministerial meeting Benin, Burkina Faso, Mali – three of the six major producers in ECOWAS requested that price-distorting northern subsidies to cotton producers be eliminated and compensation be provided to countries that have suffered from price falls which have put West African cotton at the top of the international agenda. SWAC (2006) confirmed the strategic importance of cotton in the process of significant regional agricultural transformation. In areas of the Sahel, cotton is the major viable cash crop and it will take time to develop economically feasible diversification opportunities. ECOWAS has a clear natural comparative advantage in producing cotton "all other things being equal". In zones that have benefited from the cotton production support system, cotton boom might have been accompanied by an agricultural revolution that contributed to increased cereal production SWAC (2006). Generally, the cotton production support system is driving by a process of extensive use of land accompanied by intensive production of cereals as cash crops to supply urban markets. Burkina Faso provides an example of the national cotton support systems established in cotton-producing countries under colonial administrations in order to ensure continuity between upstream (inputs supply, extension) and downstream aspects of production (collection and marketing). In Burkina Faso, cotton producers have benefited from credits from the national cotton company, SOFITEX, and the national agricultural credit bank, to purchase inputs such as fertilizer, pesticide and herbicide. Short term loans to cover the pre-harvest period and loans to purchase ox-ploughs have also been made available to cotton producers in recent years (Government of Burkina Faso 2001).

The rapid increase of cotton production over the last two decades can also be traced to the process of economic liberalization that began in the early 1980s. This gave farmers incentives to increase production so as to improve their incomes, but increased downward price pressure in international markets also requires an increase in production for producers to simply maintain incomes and purchasing power. This has occurred in all three main production zones identified above, with overall production rising from about 200,000 tonnes in the 1970s to over 1 million tonnes per year in the early 2000s (fibre, lint and seed counted together - but with seed accounting for only 5-10% exports). Production of cotton fibre in 2003/2004 reached 1,037,000 tonnes (ICAC 2004). A number of incentives exist for farmers to continue to produce cotton as a key route to access cash income particularly in the Sahelian zone of West Africa in general. These include (1) a suitable climate (limited rain); (2) natural comparative advantage given the low production cost and high quality of West African cotton fibre; (3) existence of international demand; (4) availability of a support infrastructure, agricultural and social services (e.g. extension, pharmacies, schools, etc.) and established marketing channels (5) perhaps most importantly, there are limited alternative cash crops suited to these zones for which there is sufficient market demand. On the other hand, the traditional textiles industry has a long history in certain ECOWAS countries (e.g. Mali, Ghana, and Nigeria) and may present development opportunities. Ghana and Nigeria in particular seem to have developed an efficient local cotton processing industry that uses the majority of cotton produced in these countries .Employment related to the production of traditional cloth and clothing (spinning, dying, clothmaking, sale etc.) is, according to SWAC (2006), the second largest employer in West Africa after agriculture. The study shows that about 65-70% of artisans in Mali, 50% in Burkina Faso and 30-40% in Ghana are employed in the traditional textiles industry.

The contribution of cotton to national GDP varies according to country in ECOWAS. It provides 3-5% of GDP in Benin, Burkina Faso, Mali, and Togo and less than 2% for other cotton producers. However, cotton exports generate significant resources for national economies in many ECOWAS countries, for example in 2001, it represents about 51.4%, and 37.6% of exports receipts for Burkina Faso and Benin . For Mali the figure is 25% and Togo 11.2%. This variation from country to country can be linked to the structure of each country's economy. Figure 2 shows the production, exports and imports of cotton over the analysis period.

Almost equal amount produced are exported while imports are negligible. The exports movements reflect the evolving demand and supply for ECOWAS cotton. The period 1975-2005 witnessed sharp rises in both production and exports while imports have no remarkable change. Although cotton is produced in almost all the country in the region, Benin, Burkinafaso, Cote d'Ivoire, Mali, Nigeria and Togo account for more than 90% of its production and exports.

Millets (Pennisetum glaucum (L.) R. Br.), are essential to diets of people in the semi-arid tropics where droughts often cause frequent failures of other crops. They are most important in West Africa especially Sahelian part of ECOWAS sub region, where they take about 70% of total cereal production. Generally, pearl millet is planted on about 28 million ha, mainly in Africa and India, to produce 10 million tons of grain per year for about 70 million people. Pearl millet is particularly adapted to Sahelian West Africa where landraces have evolved in different ecological niches. In five major producing countries in ECOWAS region namely Burkina Faso, Mali, Niger, Nigeria and Senegal, more than half of their population depends on pearl millet for over 1,000 calories per person per day. The yields of millet may be low under the area's environmental conditions but they are relatively the most dependable. Gradually, Africa is becoming the world's leading producer of millet. In the quarter century since the early 1970s, African millet harvests increased by 22 percent, whereas other regions registered substantial production declines. The percentage of millet used for domestic food consumption is rising steadily in Africa, but the vast and still expanding millet areas continue to produce low, but steady, yields with very few fertilizer inputs. Soon, Africa is likely to have the largest millet acreage of all developing regions with yields only slightly below the developing country average. Figure 3 indicates that the production has trended steadily upward particularly following establishment of ECOWAS in 1975. Both the exports and imports are however still very negligible.

The production of millet is concentrated in five of the ECOWAS countries including Burkina Faso, Mali, Niger, Nigeria and Senegal which altogether account for more than 85% of regional production in 2005.

3. Methodological Approaches to Productivity Growth

Productivity growth is generally defined in terms of the improvement and technical change with which inputs are transferred into outputs in the production process (shih-Hsuu 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. When measured over time it can be divided into two namely technical efficiency (firms getting close to the frontier) and technical change (shift in the frontier itself). The technical efficiency of a country is define as the degree to which it is able to convert its agricultural inputs efficiently into output relative to best practice where the best practice is defined by the frontier. Technical change on the other hand measures the extent to which the production frontier , representing the state of technology in a particular time period , shifts upward over time. Such shifts represent technological progress. The true production frontier is rarely known in practice. It is usually estimated using sample data on a number of countries.

Broadly based empirical analyses have focused on global (Rao and Coelli 1998), regional (Fulginiti et.al 2004 Coelli, 2005) and country level performace (Alabi, 2005). With regards to international comparison of TFP, there are about five different approaches namely (i) time series growth accounting (ii) cross-section growth accounting (iii) panel regression (iv) non parametric or parametric frontier and (v) partial productivity approach. Time series approach refers to the growth accounting tradition in which analysis is focused on the time-series dimension of data either in absolute or relative form. In the absolute form, time series data of individual countries are analyzed without relating these to time series of other countries. In this form, researchers obtain TFP growth rates within individual countries. This approach does not require time series data of different countries to be brought to a common currency. This limitation is overcome by time-series approach in the relative form which brought data for different countries to a common currency, using either official exchange rates or exchange rates based on purchasing power parity. The use of the absolute form is as old as the study of TFP itself. This includes Timbergen (1959) who used the framework to conduct a comparison of TFP growth in France Germany, the UK and the US for the period 1870 – 1910. Other works of this tradition include Solow (1957),and Bager (1969). An excellent survey of previous works of absolute form can be found in Christensen et.al (1981). More recent use of the approach includes Elias (1992), Chete and Adenikinju (1994) and Onjala (2002).

Jorgenson and Nishimizu (1978) initiate the relative form of time series approach to international TFP comparison. The authors conduct growth accounting for the US and Japan by considering their data in relative form. Christensen et.al. 1981 extend the method to the sample of 9 countries. Recent user of the approach includes Wolff (1994) and Jorgenson (1998). The cross-section growth accounting approach to TFP has been suggested recently by Hall and Jones (1996, 1997). The methodology is similar to that of time-series growth accounting but it is now applied along the cross-section dimension. The panel approach to international TFP comparison arose directly from recent attempts at better explaining cross-country, growth irregularities. Many researchers have used the method to investigate determinants of growth (Hall and Jones 1996, Mankiw 1992, and Islam 1999).

Apart from the above three approaches, some researchers consider the use of productivity analysis either in its parametric or non-parametric frontier form. The non parametric approach was developed and used by such researcher as Fare, et.al (1994), Nishimizu and Page (1983). Their approach relies on the methodology of linear programming activity analysis. The frontier approach does not impose any parametric production function on the data and hence is flexible. The frontier approach otherwise called Malmquist index has gained popularity in recent year. According to Shih (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 and 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 and Multilateral comparison. The method does not attract any of the statistic 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). In this paper the stochastic frontier approach is used as measures of productivity growth in rice, cotton and millet in ECOWAS (Coelli, 2003).

Stochastic Frontier Method

The stochastic production function for panel data can be written as

$$\ln(y_{it} = f(x_{it}, t, \alpha, v_{it} - u_{it}) \quad (1)$$

i = 1,2, …………..N and t = 1,2,………………….T (Battese an Coelli 1992)

Where y_{it} is production of the ith firm in year t, α is the vector of parameters to be estimated. The v_{it} are the error component and are assumed to follow a normal distribution $N(0,\sigma_{it}^2)$, u_{it} are non negative random variables associated with technical inefficiency in production which are assumed to arise from a normal distribution with mean μ and variance σ_{μ}^2 which is truncated at zero. $f(.)$ is a suitable functional form (e.g translog), t is a time trend representing the technical change. The technical efficiency of production for the ith region at the tth year can be predicted using Coelli et. al (1998). The technical efficiency are obtained as

$$TE_{it} = E(\exp)(-u_{it})/v_{it} - u_{it}) \qquad (2)$$

This can be used to compute the efficiency change component by observing that $TE_{it} = d_o^t(x_{it}, y_{it})$ and $TE_{i,t+1} = d_o^{i,t+1}(x_{i,t+1}, y_{i,t+1})$ the efficiency change (EC) is

$$EC = TE_{it} / TE_{i,t+1} \qquad (3)$$

An index of technological change between the two adjacent periods t and $t+1$ for the ith region can be directly calculated from the estimated parameters of the stochastic production frontier. This is done by simply evaluating the partial derivatives of the production function with respects to time at x_{it} and $x_{i,t+1}$. If technical change is non neutral, the technical change may vary for the different input vectors. Following Coelli et al (1998), the technical change (TC) index is

$$TC_{it} = \left\{\left[1+\frac{\delta f(x_{it}, t+1, \alpha)}{\delta t+1}\right] X \left[1+\frac{\delta f(x_{it}, t, \alpha}{\delta t}\right]\right\}^{1/2} \qquad (4)$$

The TFP index can be obtained by simply multiplying the technical change and the technological change i.e

$$TFP_{it} = EC_{it} * TC_{it} \qquad (5)$$

This is equivalent to the decomposition of the Malmquist index suggested by Fare et al (1994).

Empirical Specification

This study utilized data on output and inputs of rice, cotton and millet from major producers of the crops to construct their indices of TFP growth using the method described by equations 1 – 5. The sample data comprise annual measures of the output of each crop and 4 direct inputs (land area, seed, fertilizer and labour). The major countries producing rice are : Cote d'Ivoire Ghana Guinea Mali Nigeria Senegal. The major producers of cotton are Benin Burkina Faso, Cote d'Ivoire, Mali, Nigeria, Togo while main producers of millet are Burkina Faso, Mali, Niger, Nigeria, Senegal.

For the stochastic frontier approach, a translog stochastic production for the selected crops is specified. The output of each crop is assumed to be a function of 4 inputs – land area, seed, fertilizer and labour. A non neutrl technical change is specified and the error term is assumed to have 2 components. The production is as shown in (6).

$$\begin{aligned} \ln y_{it} &= \alpha_0 + \alpha_h \ln H_{it} + \alpha_s \ln S_{it} + \alpha_f \ln F_{it} + \alpha_l \ln L_{it} + \alpha_t T + \alpha_{hh} \ln(H_{it})^2 + \\ &\alpha_{ss} \ln(S_{it})^2 + \alpha_{ff} \ln(F_{it})^2 + \alpha_{ll} \ln(L_{it})^2 + \alpha_{tt} T^2 + \alpha_{hs} \ln H_{it} \ln S_{it} + \alpha_{hf} \ln H_{it} \ln F_{it} \\ &+ \alpha_{hl} \ln H_{it} \ln L_{it} + \alpha_{sf} \ln S_{it} \ln F_{it} + \alpha_{sl} \ln S_{it} \ln L_{it} + \alpha_{fl} \ln F_{it} \ln L_{it} + \alpha_{ht} (\ln H_{it}) t + \\ &\alpha_{st} (\ln S_{it}) t + \alpha_{ft} (\ln F_{it}) t + \alpha_{lt} (\ln L_{it}) t + v_{it} - u_{it} \end{aligned} \tag{6}$$

i = 1,2……………N, t = 1,2…………………T

Where

y_{it} is the output of crop i in the tth year

H_{it} is the hectares of land cultivated to each crop

S_{it} is the quantity of seed planted in '000 tonnes

F_{it} is the quantity of fertilizer used in '000 tonnes

L_{it} is amount of labour used in mandays

ln is the natural log

$\alpha_i s$ are unknown parameters to be estimated

$v_{it} s$ are $iidN(0, \sigma_{v^2})$ random errors and are assumed to be independently distributed of the $u_{it} s$ which are non negative random variables associated with TE inefficiency. The distribution of the $u_{it} s$ are obtained by truncation at zero. The mean is defined as:

$$u_{it} = \beta_0 + \beta_1 R_{it} + \beta_{dj} \sum_{j=1}^{n} D_{tj} + \beta_{tj} \sum_{j=1}^{n} D_{tj} t \tag{7}$$

Where

R_{it} is irrigated land area for crop i in the tth year

D_j is the dummy variable which takes the value of 1 for the jth state producing the selected crops.

βs are unknown parameters to be estimated.

4. Data And Estimation of TFP of the Selected Crops (Rice, Millet And Cotton)

Data for inputs and outputs are collected principally from FAOSTAT 2007.This is supplemented with International rice research institute's (IRRI) world rice statistics, International Cotton Advisory Committee's (ICAC) cotton statistics and millet input data from ICRISAT data base. The data covered a period of 45 years from 1961 to 2005. Rice data are from six countries producing more than 80% of rice paddy in ECOWAS. They are Cote d'Ivoire, Ghana ,Guinea, Mali, Nigeria and Senegal. Similarly Cotton data come from Benin, Burkina Faso, Cote d'Ivoire, Mali, Nigeria and Togo while millet data are obtained from Burkina Faso, Mali, Niger, Nigeria and Senegal. The selected countries account for more than 90% production of cotton and millet in ECOWAS. The TFP indices are calculated separately for each crop because of differences in the producing countries. The data set for each crop contains six inputs namely land area, seed, fertilizer, labour, irrigation and country dummies. The descriptions of the input-output data used in this study are:

Individual crop output: This refers to the quantity of each crop production is in tonnes. This is taken from FAOSTAT database

Fertilizer: This refers to the quantity of NPK in metric tonnes of plant nutrients consumed in individual crop agriculture. The quantity of fertilizer used for each crop in the producing countries is obtained from FAO FERTISTAT data base and individual country statistical database.

Labour: This is the mandays of labour engaged in the production of each crop. This is generated from farm level studies which quantify the number of mandays required per hectare of each crop in various countries covered in this study.

Land: Expressed 1000 ha, this refers to land area under each crop. Land data is also drawn from FAOSTAT data base

Seed: Drawn from FAOSTAT data base and expressed in '000 metric tones, this covers quantity of each crop seed planted.

Irrigation: This is the proportion of each crop land area that are irrigated. In case of rice, the proportion of land area irrigated is taken from IRRI world rice statistics. Such information for millet is obtained from ICRISAT database. For cotton, the study relies on FAO AQUASTAT database and individual country cotton irrigation statistics.

5. Empirical Results and Analysis

Panel Unit Root Test

In order to estimate equation 6 where the variables are in levels, it is important to first examine whether the variables are non stationary. If variables are non stationary, ordinary panel techniques of estimation by least squares are inconsistent and standard inference of the coefficient is impossible. Starting from the seminar work of Quah (1990), Breitung and Meiyer (1991) and Levin and Lin (1992, 1993), many tests have been proposed which attempt to introduce unit root tests in panel data. In this study, five unit root tests for panel data are applied to assess stationarity. The tests are Levin Lin and Chu t-stat, Breitung t-stat, ADF Fisher chi square, Phillip Perron Fisher chi square, and Hadri Z-stat. All the tests include individual constants and individual trends. Levin Lin and Chu (LLC), Breitung (BT), and Hadri Z (HAZ) assume a common root unit root process while Phillip Perron (PP) and Augmented Dickey Fuller (ADF) allow for individual unit root process so that the autoregressive coefficient can vary across units. The tests are provided by the econometric software package E-view 5. The results reported in Table 1 shows that logarithm levels of all the variables are stationary using Hadri Z-stat.

Results of the Translog Stochastic Frontier

The translog stochastic frontier model in equation 6 is estimated using FRONTIER 4.1 software (Coelli, 19996). The parameter estimates of the model for the whole period (1961-2005), pre-ECOWAS period (1961-1978) and post ECOWAS period (1979-2005) are presented in Tables 2,3 and 4 respectively. The data were mean corrected prior to estimation; hence the first order parameter indicates the elasticities. The results for different crops are discussed below.

Table 2 shows that the production elasticities for rice are dominated by land area. A 10% increase in size of land allocated to rice in the region will lead to an increase in output by about 9500 tonnes. The coefficients of seed, fertilizer and labour are negative contrary to theoretical expectation. The observations on labour are mix-grill of past analyses at different countries. It is contrary to the findings of Dawson and Lingard 1989 but conforms with Ogundele and Okoruwa (2004). The negative elasticity for labour suggests operation in stage III of the production function where there is considerable congestion in the use of labour. The results for pre-ECOWAS is quite different with respect to labour but the same for the other variables. The elasticity of labour is positive which suggests operation in the rational stage of production – stage II. The post-reform might have brought in the wake of labour surplus due to increase in nominal income of the farmers from price incentives inherent in the liberalization scheme. Though, much less negative, the labour variable is not statistically significant in the post-reform era – 1979 – 2005. The coefficient on the time trend indicates positive technological progress in rice production between 1961 and 2005. The frontier is shifting upwards at an annual rate of 10.2%. The technological progress actually takes place in post-reform era as the results indicate technological decline in pre-reform period.

Table 3 indicates that cotton production elasticities are also dominated by land area and conforms to theoretical framework. The coefficients of other variables also conform to a prior expectation of positive sign apart from labour. The result also indicates over-utilization of labour input. A lot of the surplus labour seems to have been shed in the pre-reforms era as the results of the post-reform period indicates operation in the rational stage for labour use in cotton production. The results of the Maximum Likelihood Estimate (MLE) for millet production are given in Table 4. Land area is also the most important determinant of millet production in ECOWAS region but the coefficient has an unexpected negative sign as do labour. This suggests considerable congestion in the use of these inputs. A possible explanation for this scenario might be due to several land tenure problems in the millet producing area of the region. The land area and labour were no longer over utilized in the post-reform period. The coefficients are 4.377 and 9.310 respectively and they are significant at 10% level. The coefficient on trend variable has a negative sign. This implies technological retrogression. Millet being a non-tradable, it is possible government is shifting investment in technology away from millet into other crops than can easily fetch them foreign exchange.

TFP and Its Decomposition

The indices for changes in TFP, technical efficiency and technological change for the period from 1961 – 2005 are shown in Table 5. The estimates of the technical change for rice indicate very significant technical progress during the sample period. This observation is not surprising as the estimate of α_t suggests average annual technical progress of 46% per year. The $\beta_{it}s$ also indicate improvements in the technical efficiency of the different countries producing rice in the region. A comparison of the productivity in the pre-ECOWAS era with post shows that more technological progress and hence more improvement in productivity is recorded in pre-ECOWAS than in ECOWAS period. The breakdown of the results by different rice producing countries in Table 6 indicates productivity growth in all the major rice producing countries. The highest growth is however recorded by Guinea with 40.8% growth, rate on the average. The growth is due mainly to technological progress rather than improvement in efficiency. The Table shows an average annual TFP growth of 16.8% over the entire period – 1961-2005, averaged over all the major countries producing rice. In Ghana and Senegal however, negative growth in TFP are observed perhaps due to unfavourable weather conditions. A look at the period by period breakdown shows that Guinea has the highest TFP in all the 3 periods. This means that Guinea is especially good at moving toward the frontier than other major producers. A major contributor to rice TFP growth in all the countries has been the technical change. All the countries have impressive technological progress in rice production on the whole. Guinea and Mali however, have higher technological progress in pre- ECOWAS period than in ECOWAS era.

The indices for changes in Cotton TFP, technical efficiency and technological progress show that better technological progress is made in ECOWAS region than rice perhaps due to its importance as one of the major export crop in the region. There has been a 49.3% growth in TFP over the entire analysis period. Unlike the case of rice however, the TFP growth in post-reform period 1979 – 2005 shows no significant improvement over pre-reform era. The country by country variations show that Cote d'Ivoire is the most impressive country followed by Burkina Faso. At the other end of the spectrum, Benin has the lowest growth performance. For most of the analysis period, Benin posted negative cumulative growth. The TFP growth in all the countries is due mainly to technical change. The technical change is most impressive in Burkina Faso followed by Benin. On the average, the average efficiency change ranges from 0.869 in Benin to 2.008 in Burkina Faso. The impressive efficiency change in Burkina Faso is most likely a consequence of keen interest of the countries in export of Cotton and development of indigenous industries using cotton as raw materials. With respect to reform period differences, the first point to note is that the rate of growth is lower in ECOWAS than in pre-ECOWAS period, a surprising result. The relatively low TFP for ECOWAS period is driven by Benin and Mali. In pre-ECOWAS period Burkina Faso has the highest TFP growth. In ECOWAS period, it has been overtaking by Cote d'Ivoire. By and large, all the country showcase reasonable growth in TFP in both pre-ECOWAS and ECOWAS period. The growth rate recorded can actually provide a basis for sustained growth in cotton in the region.

The results of TFP and its decomposition for millet show negative technical progress during the sample period. The estimate of α_t indicates average annual technical decline of 0.03%. Also, the β_i estimates suggest that there is decline in technical efficiency of the different countries producing millet. The decline is very much pronounced in the pre-ECOWAS period. Throughout 1961-2005, ECOWAS sub region has efficiency change approximately equal to one suggesting that the region remained on the technology frontier in respect of millet. The impressive efficiency change is far more offset by technological retrogression. Hence, the average TFP growth for millet in the region is negative. The country level breakdown indicates that the average TFP growths are 0.6, 0.614, 0.618, 0.608 and 0.614 for Burkina Faso, Mali, Niger, Nigeria and Senegal respectively. Contrary to the situation with rice and cotton the TFP growth in millet is due mainly to efficiency change rather than technological progress. The rate of growth from 1979 is almost the same with the rate of decline from 1961-2005. A comparison of the results of different reform era is shown in Table 5 show that all the countries have negative TFP in all the periods. The results are however less negative in ECOWAS period than in pre-ECOWAS era. The improvement in TFP in ECOWAS period over pre-ECOWAS is driven by Mali and Niger whose TFP growths are 0.702 and 0.704 respectively.

The evolution of the TFP for the three crops in the sample period is shown clearly in Figure 4. Cotton has the most impressive results followed by rice. The TFP of millet has a V shape. It declines progressively from 1961 to 1981 while it moves up progressively from 1981 to 2005. The highest TFP growth attained however is about the same as the lowest of rice TFP growth.

6. Conclusion and Policy Recommendation

This paper has attempted to estimate crop specific TFP in ECOWAS for rice, cotton and millet. The results show evidence of phenomenal growth in the TFP of rice and cotton but decline in the TFP of millet. Cotton however has more impressive results than rice. A closer look at the TFP in ECOWAS and pre-ECOWAS sub-period shows larger TFP in ECOWAS period (1979-2005) for rice, and millet but larger TFP in pre-ECOWAS period for cotton. In both periods, productivity growth in rice and cotton is sustained through technological progress while it is sustained through more efficient use of inputs in millet. These results may have some important effects on the ECOWAS present and future exports of the commodities. However, these may depend on adequate knowledge of the sources of the productivity growth.

In the light of the findings of this research the following policy recommendation are suggested:

1. The government of the major producers of rice and cotton should invest more in functional agricultural extension services to enhance efficient use of available productivity increasing inputs.
2. Given the contribution of efficiency change to TFP growth in millet, investment in modern technology and improved agronomic practices in millet should be increased involving all the stakeholders – farmers, processors and government.
3. Given differences in the contribution of efficiency change and technological progress to the TFP of the selected crops, ECOWAP should take a leave from EU CAP, by marrying policy with specific crop need.
4. Future works should quantify parametrically, the determinants of the productivity growth in the crops.

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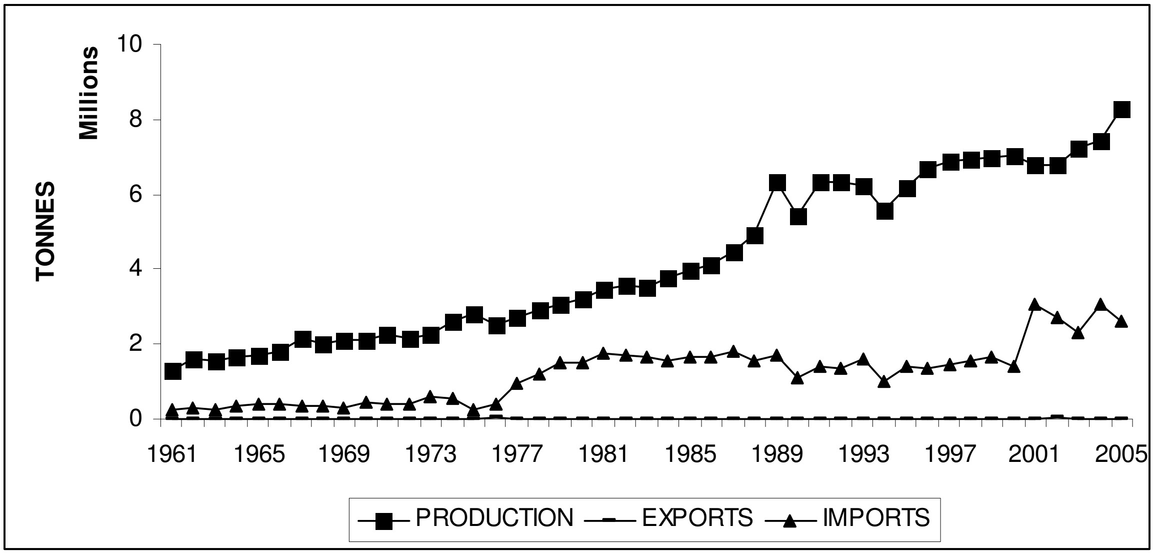

Figure 1: ECOWAS rice production, exports and imports

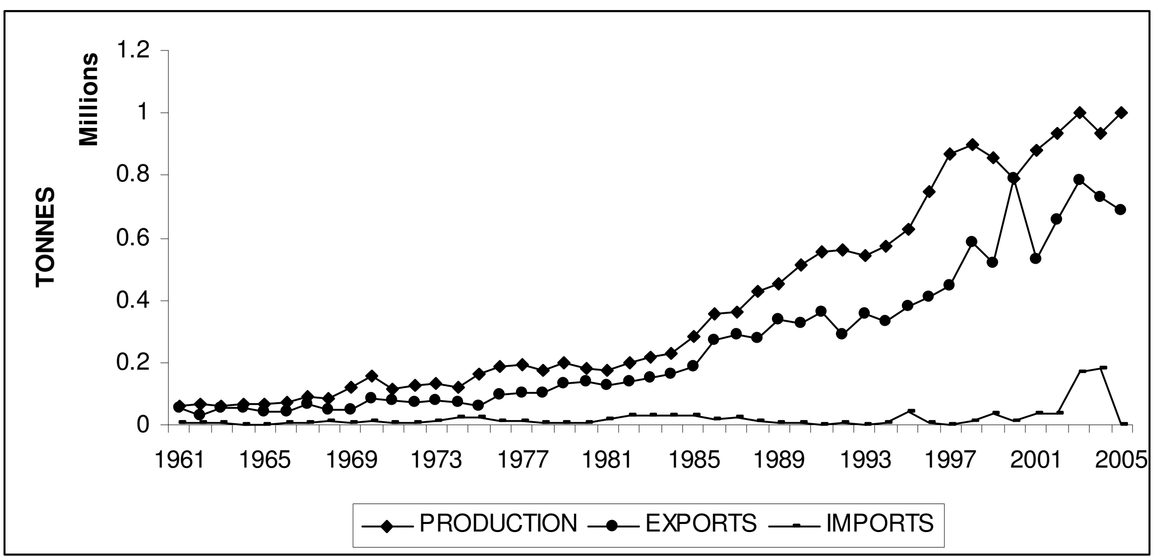

Figure 2: ECOWAS cotton production, exports and imports.

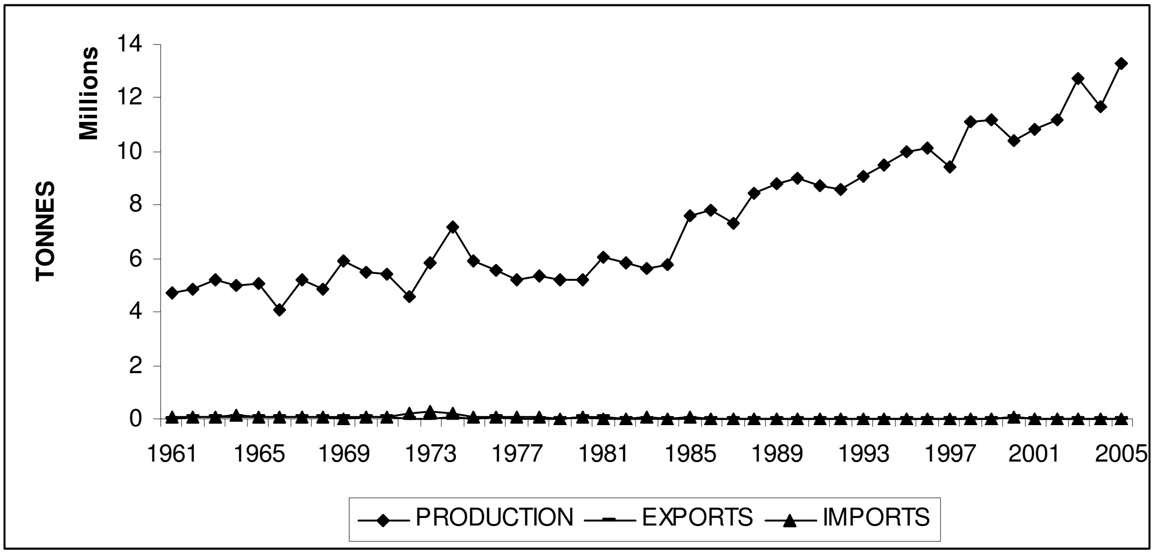

Figure 3: ECOWAS millet production, exports and imports

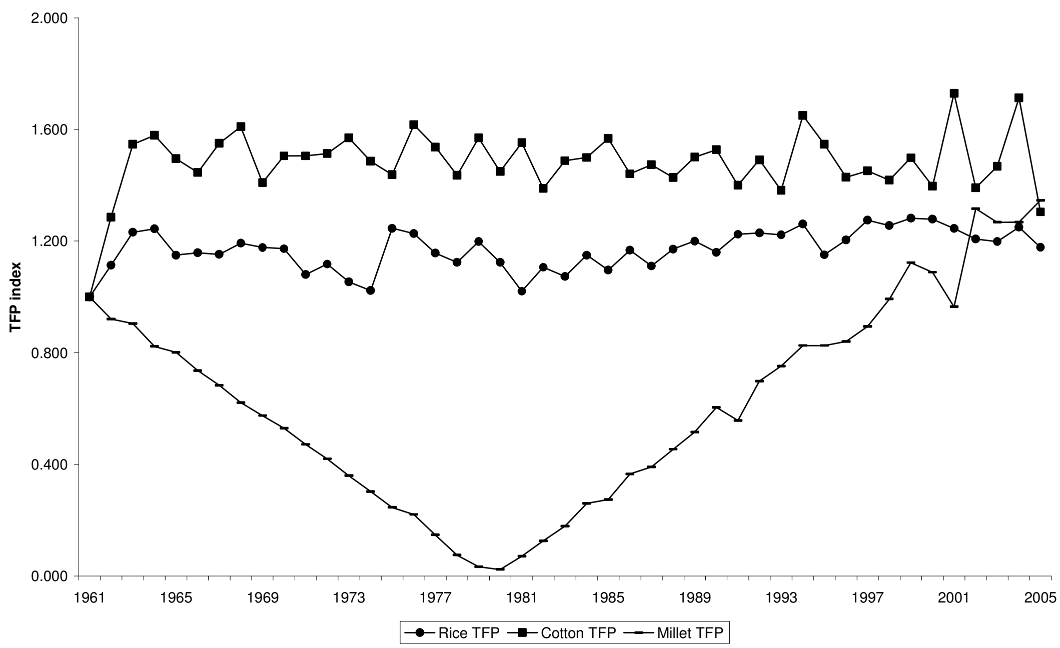

Figure 4: TFP growth in rice, cotton and millet

Table 1: Results of the Unit Root Tests

Variables	PP Fisher	Levin& Chu	ADF Fisher	Breitung	Hadri Z
Rice					
$\ln y_{it}$	38.44(0.00)	-4.68(0.00)	36.78(0.00)	-0.32(0.38)	5.49(0.00)
$\ln H_{it}$	37.41(0.00)	-14.69(0.00)	26.24(0.01)	-0.73(0.23)	4.33(0.0)
$\ln S_{it}$	17.63(0.13)	-0.84(0.20)	17.40(0.14)	0.66(0.75)	6.68(0.00)
$\ln F_{it}$	37.16(0.00)	-1.33(0.09)	9.87(0.63)	-0.29(0.39)	4.33(0.00)
$\ln L_{it}$	9.06(0.70)	0.50(0.69)	25.65(0.00)	-0.94(0.17)	4.45(0.00)
Cotton					
$\ln y_{it}$	32.76(0.00)	-1.91(0.00)	13.78(0.32)	-1.12(0.13)	4.68(0.00)
$\ln H_{it}$	16.92(0.16)	-2.21(0.00)	10.65(0.55)	-0.28(0.39)	6.25(0.00)
$\ln S_{it}$	24.31(0.02)	-3.72(0.00)	13.90(0.31)	-1.32(0.09)	4.81(0.00)
$\ln F_{it}$	13.39(0.34)	0.35(0.64)	6.58(0.88)	2.43(0.99)	7.54(0.00)
$\ln L_{it}$	16.92(0.16)	-2.21(0.01)	10.65(0.56)	-0.40(0.35)	6.25(0.00)
Millet					
$\ln y_{it}$	80.22(0.00)	-5.83(0.00)	61.76(0.00)	0.45(0.67)	3.15(0.00)
$\ln H_{it}$	44.30(0.00)	-4.26(0.00)	46.23(0.00)	0.43(0.33)	3.41(0.00)
$\ln S_{it}$	46.46(0.00)	-3.48(0.00)	44.44(0.08)	0.70(0.24)	7.30(0.00)
$\ln F_{it}$	17.37(0.07)	-0.15(0.00)	16.79(0.00)	0.70(0.24)	7.30(0.00)
$\ln L_{it}$	44.46(0.00)	-4.27(0.00)	45.90(0.00)	-0.49(0.31)	3.41(0.00)

The null hypothesis is Ho: Unit roots. P-values are in parentheses.

Table 2: MLE Estimates of The Stochastic Frontier Model For ECOWAS Rice

	1961 – 2005		1961 – 1978		1979 – 2005	
Coefficient	estimate	t-ratio	estimate	t-ratio	estimate	t-ratio
α_0	27.05*	26.64	-15.83*	15.98	28.48*	25.89
α_h	9.50*	11.80	10.85*	12.93	10.85*	14.23
α_s	-0.59	-41.20	-20.27	-0.78	-0.25	1.24
α_f	-9.30*	-16.57	-10.04*	-15.01	-10.52*	-17.70
α_l	-0.41	-1.53	2.24*	3.58	-0.47	1.30
α_t	-0.10*	5.18	-0.08*	-4.35	-0.003	-1.40
α_{hh}	0.47*	3.94	-0.20+	-2.95	0.12*	4.19
α_{ss}	-0.006	-0.13	0.38+	2.34	-0.003*	-6.80
α_{ff}	0.80*	9.99	-0.001	-0.06	-0.97	-0.55
α_{ll}	-0.005	0.32	0.77*	7.04	0.03*	11.10
α_{tt}	0.0004*	4.59	0.05	0.73	0.04	0.73
α_{hs}	0.04	1.18	-0.05	1.09	0.0003	1.11
α_{hf}	-1.39*	-7.55	-0.001^	-1.97	-0.04+	-2.44
α_{hl}	-0.04	-0.96	-0.54	-0.86	-1.77	-0.75
α_{sf}	0.06+	2.71	-1.11*	-4.28	-0.03*	-9.76
α_{sl}	-0.02	-1.13	0.34*	-4.27	-0.03	-0.40
α_{fl}	0.07^	1.89	0.11^	1.68	0.07^	1.86
α_{ht}	-0.003	-1.50	0.02+	2.36	-0.0001	-0.004
α_{st}	-0.004*	-4.38	-0.01	1.54	-0.0002	-0.54
α_{ft}	-0.005+	-2.44	-0.02^	-1.77	-0.02*	-5.51
α_{lt}	0.06^	1.63	0.03*	5.81	0.008*	3.32
β_0	0.05	0.14	-0.32	-0.79	-0.30	-0.76
β_1	-0.007	-1.57	0.55+	2.62	0.02	0.23
β_2	0.06	0.16	-0.39	-0.93	-0.17	-0.45
β_3	-1.50	1.31	0.44	1.14	0.60	1.54
β_4	-1.27*	-3.02	-1.42*	-3.17	-1.34+	-2.46
β_5	0.34	0.90	0.56	1.42	0.56	1.40
β_6	0.44	0.11	0.31	0.81	-0.43	-1.09
β_7	0.37	0.96	0.17	0.45	0.48	1.22
σ^2	0.04*	9.46	0.02*	5.71	0.03*	7.64
γ	0.99*	213.33	0.99*	8.01	0.97*	80.06
L	211.59		111.34		162.12	

*, +, ^ indicate significant at 1, 5, and 10% respectively.

Table 3: MLE Estimates of The Stochastic Frontier Model For ECOWAS Cotton

	1961 – 2005		1961 – 1978		1979 – 2005	
Coefficient	estimate	t-ratio	estimate	t-ratio	estimate	t-ratio
α_0	-5.05*	-18.50	-87.05*	-101.74	-71.72*	-103.42
α_h	5.53*	17.77	93.17*	159.96	79.72*	125.22
α_s	0.65	0.29	-0.23	-0.43	2.11*	4.65
α_f	0.91*	7.74	0.55+	2.43	0.13	0.52
α_l	-51.38*	-16.09	-93.75*	-145.09	-78.91*	-118.48
α_t	-0.24*	-14.31	-0.006+	-2.35	0.13	0.43
α_{hh}	-14.51*	-16.38	-0.006	-0.19	-0.01	0.40
α_{ss}	-0.07*	-9.00	-26.86*	-125.55	-21.40*	-63.59
α_{ff}	-0.008*	-7.07	0.03	-0.95	-0.08+	-2.70
α_{ll}	-12.02*	-12.63	-0.02*	-3.37	-0.02*	-3.72
α_{tt}	0.0001^	1.61	-0.37*	-3.02	-0.13	-0.78
α_{hs}	0.33+	2.33	-24.11*	-49.97	-19.56*	-58.28
α_{hf}	-0.55*	-8.27	-0.001	-0.87	-0.0004	0.03
α_{hl}	26.62*	14.57	0.83+	2.49	-0.28	0.88
α_{sf}	-0.02+	-3.03	-0.37+	-2.78	0.03	0.22
α_{sl}	-0.28^	-1.83	51.08*	80.85	41.63*	72.14
α_{fl}	0.57*	8.29	0.04	0.84	0.08+	2.00
α_{ht}	0.17*	18.44	-0.03	-0.99	0.08*	5.76
α_{st}	-0.002	-1.09	-0.02	-1.50	-0.005	-1.36
α_{ft}	-0.0001	0.152	0.007+	2.23	-0.005+	2.76
α_{lt}	-0.19*	-19.15	0.03	0.76	0.09*	5.73
β_0	0.19	0.49	-0.24	-0.63	-0.05	0.14
β_1	-0.0004+	-2.58	-0.002+	2.82	0.0001	0.45
β_2	0.08	0.22	0.48	1.22	0.19	0.51
β_3	0.12	0.31	-0.45	-1.16	0.11	0.28
β_4	-0.08	-0.22	0.29	0.74	-0.06	0.16
β_5	0.15	0.41	0.55	1.15	-0.12	-0.30
β_6	-0.14	-0.36	-1.68+	-2.87	-0.57	-0.01
β_7	0.05	0.14	0.57	1.44	0.27	0.71
σ^2	0.02*	9.46	0.02*	10.20	-0.03*	-11.40
γ	0.45*	3.72	0.99*	138.35	1.00*	35.84
L	122.19		145.52		70.32	

*, +, ^ indicate significant at 1, 5, and 10% respectively.

Table 4: MLE Estimates Of The Stochastic Frontier Model For Ecowas Millet

Coefficients	1961 – 2005		1961 – 1978		1979 – 2005	
	Estimate	t-ratio	Estimate	t-ratio	Estimate	t-ratio
α_0	23.53*	7.99	27.28*	26.43	4.38*	3.062
α_h	-20.15*	-9.26	-15.44*	-19.44	-5.15*	-6.60
α_s	-0.17	-0.16	-3.98*	-4.13	-4.31*	-5.03
α_f	0.27	1.18	-0.29	-0.58	0.042	0.076
α_l	21.17*	7.86	15.28*	19.80	9.92*	9.31
α_t	-0.0003	-0.43	-0.68	-0.79	-0.02	-0.10
α_{hh}	3.83*	-6.87	-0.05	-0.33	-0.26*	-5.13
α_{ss}	-0.92*	-4.00	2.64*	9.70	1.42*	3.46
α_{ff}	0.002	0.42	-0.86^	-1.96	-0.52^	-1.85
α_{ll}	2.65*	3.33	-0.076	-1.34	0.04*	4.87
α_{tt}	-0.05^	1.86	-0.27	-0.15	0.19	1.49
α_{hs}	-0.05	-0.14	2.45*	-3.92	0.12^	1.65
α_{hf}	-0.07	1.05	-0.0008	-0.73	-0.006	-1.57
α_{hl}	-6.97*	-5.17	1.75*	3.86	0.91*	3.08
α_{sf}	0.026	0.66	-0.017	-0.10	-0.28^	-1.71
α_{sl}	1.21+	2.30	-5.32	-0.91	-3.11+	-2.84
α_{fl}	0.01+	2.27	0.22+	2.23	0.12^	1.83
α_{ht}	-0.0001	-0.49	0.009	0.17	0.09*	6.15
α_{st}	0.009^	1.68	-0.077	-0.02	0.03+	2.03
α_{ft}	0.00001	0.0008	0.016+	2.83	-0.002	-0.10
α_{lt}	0.0009	0.70	0.023	0.44	-0.087*	-4.26
β_0	0.21	0.50	1.08+	2.28	0.01	0.004
β_1	-0.002*	-3.20	-0.04*	-4.30	0.001	0.78
β_2	-0.2*	-4.77	0.30	0.62	-0.27	-0.65
β_3	-0.007*	-5.86	-0.29	-0.67	0.36	0.86
β_4	0.02	1.34	1.31+	2.47	-0.002	-0.006
β_5	-0.008	1.37	-0.05	-0.11	-0.28	-0.62
β_6	0.008	0.44	-0.17	-0.39	0.20	0.46
σ^2	-0.02*	8.61	0.03*	6.06	0.06*	5.18
γ	0.99*	8.01	0.71*	5.82	0.99*	10.80
L	256.92		59.40		70.32	

*, +, ^ indicate significant at 1, 5, and 10% respectively.

Table 5: TFP and its Decomposition

	Rice			Cotton			Millet		
Year	EFFCH	TECH	TFP	EFFCH	TECH	TFP	EFFCH	TECH	TFP
1961	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
1962	0.755	1.475	1.114	0.855	1.504	1.286	0.964	0.954	0.920
1963	0.833	1.479	1.232	1.031	1.501	1.547	1.004	0.900	0.904
1964	0.838	1.484	1.244	1.053	1.500	1.579	0.973	0.845	0.822
1965	0.775	1.484	1.150	0.997	1.499	1.496	1.013	0.791	0.802
1966	0.783	1.480	1.158	0.964	1.500	1.446	0.999	0.737	0.736
1967	0.777	1.484	1.153	1.035	1.498	1.551	1.000	0.683	0.683
1968	0.800	1.491	1.192	1.077	1.495	1.610	0.987	0.629	0.621
1969	0.789	1.492	1.177	0.943	1.494	1.409	0.999	0.575	0.574
1970	0.785	1.493	1.172	1.007	1.495	1.505	1.017	0.521	0.529
1971	0.723	1.493	1.080	1.007	1.495	1.506	1.012	0.466	0.471
1972	0.748	1.495	1.118	1.013	1.494	1.513	1.019	0.412	0.419
1973	0.704	1.496	1.054	1.051	1.494	1.570	1.002	0.358	0.359
1974	0.683	1.497	1.022	0.995	1.494	1.486	0.995	0.304	0.302
1975	0.828	1.504	1.246	0.962	1.494	1.438	0.987	0.249	0.246
1976	0.812	1.510	1.227	1.083	1.493	1.617	1.130	0.195	0.220
1977	0.763	1.516	1.157	1.029	1.494	1.537	1.057	0.139	0.147
1978	0.738	1.522	1.124	0.961	1.494	1.436	0.907	0.082	0.075
1979	0.788	1.522	1.199	1.052	1.492	1.570	0.998	0.033	0.033
1980	0.741	1.516	1.124	0.971	1.492	1.449	1.031	0.022	0.023
1981	0.674	1.512	1.020	1.040	1.494	1.553	1.008	0.070	0.071
1982	0.734	1.507	1.106	0.930	1.494	1.389	0.992	0.127	0.126
1983	0.716	1.499	1.073	0.997	1.492	1.488	0.983	0.182	0.179
1984	0.764	1.504	1.149	1.006	1.491	1.500	1.101	0.236	0.259
1985	0.724	1.513	1.096	1.053	1.489	1.568	0.946	0.289	0.273
1986	0.769	1.518	1.167	0.970	1.486	1.441	1.065	0.343	0.365
1987	0.730	1.522	1.110	0.993	1.484	1.474	0.985	0.397	0.391
1988	0.771	1.518	1.171	0.963	1.483	1.427	1.008	0.451	0.454
1989	0.790	1.519	1.200	1.014	1.481	1.501	1.021	0.505	0.515
1990	0.763	1.520	1.160	1.032	1.480	1.527	1.081	0.559	0.604
1991	0.803	1.526	1.224	0.948	1.477	1.400	0.908	0.613	0.557
1992	0.802	1.533	1.229	1.010	1.477	1.491	1.047	0.667	0.698
1993	0.801	1.526	1.222	0.934	1.479	1.382	1.044	0.720	0.752
1994	0.827	1.525	1.261	1.116	1.479	1.650	1.066	0.775	0.826
1995	0.751	1.533	1.151	1.047	1.476	1.546	0.995	0.829	0.825
1996	0.787	1.530	1.204	0.969	1.474	1.429	0.950	0.884	0.840
1997	0.836	1.525	1.275	0.987	1.471	1.452	0.952	0.938	0.894
1998	0.822	1.528	1.256	0.965	1.469	1.418	1.000	0.992	0.992
1999	0.844	1.520	1.282	1.019	1.470	1.498	1.073	1.046	1.123
2000	0.846	1.511	1.279	0.949	1.472	1.397	0.989	1.100	1.088
2001	0.823	1.514	1.245	1.176	1.471	1.729	0.836	1.154	0.965
2002	0.797	1.514	1.208	0.947	1.469	1.391	1.090	1.208	1.316
2003	0.792	1.513	1.198	0.999	1.468	1.467	1.004	1.262	1.268
2004	0.826	1.513	1.250	1.167	1.468	1.713	0.963	1.317	1.268
2005	0.779	1.513	1.178	0.889	1.467	1.304	0.982	1.371	1.346

Table 6: Total Factor Productivity by Reform Periods

Country	1961 – 2005			1961-1978			1979 – 2005		
	EFFCH	TECH	TFP	EFFCH	TECH	TFP	EFFCH	TECH	TFP
				Rice					
C.Ivoire	0.867	1.510	1.308	0.859	1.495	1.284	0.867	1.519	1.317
Ghana	0.606	1.544	0.931	0.676	1.543	1.042	0.548	1.566	0.858
Guinea	0.980	1.437	1.408	0.983	1.476	1.450	0.977	1.460	1.428
Mali	0.690	1.550	1.065	0.652	1.551	1.011	0.702	1.570	1.102
Nigeria	0.867	1.518	1.314	0.824	1.526	1.257	0.889	1.526	1.257
Senegal	0.688	1.437	0.984	0.642	1.423	1.074	1.000	1.532	1.362
Mean	0.783	1.499	1.168	0.773	1.502	1.186	0.831	1.529	1.221
				Cotton					
Benin	0.869	1.495	1.299	1.006	1.489	1.497	1.004	1.464	1.470
B. Faso	1.227	1.510	1.852	1.011	1.522	1.538	1.003	1.504	1.509
C.Ivoire	2.008	1.486	2.984	0.996	1.517	1.511	1.022	1.491	1.523
Mali	0.927	1.466	1.359	1.002	1.475	1.478	0.987	1.455	1.436
Nigeria	1.061	1.481	1.571	1.004	1.488	1.493	1.008	1.488	1.500
Togo	1.006	1.479	1.488	1.020	1.487	1.517	0.997	1.473	1.468
Mean	1.005	1.486	1.493	1.006	1.496	1.506	1.004	1.479	1.484
				Millet					
B. Faso	0.994	0.614	0.600	0.999	0.487	0.481	0.999	0.702	0.683
Mali	1.008	0.611	0.614	1.002	0.488	0.487	1.012	0.695	0.702
Niger	1.013	0.609	0.618	1.006	0.495	0.493	1.019	0.688	0.704
Nigeria	1.006	0.612	0.608	1.008	0.502	0.504	1.005	0.688	0.679
Senegal	0.998	0.614	0.614	1.003	0.491	0.496	0.994	0.698	0.695
Mean	1.004	0.612	0.611	1.003	0.493	0.492	1.004	0.694	0.692