Agricultural Productivity Growth in Sub-Saharan Africa, 1990-2010: the role of Investment, Governance and Trade[1]

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Abstract

The 2013 Human Development Report recommends the need to strengthen regional integration and South–South cooperation as part of measures to harness the wealth of knowledge, expertise, and development thinking in the South towards achieving more robust growth and development of the developing countries. Past experiences of many African countries with globalization and trade, however suggest the need for caution and that actions need to be much more informed. Against this background, this study examined the role of international trade and economic integration as well as quality of governance and public/private investment in explaining the wide differences in agricultural productivity growth performance among countries in SSA between 1990 and 2010. The study was based on a panel data on 42 countries in SSA over the period 1990 – 2010. The study was undertaken within the combined framework of neo-classical and endogenous growth theories. Agricultural Labor Productivity (ALP), measured as agricultural value-added per economically active person in agriculture, as well as Malmquist index of agricultural Total Factor Productivity (ATFP) generated by Data Envelopment Analysis, were subjected to neo-classical convergence tests, with influence of various factors on productivity growth assessed within the framework of panel data econometrics in which influences of country specific unobserved heterogeneity were controlled. The study evidences support the need for substantial capital deepening and increase public expenditure to enhance access to infrastructure, strengthen agricultural institutions and support domestic food production as key measures needed to significantly raise agricultural productivity in SSA. In addition, the study identified increased integration into African economies that are yet to be part of any regional economic integration group as well as with the Multilateral Free Trade area between Australia and New Zealand as those with significant and positive impacts on ALP and TFP in SSA respectively. The study thus recommend, support for the ongoing efforts by the African Union (AU) to harmonize policies of various regional economic groups in Africa into forming an African Economic Community with unified trade policies among member state is the right direction to move Africa forward. It also recommends the need for each country to adopt measures appropriate protect the domestic agriculture against unduly stiff competition from better supported and sometimes subsidized agricultural products from the more developed nations as short-medium term policy measures to enhance the ongoing recovery from past neglects.

1. Introduction

While the 2013 Human Development Report (UNDP, 2013) revealed that significant progress has been made in various dimensions of the Human Development Index (HDI) by all the developing countries between 1990 and date, with notable convergence in HDI values globally, the progress cum impacts within the sub-Saharan Africa (SSA) remains very limited. Most countries in the region, particularly those in the East, Middle and West Africa, remain within the Low Human Development (LHD) bracket with poverty, hunger and food insecurity remaining very high in the sub-regions. For example, while efforts geared towards achieving the Millennium Development Goals (MDGs) of halving incidences of extreme poverty and hunger between 1990 and 2015 have yielded the desired results in virtually all other regions of the World, the proportion of people living on less than US$1.25/day in SSA only fell marginally from 56% in 1990 to 48% in 2010 while the proportion of people that are undernourished fell marginally from 32% in 1990/92 to 27% in 2010/12 (UN, 2013).

At the centre of the high incidence of extreme poverty and hunger in SSA is a rather too low productivity within her agricultural sector, within which about 53% of the economically active people were employed in 2010 (FAOSTAT data, 2013). Output of an average farmer in Africa in 2010 (US$936.15 in constant 2004/06 prices) was barely about 1% of what obtains in Northern America and 14.8% of what obtains in Southern America (FAOSTAT data, 2013). The gap within SSA is also very wide, ranging from as low as US$241.83 in Middle Africa to US$1,912.89 in West Africa and US$6,005.04 in Southern Africa (FAOSTAT data, 2013). Unfortunately, some evidence in literature suggests that most crop output increases in SSA has been through increases in crop hectares rather than yield increases, while Fulginiti, *et al*. (2004) reported that several countries in SSA recorded negative agricultural productivity growth between 1962 and 1999.

More recent evidences however suggest that agricultural productivity in many part of Africa has been increasing since the mid-1980s, but this represents catching-up with the levels achieved in the early 1960s (Benin, *et al*. 2011). Very wide disparity in agricultural productivity and productivity growth was also shown to exist among the countries. For example, while a handful of countries – notably South Africa, Swaziland, Benin, Cameroon and Togo – were reported as having recorded overall increase in Total Factor Productivity (TFP) over time, with significant technical change, the recovery in most of the countries have been largely due to efficiency change while productivity level and rate of catching-up in some countries (notably – Gabon, Gambia, Lesotho and Senegal) remain very low (Benin, *et al*. 2011).

The big question has always been - what policy, actions and interventions are necessary to move the huge number of poor people in SSA out of poverty? Raising agricultural productivity has long been recognized as part of the agenda of the highest priorities for actions (UN-MDP, 2005). Recent experiences of many developing countries including China, Brazil, Ghana and South Africa as harmonized in UNDP (2013) also suggests the solution may be in having a more proactive developmental state, putting in place a much more determined social policy and innovation, and strengthening of regional integration and South–South cooperation in a bid to harness the wealth of knowledge, expertise, and development thinking in the South. UNDP (2013) drew attention to the need for a critical look at governance institutions, with emphasis on the need for greater transparency and accountability. It stressed the need to invest in people's capabilities, through health, education and other public services, and suggested a gradual and sequenced integration with the world economy as part of the general development strategies.

Extensive researches have been conducted on issues relating to agricultural productivity and productivity growth as well as the drivers and impacts on poverty and overall economic development in both the developed and developing countries. Common evidence has been that raising agricultural productivity is crucial in the struggle to significantly reduce poverty and enhance socio-economic development (Irz *et al*. 2001; Thirtle, 2003; Majid, 2004; UN-MDP, 2005; Hassine and Kandil, 2009; Alene and Coulibaly, 2009; Shittu *et al.* 2010). For example, Thirtle (2003) reported that the productivity growth arising from research-led technological change in agriculture have been generating sufficiently high rates of return in Africa and Asia that has been reducing the number of poor people by about 27 million per annum in these regions. The main effect of agricultural productivity growth in SSA was shown to be significant increases in per capita incomes, with income increases finally having significant poverty-reducing effects (Alene and Coulibaly, 2009). Irz *et al*. (2001) noted that "*it is unlikely that there are many other development interventions capable of reducing the numbers in poverty so effectively*" as increased agricultural productivity.

While most studies seeking to identify drivers of productivity growth in the developing countries were often focused on assessing the role of domestic policies and actions vis-à-vis the role of agricultural research and development as driver of technological progress (e.g. Thirtle, 2003; Self and Grabowski, 2007; Alene and Coulibaly, 2009; Evenson and Fuglie, 2010; and many others) and increased investment in human, social and infrastructural capital as well as institutions to enhance efficiency change (Fulginiti, *et al*., 2004; Evenson and Fuglie, 2010; Fuglie, 2010, etc), UNDP (2013) suggests that some focus on the external trade policy to strengthen regional integration and cooperation among developing countries could prove very helpful in harnessing the wealth of knowledge, expertise, and development thinking in the South towards enhancing productivity growth.

This view is supported by evidences in literature such as Robinson and Thierfelder (2002) who surveyed empirical literature on trade liberalization and regional integration using multi-country computable general equilibrium (CGE) models and found that regional trade agreements (RTA) improve welfare, that trade creation greatly exceeds trade diversion, and that they are consistent with further global liberalization support. They conjectured that an RTA expands market size and stability, allowing firms to pursue economies of fine specialization, generating additional ‘‘Smithian’’ efficiency gains. Yean (1997) also showed that productivity growth in the Malaysian manufacturing sector was influenced positively and significantly by trade liberalization and foreign investment, and that the impact was much better than those associated with increase in capital intensity.

While studies focused on trade – productivity linkages in agriculture are very few, Hassine and Kandil (2009) working with a panel data between 1990 and 2005 on nine Mediterranean countries, found that trade liberalization exert positive and significant influence on farming efficiency and agricultural productivity among countries in the region. Similarly, Rakotoarisoa (2011) found that trade regulation via the high levels of rice subsidies and protection in rich countries and taxation of rice farming in poor countries contribute towards widening the gap in rice productivity among 33 rice producing countries in the study. It is however, instructive to note that past experiences of many African countries with trade liberalization were reported to have failed to achieve the targeted goals (see: for example, Skarstein, 2005), hence suggesting trade impacts could vary widely, and might be influenced by many non-trade factors.

In this paper, the role of international trade and economic integration as well as governance and investment (private and public) in explaining the wide differences in agricultural productivity and productivity growth among countries in SSA in recent times (1990 - 2010) were examined. Evidences are provided on the trends as well as determinants of agricultural productivity and productivity growth among countries in the region. The analyses were undertaken with a view to providing answers to the following research questions. (1) To what extent has South-South cooperation and globalization impacted agricultural productivity growth among countries in the sub-regions? (2) Are there evidences of agricultural productivity convergence among countries in various sub-regional economic integrations and groups in SSA? (3) How has quality of governance affected agricultural productivity growth within the sub-regions? (4) What have been the influences of capital deepening in agriculture as well as past patterns of public investment on education, health, and other public services on agricultural productivity growth within the sub-regions, among others?

The rest of the paper is organized thus: this introduction is followed by a brief review of relevant literature and the theoretical framework for the study. The third section presents the study methodology including a description of the study data and their sources as well as the analytical procedure. The fourth section presents the results and their discussion, while the final section provides a summary of main findings and their implication for trade and agricultural development policy in SSA.

2. Conceptual Framework

2.1 Concepts of Productivity and Productivity Growth

Productivity is generally defined as the ability of production factors to produce the output. It measures the efficiency with which inputs are transformed into outputs in a given economy (Li and Prescott, 2009). It is usually estimated using one of two categories of measures: Partial Factor Productivity (PFP) or Total Factor Productivity (TFP).

PFP, also called single factor productivity, relates a measure of output (Y) to a measure of only one input e.g. land or labor (x_i). That is:

$$PFP_i = \frac{Y}{x_i} \qquad (1)$$

PFP measures such as crop yield and labor productivity only measure the contribution of a specific input (land and labor respectively) to production ignoring the contributions from other input factors (Ajao 2011). TFP on the other hand, which is sometimes referred to as multifactor productivity, is the average output of all factors employed in production. It relates a measure of output(Y) to a bundle of inputs (land, labor capital). It is defined as the ratio of an index of output(s) to an aggregate index of all factors employed in producing the output(s). It is the weighted average productivity of all inputs, where the weights (β_i) attached to the inputs, are usually their shares in the total cost of production. That is:

$$TFP = \frac{Y}{\sum \beta_i x_i} \tag{2}$$

Changes in productivity of an economy or sector from one time period to another, often called *productivity growth*, are most commonly ascribed to technical change and/or efficiency change. While *efficiency change* measures the rate at which a country moves towards or away from the best-practice production frontier, *technical change* signifies a shift in the production frontier through time.

Evidences from neoclassical and endogenous growth literature have shown that while growth in PFP may arise from capital deepening (i.e. increased investment in physical capital per worker), TFP growths are primarily driven by technological progress, innovation and increased investment in human capital (education, skill and knowledge that enhances ability of labor to use new technologies more productively) as well as investment in social infrastructure (Banerjee and Duflo, 2005). Good governance manifested by putting in place appropriate policies, institutions and relevant intervention that lift constraints to production, including the problems of market imperfection in the developing countries, also contribute to productivity growth (Fulginiti *et al.*, 2004; Barrientos, 2012).

2.2 Economic Integration and Productivity Growth

Economic integration as defined by Balassa (1987) is a set of political and economic measures designed to abolish discriminations that exist between economic units that belong to different national states. It entails combining separate economies into a larger economic region (Malchlup, 1977). Ricardo (2000) views economic integration as a path that is followed in order to achieve decreasing levels of discrimination among countries.

Amr (2013) identified the following forms of economic integration among countries across the globe, arrange in an increasing order of the depth of integration:

- ***Preferential Trade Agreements (PTAs)***: this is a trade agreement between two or more countries such that goods produced within the unions are subjected to lower trade barriers when compared to goods produced outside the unions.
- ***Free Trade Agreement (FTAs)***: with this trade agreement, no trade barrier is placed on goods produced within the union. That is, there are zero tariffs on goods produced within the union. However, trade barriers exist for trade with non-member countries.
- ***Customs Unions (CUNs)***: within this type of treaty, member countries remove all barriers to trade among themselves and further adopt a common set of tariffs to be applied to third party countries. The common set of tariffs can differ among goods but not among partners.
- ***Common Markets (CMs)***: the CMs are similar to that of the CUNs but in addition, the union allows for full mobility of labor and capital. It also defines a common policy regulating factor flow with third countries.

- ***Economic Unions***: in this case, the monetary and fiscal policies of members' states are completely unified and there is a common pattern of foreign relations in addition to having the features of the CUNs and CMs.

At least five Economic Integration Groups (EIGs) currently exist in SSA. These include:

CEMAC - ***Communauté Économique et Monétaire de l'Afrique Centrale*** (The Economic and Monetary Community of Central Africa), a customs and monetary union consisting of Angola, Burundi, Cameroon, Central African Republic, Chad, Republic of Congo, Equatorial Guinea and Gabon. It was officially formed in 2000 with history dating back to 1994.

UEMOA - ***Union économique et monétaire ouest-africaine*** (The West African Economic and Monetary Union), a customs and monetary union consisting of Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo. It was established by a treaty in 1994, with Guinea-Bissau joining in 1997.

EAC - ***East African Community***, a custom union (CUN) in African Great Lake region of East Africa consisting of Burundi, Kenya, Rwanda, Tanzania and Uganda. It was founded in 1967, collapsed in 1977 and officially revived in 2000, and is working towards forming a free trade area with SACU and COMESA since 2008.

SACU - ***Southern African Customs Union***, a custom union among five countries of Southern Africa: Botswana, Lesotho, Namibia, South Africa and Swaziland. It was established since 1910, but was officially re-launched in 1970.

COMESA - ***Common Market for Eastern and Southern Africa*** is a free trade area with nineteen member states stretching from Libya to Swaziland. It was formed in 1994, with nine of the member states forming a free trade area in 2000. These include seven countries in the study Djibouti, Kenya, Madagascar, Malawi, Mauritius, Zambia and Zimbabwe, with Rwanda and Burundi joining the FTA in 2004.

Evidences in literature (see for example: Nirodha, 2013; El-Agraa, 1997) suggest that economic integration and trade openness could translate to increased welfare through:

a) enhanced efficiency in production through increased specialization;
b) a change in the quantity of goods produced through better exploitation of economics of scale as a result of increase in market size;
c) an improved international bargaining position made possible by the larger size, leading to better terms of trade;
d) enforced changes in efficiency due to intensified competition between firms;
e) changes affecting both the amount and quality of the factors of production because of technological advances;
f) change in the degree of discrimination between domestic and foreign goods; and
g) a redistribution of income between the nationals of different countries and finally income redistribution within individual countries

The main link between trade and productivity is the fact that trade serves as a means of transfer of technology and knowledge embodied in the traded good, and these could exercise significant and positive impacts on productivity (Hassine *et al.,* 2010). It is however instructive to note that the use and impact of the transferred technology on the productivity of the country depends on the quality and knowledge of the workforce; hence the need for increased investment in human capital development as well as institutions.

2.3 *Productivity Growth Measurement*

Productivity growth is commonly measured using one of two popular approaches: econometric estimation of a production, cost, or some other function, and the construction of index numbers such as Malmquist, Fisher, Tornquist and Laspeyes. In this study, the Malmquist Index approach is adopted because of its many advantages, most especially in relations to data limitations.

The Malmquist Productivity Index (MPI) is a bilateral index that can be used to compare the production technology of two economies Daskovska *et al.* (2010). It is sometimes preferred to other indices because it does not require input prices or output prices for its construction which makes it suitable in situations where prices are inaccurate or non-existent. Also, it does not require the cost minimization or profit maximization assumption. The Malmquist quantity index is based on the concept of a distance function, which could be an input or output distance function. Output distance function describes the maximal proportional output expansion that is feasible without altering the input quantities (Coelli, Rao, and Battese 1998). Similarly, an input distance function indicates by how much input use can be reduced for a given output level and within the production possibilities (OECD 2001).

The output distance function - $D_0^t Q^t X^t$- indicates the output technical efficiency of an observed production process where a vector of input quantities in period t, X^t, produces output quantities, Q^t under a technology prevailing at time t. When the distance function $D_0^t Q^t X^t$, takes on the value of 1 it implies that the production unit is technically efficient since it operates on the production function (Daskovska et al. 2010).

Following Fare *et al*. (1994) and Coelli (1996), the Malmquist output oriented TFP index between period t and t+1 is defined as:

$$M_0 = \left[\frac{D^t{}_0(x^{t+1}, y^{t+1})}{D^t{}_0(x^t, y^t)} \times \frac{D^{t+1}{}_0(x^{t+1}, y^{t+1})}{D^{t+1}{}_0(x^t, y^t)} \right]^{1/2} \tag{3}$$

Where $D^t{}_0(x^s, y^s)$ is the distance of a production unit using input x to produce output y in period s to the production possibility frontier (PPF) in period t. The Malmquist output oriented TFP index in (3) is the geometric mean of two ratios: one being a ratio of the distances of the production unit in period t+1 to that of period t, where both distances were measured relative to the PPF in period t, and the other, a ratio of similar distances measured relative to the PPF in period t+1. A value greater than one would indicate a TFP growth between period t and t+1, while a value less than one indicates a declining TFP between the period with value of unity implying TFP stagnation.

The decomposition of Malmquist TFP index into the technical change and efficiency change components, following Fare *et al*. (1994), may be defined as follows:

$$M_0 = \frac{D^{t+1}{}_0(x^{t+1}, y^{t+1})}{D^t{}_0(x^t, y^t)} \times \left[\frac{D^t{}_0(x^{t+1}, y^{t+1})}{D^{t+1}{}_0(x^{t+1}, y^{t+1})} \times \frac{D^t{}_0(x^t, y^t)}{D^{t+1}{}_0(x^t, y^t)} \right]^{1/2} \tag{4}$$

The term outside the brackets in (4) gives the index of efficiency change (EC) between period t and t+1, while the expression inside brackets is the index of technical change (TC), which is measured as the geometric mean of the shift in the technological frontier between t and t+1 evaluated using frontier at t and at t+1, respectively (Nin-Pratt *et al*., 2010). The EC component investigate whether a unit is drawing closer or away from its efficiency frontier over time while the TC component examines the change in technology frontier over the two time periods. Values of either of these components greater than 1 suggest improvement, while values less than 1 suggest the opposite (Daskovska *et al*., 2010).

2.4 *Productivity Convergence Hypothesis and Tests*

Convergence according to Rezitis (2010) is focused on narrowing initial differences in productivity, either defined as labor productivity, income per capita or total factor productivity, over a time period. Productivity convergence occurs when the less developed economies experience faster TFP growth rates than their developed counterparts, therefore, reducing the technological gap between them, over time. The convergence hypothesis has its foundation in neo-classical growth theory. It is based on the assumption that capital is scarce and the production function strictly concave, implying diminishing returns to increased capital use. Hence, the marginal productivity, and therefore rate of returns to capital, is expectedly higher in poor countries (having production systems that are characterized by low capital-labor ratio) than the relatively more developed (rich) countries having higher capital-labor ratio. It is this higher return to capital that is expected to encourage higher rates of savings and reinvestment in poorer countries, which together should make real income (output) of poor countries to grow faster and catch-up with those of richer countries (Banerjee and Duflo, 2005).

Three types of convergence are commonly discussed and/or tested in literature: beta (β) convergence – absolute or conditional, sigma (σ) convergence, and stochastic or long-run convergence (Lusigi *et al*. 1998; Carlos *et al.* 2006; Poudel *et al.*, 2011). The first two are tested based on cross-section techniques while the third is tested based on time series techniques. The test of β-convergence examines whether poorer countries grow faster than richer ones. It is commonly examined by a regression of the productivity growth rate of each country in the cross section (or panel) against its initial level, sometimes with other country/regional specific determinants of long-run growth included as explanatory variable(s) in the regression.

The general form of β-convergence test regression, working with TFP for example, is:

$$T\hat{F}P_{it} = \alpha + \beta lnTFP_{it} + \gamma Z_{it} + \varepsilon_{it} \qquad (5)$$

Where TFP represents the total factor productivity level at the beginning of each period; the circumflexes (^) denotes the time derivatives or relative rate of change; Z are control variables that are commonly introduced into the model bearing in mind the fact that convergence tends to be relative with countries tending to move along different steady state paths (Margaritis *et al.*, 2007); α, β and γ are parameters to be estimated and ε_{it} is an error term with zero mean and finite variance.

If, without including the variables in Z in the regression, the coefficient, β, is negative and significantly different from zero, then there is said to be absolute β-convergence (Rezitis 2010), implying that all countries in the cross-section/panel have the same steady state and that TFP converges to the same level across all countries. If some control variables are included, they should be jointly insignificant for absolute convergence to hold (Barro and Sala-i-Martin, 1995; Lusigi *et al.*, 1998). Conditional β-convergence is established if $\beta<0$ significantly, and at least one of the variables in Z prove to be significant (Barro and Sala-i-Martin, 1995; Lusigi *et al.*, 1998). Implication of conditional convergence is that each country (or region) has, in principle, a unique steady state and is converging to its own steady state (McCunn and Hauffman, 2000).

Test of β-convergence has however been criticized on the ground that it requires a large cross-sectional sample size, and the fact that a negative relationship between productivity growth rates and initial productivity levels does not guarantee a reduction in the dispersion of productivity level over time (Lusigi *et al.*, 1998). In addition to this, Friedman (1992) and Quah (1993) have also challenged its use on various grounds including the classical regression fallacy argument. With reference to agriculture, where production is one of biological processes and geo-climatic conditions have a major impact on the production processes, McCunn and Huffman (2000) observed also that unconditional convergence seems unlikely.

Against the common criticism of β-convergence (absolute or conditional), the evidence is generally considered as a necessary and not sufficient condition for productivity convergence. A sufficient condition is that the cross-sectional dispersion in TFP growth declines over time, and is termed σ–convergence. It is commonly examined via test of significance of the coefficient, $\emptyset_2$, in the following regression (see: for example, Lichtenberg, 1994; Poudel *et al.,* 2011):

$$var(lnTFP_t) = \emptyset_1 + \emptyset_2 t + \varepsilon_t \qquad (6)$$

Where var stands for standard deviation; $\emptyset_1$ and $\emptyset_2$ are parameters to be estimated; and ε_t is an error term with zero mean and finite variance. A sufficient condition for σ-convergence is that $\emptyset_2$ is negative and statistically significant.

As noted by Barro and Sala-i-Martin (1995, p. 385), σ-convergence tends to be sensitive to shocks that have a common influence on subgroup regions. Moreover, a major shortcoming of all cross-sectional approaches to testing the convergence hypothesis is that they either ignore intra-distribution dynamics or confound short-run transitional dynamics and long-run steady-state behavior (Bernard and Durlauf, 1995; Bianchi, 1997). They may therefore not provide evidence of long run productivity convergence. It is for this reason that most recent work uses time series methods based on unit roots and cointegration analysis to carry out tests of convergence (Färe *et al.*, 2006), and this is referred to as stochastic or long-run convergence.

In the time series approach, convergence is assumed if country-specific shocks only have temporary effects on productivity (or income) in country A relative to country B (or a country group average). These relative productivity levels would hence follow a stationary process. Without it been stationary, relative productivity shocks would lead to permanent deviations. The first step in testing for stochastic or long run convergence, therefore, is to conduct appropriate unit root tests on each country's productivity series to determine their long-run properties. For those countries whose measured productivity measures are non-stationary, the second step involves testing for cointegration among the non-stationary series. If a linear combination of two or more non-stationary series is stationary, then these series are said to be co-integrated, indicating a long term relationship in the diffusion of technology between those countries.

As noted in Färe *et al.* (2006), given the productivity series of a group of k countries, there is a requirement that the $(k-1)$ pairs of productivity differentials are zero mean or level stationary, i.e., they are linked by $(k-1)$ cointegration vectors and are driven by one common trend. They stressed however, that in most practical situations with a large number of countries and relatively short horizons, it will be difficult to ascertain the required convergence results through the use of cointegration methods. An alternative proposed by Bernard and Jones (1996), and is commonly used in literature (see: Lusigi *et al.*, 1998 and Margaritis *et al.*, 2007, for example), is to take convergence to mean that differences in (log) productivity relative to a benchmark country (or the group average) are mean reverting (stationary) processes over long horizons. It is applicable where panel data is available. The test is commonly based on the following regression:

$$\ln D_{it} = (\delta_r - \delta_i) + (1-\lambda)\ln D_{it-1} + \varepsilon_{it} \qquad (7)$$

Where: $\ln D_{it} = \ln A_{rt} - \ln A_{it}$ for i = 2, ..., N; A_{rt} is the productivity measure in the reference country (r) in year t; A_{it} is the productivity measure in country i in year t, ε_{it} is a stochastic residual, while $(\delta_r - \delta_i)$ and $(1-\lambda)$ are parameters. The null hypothesis is $\lambda = 0$ {that is, $(1-\lambda) = 1$ } and $(\delta_r - \delta_i) \neq 0$ implying no convergence. If the test that $(1-\lambda) = 1$ (a test for that lnDit is stationary) implying $\lambda > 0$ significantly, then productivity in country i is "catching-up" to that of the benchmark country, otherwise there is no "catching-up" or evidence of productivity convergence.

In Margaritis *et al.* (2007), a panel unit root (Maddala–Wu, 1999) test was applied to differences in (log) productivity relative the group average. The test procedure uses separate unit root tests for each of the individual series in the panel, and then combines them into a Fisher type test. The main advantage of this approach over other commonly used convergence test procedures is that it avoids a spurious rejection of the no convergence null that is possible with cross-section tests (Margaritis *et al.* 2007).

3. Methodology

The central theme of this study has been to examine the roles of trade as well as economic integration, investment and quality of governance in explaining the wide differences in agricultural productivity among countries in SSA since the 1990s. The study was undertaken within the combined framework of neo-classical and endogenous growth theories as described in the following sub-sections.

3.1 Study Data, Variables and Measurements

The study was based on a panel data on agricultural resource use, output, trade and other relevant variables on economic integration, governance and public as well as private investment within the agricultural sector of 42 countries in SSA over the period, 1990 - 2010. These are countries on which relevant data could be extracted from various sources. Data on agricultural resource use and outputs (real value-added) as well as aggregate agricultural imports and exports, and various indicators of quality of governance (road density, access to improved water source, access to improved sanitation facilities, and index of political stability and absence of violence) were extracted from FAOSTAT: the online statistical database of the Food and Agricultural Organization of the United Nations (FAO). Multilateral trade data between each of the sub-Sahara African countries and the rest of the World were extracted from the United Nations – online Commodity Trade (UNcomtrade) database. In addition, public agricultural expenditures were extracted from Yu (2013) - Statistics on Public Expenditure for Economic Development (SPEED) database available on International Food Policy Research Institute (IFPRI) website; while adult literacy rates were extracted and/or extrapolated based on various issues of UNDP – Human Development Reports.

Two measures of agricultural productivity were employed in the study: agricultural labor productivity (ALP) and agricultural Total Factor Productivity (ATFP). ALP was measured as the output (real agricultural value added in constant 2005 US$) per economically active person in agriculture. ATFP index as well as ATFP growth rates were computed from an output oriented Malmquist index of ATFP Change (TFPCH), as earlier defined in equation (3), together with the component - index of Technical Change (TECHCH) and index of Efficiency Change (EFFCH) earlier defined in equation (4) in an application of Data Envelopment Analysis (DEA) to construct the SSA agricultural production frontier and distance functions following Fare *et al*. (1994). The indices were constructed using the appropriate routine in the popular DEA program of Coelli (1996) under assumption of Constant Return to Scale (CRS) technology with the output defined as the real agricultural value added (constant 2005 US Dollar). The inputs include agricultural area (hectares), labor – measured in proxy by the total number of the economically active people in agriculture (persons), net agricultural capital stock (constant 2005 US Dollar), and total fertilizer consumption (metric tons).

The TFPCH generated from an output oriented Malmquist – DEA for a given period (t+1) is essentially the ratio of TFP in that period relative to that of the previous period (t). That is:

$$TFPCH_{t+1} = \frac{TFP_{t+1}}{TFP_t} \qquad (7)$$

Therefore, the corresponding TFP growth rates (g) may be defined, and were therefore, derived from the TFPCH as follows:

$$g_{t+1} = \frac{TFP_{t+1} - TFP_t}{TFP_t} = \frac{TFP_{t+1}}{TFP_t} - \frac{TFP_t}{TFP_t} = TFPCH_{t+1} - 1 \quad (8)$$

Similarly, given that from (7), $TFP_{t+1} = TFP_t \times TFPCH_{t+1}$, the following are true for TFPs observed over the period t = 0, 1, 2, . . ., n, where t=0 is the base year:

$$TFP_1 = TFP_0 \times TFPCH_1$$

$$TFP_2 = TFP_1 \times TFPCH_2 = TFP_0 \times TFPCH_1 \times TFPCH_2 ,$$

$$TFP_3 = TFP_0 \times TFPCH_1 \times TFPCH_2 \times TFPCH_3$$

Hence:

$$TFP_{t=s} = TFP_0 \times \prod_{t=1}^{s} TFPCH_t \quad (9)$$

It follows, therefore, that the TFP index at a point in time relative to a chosen base period may be defined, and were therefore computed from the TFPCH, as:

$$TFPI_{t=s} = \frac{TFP_t}{TFP_0} = \prod_{t=1}^{s} TFPCH_t \quad (10)$$

Growth rates and productivity indices for Technical Change and Efficiency Change were also derived by substituting the relevant productivity indicator for TFP in (8) and (10).

3.2 Test of Productivity Convergence Hypothesis

The neo-classical productivity convergence hypothesis was tested among countries in SSA in general, as well as among those in various economic cooperation in the sub-region (CEMAC, UEMOA, EAC, COMESA and SACU) using the standard sigma (σ) convergence test in equation (6) as well as panel unit root test following Margaritis *et al.* (2007). In conducting the panel unit root test to verify long-term convergence, Phillips-Perron Fisher test procedure in E-Views Econometric Software was applied to the mean differences in (log) productivity of the countries relative to the group average as well to the mean differences in (log) productivity in the countries relative to a reference country defined as the country with the maximum productivity level in each of the years.

3.2 Determinants of Productivity Growth

Influence of various factors – trade, economic integration, investment and governance, among others – on agricultural productivity growth were assessed within the framework of the following panel data model, in which the possible influences of country specific unobserved heterogeneity were controlled:

$$y_{it} = x_{it}'\beta + c_i + \varepsilon_{it} \quad (11)$$

Where y_{it} is the log of the referenced agricultural productivity measure (LP, TFPI, EFFCHI and TECHCHI) achieved by country i in year t; x is the vector of hypothesized determinants of y; β is the vector of parameters to be estimated; ε is the stochastic residual term while c is the unobservable country specific effects, which may be due to factors such as differences in soil, climate, quality of infrastructure, etc. It is assumed that c is time invariant.

Role of international trade and economic integration on agricultural productivity growth were assessed via the influence of following variables in the model: (a) agricultural trade volume measured as total agricultural export as well as agricultural import, each expressed as a share of agricultural GDP; and (b) degree of each nation's overall economy's integration into various economic groups in the World, measured as the share of the referenced country's total merchandise trade (export plus import) with other countries in the group relative to its GDP. *A-priori*, we expect coefficient of agricultural export to be positive as farmers in exporting countries are expected to strive to match highest quality available in the highly competitive global market. However, coefficient of agricultural import may be positive or negative depending on the kind of import, and whether or not farmers in the importing countries are also striving to match the quality of imported goods to wade-off competition. The coefficients of the Economic Integration Group (EIG) dummy variables may also be positive or negative depending on how the average growth rates achieved by the group members compare with the average of countries that do not belong to any of these groups.

Roles of investment and investment structure on agricultural productivity growth were assessed by introducing the net capital stock per agricultural worker into (11), decomposed into four variables: land development, all livestock capital, mechanization (machineries and equipment) and plantations. *A-priori*, we expect coefficients of these four variables to be positive, give the neo-classical expectations of capital deepening as a driver of economic growth.

The role of governance in explaining differences in agricultural productivity growth was accessed by introducing some indicators of access/quality of social infrastructure and absence of violence/political instability in the countries into the model. Variables in this respect include: (a) government agricultural expenditure per economically active person in agriculture (2005 US$ per person); (b) Road density (km of road per 100 sq. km of land area); (c) Access to improved water source (% of population with access); (d) Access to improved sanitation facilities (% of population with access); and (e) index of political stability and absence of violence, which measures perceptions of the likelihood that the government will be destabilized or overthrown by unconstitutional or violent means, including politically-motivated violence and terrorism. According to FAO (2013) the index - values vary from approximately -2.5 (weak stability) to 2.5 (strong stability). In additions to these, the role of human capital on productivity differences and growth was also assessed by introducing a variable on adult literacy rate in each of the countries in the panel in each of the years. *A-priori*, we expect coefficients of all these variables to be positive, given that increased access to infrastructure, good governance and human capital are expected to enhance innovation and eliminate constraints limiting adoption of improved technology in addition to facilitating market access.

Parameters of equation (11) were estimated within the Generalized (GLS) random effect framework using Stata Econometric Software. This permits accommodation of dummy variables on membership of various EIGs in the model while controlling the country specific effects in exploring the panel data. Because of data limitation (availability) however, only 30 countries whose production and trade data could be extracted from various sources for the period 1995 – 2010 were accommodated in the analysis. Missing data within the periods were replaced either by linear interpolation or linear trend at points, as considered appropriate.

4. Results and Discussion

The central theme of this study has been to examine the roles of quality of international trade and economic integration as well as investment and governance in explaining the wide differences in agricultural productivity and productivity growth performance among countries in SSA since the 1990s. The study evidences are summarized in the following subsections.

4.1 Investment Pattern and Governance Statistics

As background information, Table 1 presents the average level of net capital stock in a typical year between 1990 and 2010 in each of the 42 countries in the study and the distribution among various components of net capital stock reported in FAOSTAT. The average farmer in the typical sub-Sahara African country had investment worth US$ 3, 300.71 in 2005 price on his farm in an average year between 1990 and 2010. About half (51.5% of the cumulative investment on capital was on livestock production assets with another 8.1% on livestock inventory. About a quarter (25.1%) the cumulative investment on capital was devoted to land development – viz. irrigation, dams, drainages, etc. – while mechanization (machinery and equipment) was devoted the least share (3.6%) of the investment.

The average net capital stock per farmer, as shown in Table 1, varied widely across the countries, ranging from as low as US436.25 in Burundi to as high as US$29,764.80 in South Africa. The net capital stock per farmer in 30 (71.4%) of the countries fell below the mean with as much as eighteen countries (42.9%) not achieving up to half of the mean net capital stock per farmer in the sub-region. A close look at the distribution of the net capital stock among the components, also show that the countries emphases also vary widely. While about 70% of the countries had at least half of their capital stock invested within the livestock sub-sector, investment was predominantly on plantation crops in Côte d'Ivoire and Equatorial Guinea with Gabon and Liberia also having at least 40% of their agricultural investment devoted to plantation crops. Mauritius was found to be the only country where land development took a lion share (61%) of the net capital stock. However, Madagascar and Nigeria also had at least 40% of their agricultural capital stock devoted to land development.

While noting that private investments, measured by the net capital stock, is a key driver of production activities and productivity level, public investment in education, social infrastructure and good governance creates the necessary enabling environment for effectiveness of both labor and capital. In this study, influences of both the quantitative and qualitative aspects of public investments were considered crucial for productivity growth. Key indicators of governance quality examined include road density, rates of access to safe water and sanitation facilities as well as adult literacy rate among the people. These were considered necessary as indicators of the quantum and quality of cumulative government investment in social infrastructure and human capital over the years. Index of political stability was also considered as an indicator of security of public and private investments, and therefore, quality of governance. Current public investment within the agricultural sector is assessed in terms of government expenditure per farmer. Table 2 presents the mean values of these indicators of quality of governance in the 42 countries on which data were available over the period, 1990 - 2010.

Evidence on Table 2 suggests that quality of governance in most sub-Sahara African countries were generally adjudged poor by the people, with only 13 (31%) of the sub-Sahara African countries adjudged to be politically stable. Most (69%) had negative index of political stability with overall average being -0.6. On the average, only 58.5% of the adults in an average sub-Sahara Africa country were literate; with only 31% of the people having access to good sanitation facilities and 61.2% having access to portable/safe water. The current level of government investment in agricultural institutions/infrastructure was also generally low: US$100.82/farmer/year, with a very wide variation across countries. The figures were as low as an average of US$0.01/farmer/year in Zimbabwe and US$0.64/farmer/year in Mali to as high as US$938/farmer/year in Mauritius, followed by US$506.39/farmer/year in Botswana and US$442.99/farmer/year in Namibia. The main implication of the foregoing is that low level of agricultural productivity in SSA might be linked to the very low level of investment in physical, human and infrastructural capital, among other factors.

Table 1: Average net capital stock and investment structure by country, 1990 – 2010

Country	Net Capital Stock (US$m)	Capital/ Farmer ($)	Land Dev.	Livestock Assets	Mech.	Plantation Crops	Livestock Inventory
Angola	6,258.38	1,412.01	32.4%	46.4%	4.4%	9.7%	7.2%
Benin	2,526.26	1,677.46	31.8%	48.1%	1.9%	10.8%	7.5%
Botswana	1,839.39	7,003.23	4.7%	76.2%	7.7%	0.1%	11.4%
Burkina Faso	7,886.89	1,598.64	11.9%	73.5%	2.5%	0.6%	11.5%
Burundi	1,350.17	436.25	19.9%	45.0%	7.2%	20.4%	7.4%
Cameroon	6,948.23	1,987.18	25.0%	48.2%	1.7%	17.9%	7.2%
Cape Verde	165.43	4,828.21	22.2%	64.1%	0.8%	1.9%	11.0%
Central African Rep.	2,193.90	1,891.77	17.9%	67.6%	1.7%	3.2%	9.6%
Chad	5,800.35	2,297.38	20.5%	67.5%	1.4%	0.6%	10.1%
Congo	568.98	1,146.01	35.6%	39.5%	5.6%	12.7%	6.7%
Côte d'Ivoire	7,223.95	2,607.09	18.1%	14.9%	2.6%	62.1%	2.3%
Democratic Republic	5,064.56	455.17	37.5%	31.3%	8.3%	17.8%	5.1%
Equatorial Guinea	394.10	2,831.25	25.0%	3.2%	1.4%	69.8%	0.6%
Ethiopia	37,570.21	1,508.07	6.6%	78.1%	2.2%	1.0%	12.1%
Gabon	438.62	2,164.15	25.9%	23.2%	6.9%	40.2%	3.9%
Gambia	302.41	670.28	21.3%	63.2%	5.1%	1.4%	9.1%
Ghana	5,806.09	1,214.12	17.7%	38.7%	3.5%	33.6%	6.4%
Guinea	3,995.28	1,130.18	13.9%	63.0%	2.9%	10.2%	10.0%
Guinea-Bissau	1,579.76	3,878.83	26.6%	39.4%	0.8%	26.8%	6.4%
Kenya	17,030.17	1,597.76	15.4%	66.9%	3.3%	3.9%	10.5%
Lesotho	1,047.13	3,250.14	13.0%	71.5%	3.6%	0.5%	11.4%
Liberia	554.20	802.59	26.3%	21.3%	4.8%	44.0%	3.6%
Madagascar	17,231.54	3,175.11	46.8%	41.4%	1.3%	4.1%	6.5%
Malawi	2,416.18	594.26	39.2%	41.8%	6.9%	5.2%	6.8%
Mali	9,739.35	4,302.44	30.7%	57.5%	1.9%	1.0%	9.0%
Mauritania	3,842.88	6,387.53	10.5%	76.2%	0.7%	0.3%	12.3%
Mauritius	260.16	4,390.89	61.0%	26.0%	6.7%	2.0%	4.4%
Mozambique	4,392.99	615.07	38.5%	41.3%	7.9%	5.5%	6.8%
Namibia	2,480.51	10,161.60	15.3%	70.6%	2.9%	0.3%	10.9%
Niger	10,748.75	3,360.37	33.0%	56.9%	0.9%	0.2%	8.9%
Nigeria	51,008.77	4,124.13	40.6%	38.5%	3.1%	11.6%	6.2%
Rwanda	1,561.55	472.95	12.1%	60.4%	6.4%	11.3%	9.8%
Senegal	9,698.64	3,132.12	11.9%	74.1%	1.1%	0.4%	12.5%
Sierra Leone	1,649.25	1,458.09	36.2%	41.9%	2.3%	12.9%	6.8%
Somalia	13,050.23	6,306.40	22.2%	66.3%	0.7%	0.4%	10.5%
South Africa	42,758.03	29,764.80	33.6%	46.6%	6.6%	8.0%	5.2%
Swaziland	840.64	5,875.39	35.8%	52.4%	1.6%	2.1%	8.1%
Tanzania	39,500.99	1,210.84	28.9%	50.7%	2.5%	10.2%	7.6%
Togo	1,509.64	1,324.04	39.8%	43.0%	2.6%	7.4%	7.2%
Uganda	7,396.08	850.10	14.1%	52.0%	4.7%	21.3%	7.8%
Zambia	5,462.54	2,031.00	28.2%	57.8%	3.8%	0.7%	9.4%
Zimbabwe	8,642.30	2,705.12	7.2%	75.2%	4.8%	0.6%	12.3%
Average	***8,350.84***	3,300.71	***25.1%***	***51.5%***	***3.6%***	***11.8%***	***8.1%***

Source: Authors computations based on FAOSTAT data, 2014

Table 2: Mean values of governance quality and infrastructure capital by country, 1990 - 2010

Country	Road Density	Water Access (%)	Sanitation Access (%)	Political Stability	Adult Literacy Rates (%)	Public Expend/ Farmer (US$)
Angola	4.8	46.5	43.1	-1.4	47.8	27.02
Benin	16.6	66.6	9.4	0.6	38.6	31.89
Botswana	3.8	94.8	52.5	0.9	81.2	506.39
Burkina Faso	28.1	60.9	12.1	-0.1	24.1	40.09
Burundi	48.7	72.0	45.8	-2.2	50.2	3.43
Cameroon	7.8	62.7	47.5	-0.6	72.9	22.22
Cape Verde	30.7	83.3	46.1	0.9	75.2	272.12
Central African Rep	3.7	62.9	22.7	-1.5	46.5	7.87
Chad	2.8	45.0	9.8	-1.5	38.3	
Congo	4.3	70.8	19.6	-1.3	75.2	16.45
Côte d'Ivoire	25.0	77.7	21.8	-1.7	46.9	35.60
Democratic Republic	6.6	44.3	23.0	-2.4	60.6	5.79
Equatorial Guinea	10.1	50.9	88.9	-0.2	83.8	129.82
Ethiopia	3.0	29.9	9.3	-1.3	37.2	9.29
Gabon	3.2	85.2	35.2	0.3	68.2	
Gambia	27.7	83.3	63.5	0.4	37.8	
Ghana	24.0	71.5	10.0	-0.1	68.7	4.92
Guinea	14.9	63.6	14.4	-1.3	37.0	
Guinea-Bissau	10.7	53.1	12.9	-0.8	40.3	2.32
Kenya	10.9	52.1	27.0	-1.1	81.9	16.83
Lesotho	18.7	79.3	25.0	0.0	84.0	123.79
Liberia	9.4	62.6	12.7	-1.9	59.1	6.13
Madagascar	7.9	38.3	10.7	0.1	64.7	12.70
Malawi	12.9	63.2	45.8	-0.1	61.7	19.40
Mali	1.4	46.5	18.4	0.3	36.7	0.64
Mauritania	0.8	40.9	21.1	0.2	44.7	
Mauritius	96.3	99.4	89.4	1.0	84.9	938.03
Mozambique	3.7	41.0	14.1	0.1	45.2	10.76
Namibia	7.1	80.8	28.3	0.4	82.5	442.99
Niger	1.1	42.6	7.2	-0.2	20.4	33.02
Nigeria	20.1	54.8	34.3	-1.5	61.1	39.35
Rwanda	51.8	65.9	47.3	-1.5	65.5	11.75
Senegal	7.3	66.5	43.6	-0.4	38.8	48.20
Sierra Leone	15.8	47.3	11.9	-1.0	33.3	4.47
Somalia	3.5	22.6	21.9	-2.6	37.7	
South Africa	29.0	86.8	68.9	-0.3	85.8	292.29
Swaziland	19.3	53.1	52.1	-0.1	80.1	249.65
Tanzania	9.1	54.3	9.0	-0.6	74.1	9.52
Togo	15.8	53.6	12.2	-0.5	55.6	14.13
Uganda	29.3	57.7	31.1	-1.4	66.7	4.78
Zambia	8.1	55.1	41.2	0.0	75.2	39.53
Zimbabwe	24.3	79.6	40.4	-1.2	88.2	0.01
Average	***16.2***	***61.2***	***31.0***	***-0.6***	***58.5***	100.82

Source: Authors computations based on FAOSTAT data, 2014

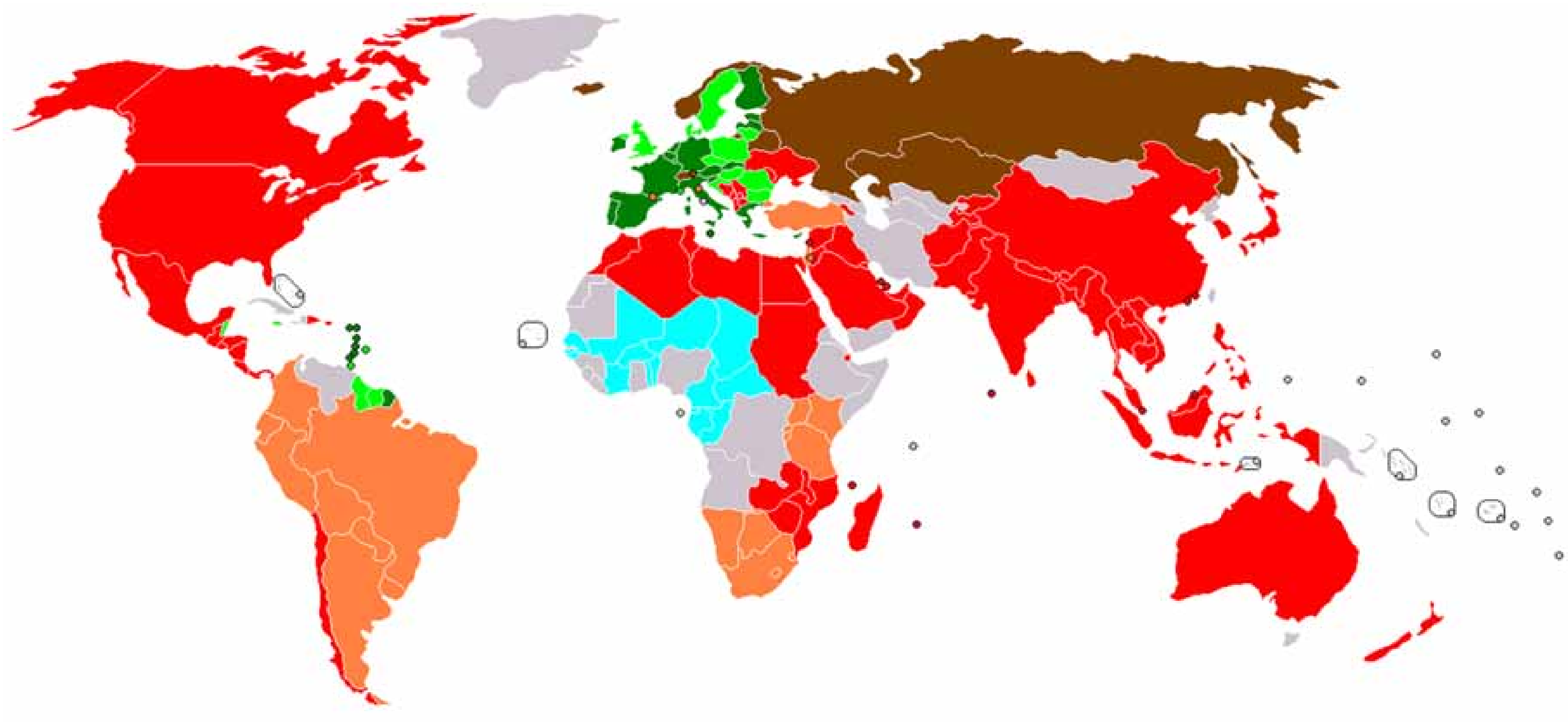
4.2 Pattern of Trade and Economic Integration

The central theme of this study has been to examine the role of international trade and level of economic integration in explaining differences in agricultural productivity growth among sub-Sahara Africa countries. As background information, Tables 3 summarizes the average volume of agricultural trade in an average year between 1995 and 2010 and the associated agricultural export share as well as import penetration for various countries in SSA classified by types of economic cooperation, while Table 4 summarize average annual volume of total merchandize trade and the trade shares of various categories of partners around the World. The partner countries were categorized into eight (8) based on the most advanced forms of economic integration they have adopted, following Alinor at en.wikipedia (2012) as summarized in Figure 1. These include:

1. ***Common Markets (CMKs):*** including some economies in the old USSR (Belarus, Kazakhstan and Russia) and some non-EU countries in Europe (Iceland, Liechtenstein, Norway, and Switzerland in European Free Trade Association (EFTA) as well as Iceland, Liechtenstein and Norway in European Economic Area – (ECA)).
2. ***Custom and Monetary Unions (CMUs):*** including economies in Central Africa's CEMAC and West Africa's UEMOA as earlier defined.
3. ***Custom Unions (CUNs):*** including economies in East Africa's EAC, Southern Africa's SACU, most economies in Southern America (except Chile, Venezuela, Guyana, Suriname & French Guiana) and non-EU members of European Union Custom Union (Andorra, Monaco, San Marino and Turkey).
4. ***Economic and/or Monetary Unions (EMUs):*** including all the economies in the European Union (EU).
5. ***Multilateral Free Trade Zones in the Developed North (MFT-DN):*** including the MFT areas of countries in North and Central America.
6. ***Multilateral Free Trade Zones in the Developed South (MFT-DS):*** including the MFT of Australia and New Zealand.
7. ***Multilateral Free Trade Zones in the Developing Countries (MFT-DC):*** including the Free Trade Areas established among developing countries in Asia, Africa, South America, etc.
8. ***Other (OTH):*** Other countries that are not members of the economic cooperation in 1 – 7.

As shown in Table 3, about 8% of net agricultural production in an average sub-Sahara African country ($5,727.54 million in 2005 prices) was exported in an average year between 1995 and 2010. In return, the average country also expended about 7% of her agricultural income on agricultural imports. The agricultural export share (that is, agricultural export per Dollar of net agricultural income) however, varied widely among the 30 countries. The figure ranged from as low as about 1% in Nigeria to as high as 73% in Mauritius. However, the export shares in most (70.3%) of the countries were below 10% of the net agricultural output, with about one-third (11) of the countries exporting less than 5% of their agricultural outputs. The pattern with respect to import penetration (fraction of agricultural income devoted to agricultural import) is also similar in some respect. The figure ranged from 2% in each of Central African Republic, Burundi, Uganda and Madagascar to as high as 76% in Botswana. But, while the average sub-Sahara African country is a net exporter of agricultural commodities, about half (48.4%) of the countries were net importer of agricultural commodities.

Focusing on total merchandise trade, results on Table 4 shows that, while the European Union (countries constituting the EMU) accounted for about 30% of the total merchandize trade (import and export) of an average sub-Sahara African country in an average year between 1995 and 2010, the developing countries in the south (i.e. countries in CMUs + CUNs + MFT-DC) accounted about 56% of the import and about 45% of the export.



NOTE: Each country is colored according to the most advanced agreement that it participates in.

Economic and monetary union	Economic union	Customs and Monetary Union
Common market	Customs union	Multilateral Free Trade Area

Figure 1: Stages of economic integration around the World

Source: Alinor at en.wikipedia (2012). Retrieved from "http://en.wikipedia.org/wiki/File:Economic_integration_stages_(World).png" on 04/04/2014

Table 3: Average Annual Agricultural Trade Volume by country/group, 1995 - 2010

Country by Economic Integration Groups	Net Production (Y)	Export (X)	Import (M)	Export Share (X/Y)	Import Penetration (M/Y)
	(Millions of constant 2005 Int.$)				
CEMAC					
• Cameroon	6,656.79	533.14	341.65	0.08	0.05
• Central Afr. Rep.	1,565.86	51.37	25.29	0.03	0.02
• Congo	614.18	26.97	188.34	0.04	0.31
• Gabon	455.91	30.86	222.93	0.07	0.49
• ***CEMAC Avg.***	2,323.19	160.59	194.55	0.07	0.08
COMESA					
• Madagascar	5,517.95	122.47	137.30	0.02	0.02
• Malawi	3,685.18	524.28	129.05	0.14	0.04
• Mauritius	501.50	366.49	355.51	0.73	0.71
• Mozambique	3,748.33	147.94	310.52	0.04	0.08
• Zimbabwe	3,234.98	871.85	691.47	0.27	0.21
• ***COMESA Avg.***	3,337.59	406.60	324.77	0.12	0.10
EAC					
• Burundi	1,962.28	51.98	30.64	0.03	0.02
• Kenya	10,919.85	1,249.04	594.51	0.11	0.05
• Rwanda	2,715.03	55.81	77.24	0.02	0.03
• Uganda	9,435.05	331.44	235.77	0.04	0.02
• ***EAC Avg.***	6,258.05	422.07	234.54	0.07	0.04
SACU					
• Botswana	450.39	130.06	341.70	0.29	0.76
• Lesotho	249.53	4.27	151.03	0.02	0.61
• Namibia	810.81	209.86	242.01	0.26	0.30
• South Africa	20,450.25	3,044.30	2,288.53	0.15	0.11
• Swaziland	520.17	238.41	190.58	0.46	0.37
• ***SACU Avg.***	4,496.23	725.38	642.77	0.16	0.14
UEMOA					
• Benin	3,011.28	333.10	265.09	0.11	0.09
• Burkina Faso	3,725.82	211.51	190.86	0.06	0.05
• Côte d'Ivoire	10,182.20	2,876.99	623.45	0.28	0.06
• Mali	4,652.42	241.57	166.85	0.05	0.04
• Niger	3,957.91	66.60	176.66	0.02	0.04
• Senegal	2,181.02	169.71	720.06	0.08	0.33
• Togo	1,348.32	121.13	106.56	0.09	0.08
• ***UEMOA Avg.***	4,151.28	574.37	321.36	0.14	0.08
OTHERS					
• Gambia	213.90	14.75	128.57	0.07	0.60
• Ghana	9,558.27	839.64	554.53	0.09	0.06
• Guinea	3,100.83	59.10	249.79	0.02	0.08
• Mauritania	815.53	65.09	281.21	0.08	0.34
• Nigeria	55,584.53	540.26	1,976.92	0.01	0.04
• ***Others Avg.***	13,854.61	303.77	638.20	0.02	0.05
SSA Avg.	5,727.54	452.61	399.82	0.08	0.07

Source: Authors computations based on FAOSTAT data, 2014

Table 4: Average Annual Total Merchandise Trade and shares of Trading Patterns, 1995 - 2010

Description	Avg. Trade Volume (2005 US$ million)	Share of Trade with Partners in various World Economic Zones							
		CMKs	CMUs	CUNs	EMUs	MFT-DC	MFT-DN	MFT-DS	OTH
Import by the Average Country in:									
• CEMAC	1,413.73	1.1%	14.6%	5.3%	44.5%	15.1%	6.2%	0.1%	13.0%
• COMESA	1,973.84	1.2%	2.5%	31.2%	21.0%	33.1%	3.9%	1.2%	4.8%
• EAC	2,038.70	1.6%	6.6%	26.4%	20.2%	38.3%	4.6%	0.4%	1.6%
• SACU	14,353.43	0.8%	1.4%	64.9%	12.3%	13.9%	3.3%	0.7%	1.3%
• UEMOA	1,751.77	1.7%	20.7%	5.2%	35.9%	21.0%	5.0%	0.2%	10.1%
• OTHERS	3,897.38	2.2%	13.2%	6.9%	37.1%	26.1%	8.4%	0.6%	5.1%
Average Annual Import	***3,543.19***	***1.5%***	***10.8%***	***19.9%***	***29.6%***	***25.4%***	***5.4%***	***0.6%***	***6.3%***
Export by the Average Country in:									
• CEMAC	2,309.27	2.0%	20.9%	10.0%	27.6%	12.6%	20.4%	0.1%	4.4%
• COMESA	1,489.34	5.5%	4.7%	15.1%	38.7%	19.7%	8.9%	0.3%	6.9%
• EAC	996.06	11.4%	6.5%	30.4%	20.4%	16.7%	2.4%	0.3%	12.0%
• SACU	12,522.70	2.8%	5.8%	25.5%	31.0%	13.6%	13.6%	1.3%	5.0%
• UEMOA	1,458.41	7.5%	25.4%	8.9%	19.0%	18.4%	3.1%	0.2%	16.4%
• OTHERS	5,577.35	4.8%	17.1%	7.3%	37.9%	12.3%	10.7%	0.1%	9.4%
Average Annual Export	***3,499.53***	***5.9%***	***14.4%***	***14.6%***	***29.4%***	***16.0%***	***8.9%***	***0.3%***	***9.8%***

Source: Authors computations based on UN-comtrade data, 2014

4.3 *Patterns of Agricultural Productivity Growth*

Figures 1, 2 and 3 present, respectively, the trends in average Agricultural Labor Productivity (LP), components of Total Factor Productivity (TFP) and drivers of Efficiency Change among the 42 sub-Sahara African countries included in the study between 1990 and 2010, while Table 5 presents average annual productivity levels/indices and growth rates achieved by each of the countries over the period. Evidence from Figure 1 suggests that the mean agricultural LP (±1.96 x standard error of mean) had increased steadily from US$736.30 ± 124.06 in constant 2005 US Dollar in 1992 to US$869.21 ± 167.61 in 2000 and US$1,104.42 ± 231.84 by 2010. Similarly, average agricultural TFP index (TFPI; 1990=100), also rose steadily from 88.2 in 1994 to 100.7 in 2000 and stood at 114.3 in 2010. Hence, agricultural LP (ALP) was found to have grown at an average of 0.9% per annum between 1990 and 2010, while agricultural TFP also grew at an average of 1.7% per annum over the period (Table 5).

Close examination of the SSA's agricultural productivity statistics (Figure 1 and Table 5) reveals, however, that the agricultural productivity growth in the sub-region is being accompanied by a widening disparity (productivity gap) among the countries. Note, for example, that the standard errors of the mean LPs rose from US$124.06 in 1990 to US$167.61 in 2000 and US$231.84 by 2010. Similarly, a sizeable number (33%) of the countries (Burundi, Cape Verde, Democratic Republic of Congo, Guinea, Guinea Bissau, Kenya, Lesotho, Madagascar, Mauritania, Namibia, Senegal, Somalia, Uganda and Zimbabwe) recorded a decline in either their ALP and/or ATFP between 1990 and 2010. Also worthy of note is the fact that the agricultural productivity growths recorded by most of the countries were driven mainly by efficiency change (EFFCH): see Figures 2 and 3; which, in turn, were derived mainly from improved scale efficiency change (SECH) as against technical change (TECH) or pure (technical) efficiency change (PECH). Similar evidences were reported by Benin *et al.* (2011), who also alluded to the fact that this might be due to the fact that agricultural investments as well as research & development (R&D) capacities in the sub-region have been eroded through years of neglect. The rising tendencies for African governments to withdraw or reduce subsidies on agricultural inputs may also be pushing many farmers away from adopting improved technologies, with negative implications on technical progress.

Focusing on the trends in various indicators of productivity growth on Figures 1 – 3, it is instructive to note that the movements of key were steadier between 2000 and 2010, with ALP, ATFP and EFFCH improving on the aggregate than what was observed in the previous decade. This period coincide with period of renewed efforts among various regional economic groups to strengthen economic cooperation and trade among member States. For example, EAC was revived in 2000 while the free trade area among member states in COMESA were established and strengthened within the last decade (2000 – 2010). Bearing in mind therefore, that most of the agricultural productivity growth in SSA since 1990 were driven by efficiency change that was due largely to economies of scale, it would appear that the role of trade and regional economic integration in raising agricultural productivity in SSA may be linked to the impacts in enhancing scale economies in agricultural production among countries in the sub-region.

4.4 *Convergence in Agricultural Productivity*

A key prediction of neoclassical growth theory is that poor (less developed) economies would experience faster productivity growth rates than their richer (more developed) counterparts, leading to a catching-up (convergence) in productivity in the long run (Banerjee and Duflo, 2005). This convergence is expectedly much more facilitated when barriers to trade, mobility of resources and technology transfer among a group of nations are eliminated or reduced through economic integration. Hence, this study examined if indeed, the various efforts to promote regional economic integration in SSA have led to any form agricultural productivity convergence in the sub-region, and tried to identify which countries are catching-up or lagging behind the productivity frontier(s).

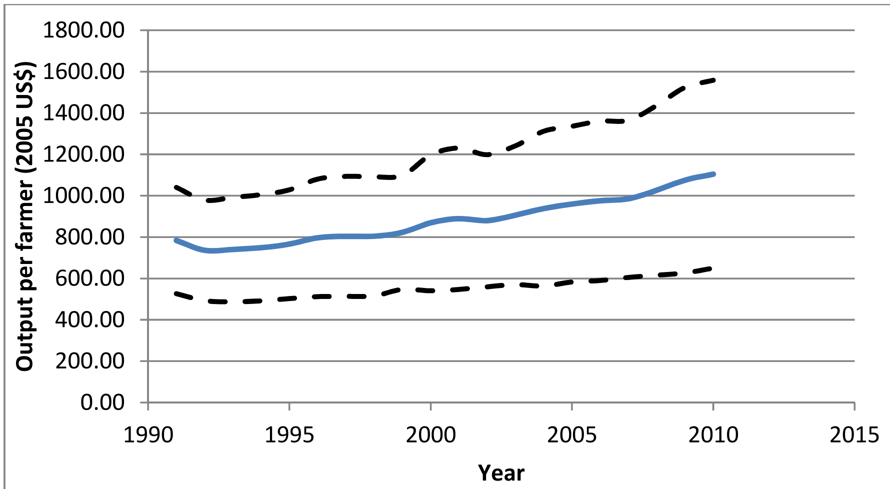


Fig. 1: Trend in Avg. Agric Labour Productivity in sub-Saharan Africa

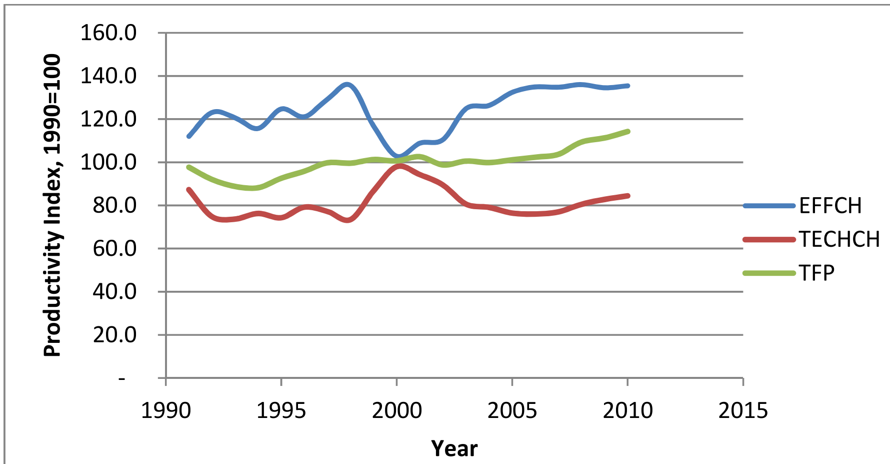


Fig. 2: Trends in sub-Saharan Africa's Agric. TFP and components

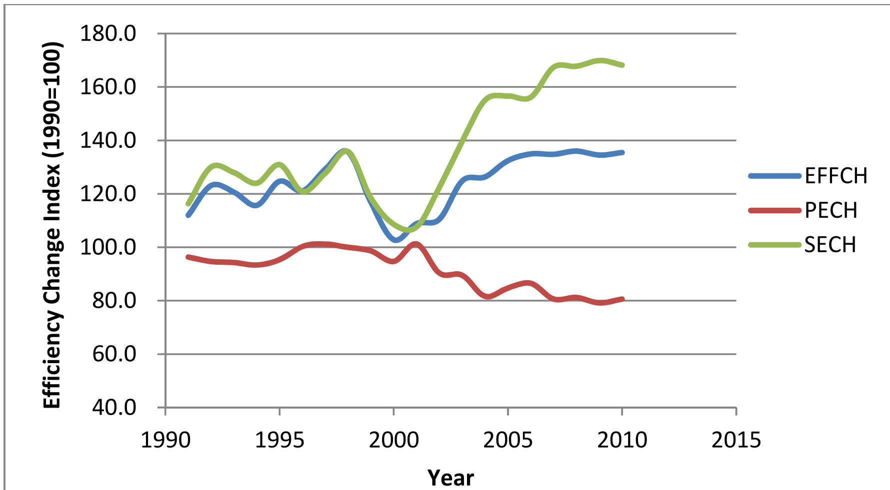


Fig. 3: Trends in components of Efficiency Change

Table 5: Spatial Pattern of Agricultural Productivity Growths, 1990-2010

Country	Productivity Level			Avg. Annual Growth Rates			
	ALP:1990	ALP:2010	ATFPI:2010*	ALP	ATFP	TECHCH	EFFCH
Angola	609.03	744.84	151.0	1.0%	4.8%	-0.8%	6.0%
Benin	612.31	967.51	209.5	2.3%	5.4%	0.3%	5.7%
Botswana	896.19	940.11	106.1	0.2%	0.9%	1.9%	-0.5%
Burkina Faso	178.02	470.27	242.4	4.9%	6.4%	0.2%	7.0%
Burundi	215.91	170.94	124.8	-1.2%	2.3%	0.1%	3.3%
Cameroon	686.35	1,052.46	163.5	2.1%	2.6%	0.2%	3.2%
Cape Verde	2,954.09	3,975.31	23.4	1.5%	-5.5%	-5.5%	0.0%
Central African Rep.	460.91	619.13	184.1	1.5%	4.0%	0.4%	4.4%
Chad	383.37	531.02	135.7	1.6%	1.8%	0.4%	2.5%
Congo	504.03	623.44	106.9	1.1%	0.8%	0.4%	0.9%
Côte d'Ivoire	1,258.34	1,568.40	99.9	1.1%	0.1%	0.4%	0.6%
Democratic Rep. of Congo	400.79	294.83	135.0	-1.5%	3.9%	1.3%	3.4%
Equatorial Guinea	826.43	893.61	149.2	0.4%	2.7%	2.7%	0.0%
Ethiopia	155.25	231.19	197.3	2.0%	4.4%	0.0%	5.9%
Gabon	1,059.10	2,063.60	139.7	3.3%	2.1%	0.0%	2.9%
Gambia	311.60	377.28	137.4	1.0%	2.3%	0.3%	2.0%
Ghana	832.86	1,082.11	122.9	1.3%	1.1%	0.3%	1.4%
Guinea	147.62	143.94	67.9	-0.1%	-1.3%	-0.7%	0.8%
Guinea-Bissau	550.11	595.66	50.1	0.4%	-2.3%	-5.0%	4.0%
Kenya	424.52	361.18	136.3	-0.8%	1.7%	0.2%	2.1%
Lesotho	441.47	424.09	103.8	-0.2%	1.2%	0.7%	2.0%
Liberia	609.70	620.22	130.1	0.1%	4.8%	1.2%	3.6%
Madagascar	239.21	197.47	143.4	-1.0%	2.4%	-1.3%	5.2%
Malawi	193.96	189.86	86.8	-0.1%	0.4%	1.3%	-0.2%
Mali	727.64	973.49	109.8	1.5%	0.9%	1.1%	1.3%
Mauritania	1,222.34	845.73	74.2	-1.8%	-1.2%	-1.8%	1.6%
Mauritius	4,104.31	7,497.04	149.2	3.0%	2.8%	2.8%	0.0%
Mozambique	166.46	266.33	155.2	2.3%	2.7%	0.1%	4.2%
Namibia	1,950.54	2,298.55	29.8	0.8%	-2.5%	-3.8%	0.9%
Niger	344.88	462.69	87.0	1.5%	2.7%	-4.9%	10.5%
Nigeria	1,054.68	4,026.63	255.7	6.7%	5.2%	0.4%	6.3%
Rwanda	250.94	282.66	127.4	0.6%	2.5%	-0.3%	4.2%
Senegal	401.99	394.68	111.1	-0.1%	1.1%	-0.6%	3.0%
Sierra Leone	835.34	867.18	97.5	0.2%	0.8%	-0.2%	1.9%
Somalia	944.12	555.10	75.7	-2.7%	-1.2%	-3.7%	4.2%
South Africa	3,160.67	5,414.50	171.7	2.7%	3.5%	3.8%	1.6%
Swaziland	1,173.49	1,319.49	115.3	0.6%	1.0%	2.3%	-0.7%
Tanzania	203.97	295.34	132.8	1.9%	1.7%	0.4%	2.2%
Togo	609.42	766.62	183.3	1.1%	3.6%	-0.1%	4.4%
Uganda	199.91	229.37	50.0	0.7%	-1.9%	-4.2%	5.0%
Zambia	476.61	558.44	135.1	0.8%	3.5%	0.7%	3.2%
Zimbabwe	264.98	193.17	86.8	-1.6%	0.9%	0.2%	1.0%
Average	***786.75***	***1,104.42***	***126.07***	***0.9%***	***1.7%***	***-0.2%***	***2.9%***

Note: *ATFPI are ATFPs in year t relative to ATFP in 1990 (i.e. figure in 1990=100)
Source: Authors computations based on FAOSTAT data, 2014

Tables 6 summarize results of standard cross-sectional σ-convergence tests conducted. It shows that there is no evidence to support existence of σ-convergence in either ALP or ATFP among countries in SSA as a whole. The evidence, however support σ-convergence in both ALP and ATFP among countries in the East Africa's Custom and Monetary Union (CEMAC) between 2000 and 2010, as well as σ-convergence in only ALP among countries in the West Africa's Custom and Monetary Union (UEMOA) both within 2000 and 2010 as well as over the two decades: 1990 – 2010. It is instructive to note that the only factor common to CEMAC and UEMOA that is not found among other EIGs in SSA is adoption of common currency among the member States. The results would therefore suggest that adoption of common currency in addition to establishment of free trade areas and common policy on external trade might be crucial in the proposed strengthening of regional integration and South–South cooperation to harness the wealth of knowledge, expertise, and development thinking in the South.

Further evidences on long-run productivity convergence are summarized on Tables 7 and 8 for ALP and ATFP respectively. Four (4) versions of the Panel Unit root (convergence) hypothesis were examined: convergence to SSA productivity frontier (with productivity gap defined relative the highest level achieved in SSA in each of the years); convergence to SSA average productivity in a similar fashion to what was adopted by Bernard and Jones (1996), Lusigi *et al.* (1998) and Margaritis *et al.* (2007), among others. The third and fourth versions allowed the frontier and average to vary across different EIGs, but common to members of each EIG. We posit that using the maximum productivity level in each year in computing the (log) productivity gaps accords at least two advantages: (1) it avoids ambiguity in interpretation of non-convergence where we have cases of some countries growing faster that the group average as a result of higher rates technical progress that define new frontiers as against cases of countries that lag behind existing frontier; (2) using the maximum seems more consistent with the notion of a productivity frontier. The second point is particularly strong where no clear/consistent leader exists among members of the group.

Irrespective of the version of the panel unit root (convergence) test that was adopted, results in Tables 7 and 8 reveal that the null hypothesis that the differences in (log) ALP as well as ATFP relative to the group average (or the productivity frontier) are stationary processes over long horizons are all rejected for SSA as a whole. Hence, the evidences do not support long-run productivity convergence among all countries in SSA. However, focusing on intermediate Phillips-Perron test results for individual countries in the panel, the hypotheses were not rejected for majority (69 – 90%) of the countries. In general, the numbers of countries that were not catching up to the productivity levels in a group (SSA or EIG) were fewer where the group mean values were used as the reference point than the cases where the group maximum values were use. We also have fewer cases of countries that were not catching-up to the productivity levels in a group where we allow the reference point for the EIGs to differ. These results are consistent with cases where the EIGs (and perhaps, some countries) have different steady states that may be conditioned by factors other than membership of an EIG.

Focusing on specific measure of productivity, results on Table 7 shows that only seven (7) countries – Côte d'Ivoire, Ethiopia, Mali, Niger, Somalia, Swaziland and Zambia - were neither catching-up to SSA ALP average nor to their respective EIGs ALP averages; with four (4) of these countries - Ethiopia, Niger, Somalia, and Zambia – also not catching-up in terms of ATFP. While the reason(s) for this is not immediately clear, it is instructive to note that economies of Ethiopia and Somalia are relatively isolated (at least, trade policy-wise) from those of their neighboring countries belonging to either COMESA or EAC to which neither Ethiopia nor Somalia belong. Niger, though a member of UEMOA, has also been a victim of incessant drought and desertification in the past decades, while the case of Zambia is most likely because her ALP and ATFP as well as rates of productivity growth is much higher than what obtains among COMESA members in SSA (see: Table 4).

Table 6: Regression results in tests of sigma-convergence

Group	Labor Productivity				Total Factor Productivity Index			
	ϕ_1	ϕ_2	R^2	F-value	ϕ_1	ϕ_2	R^2	F-value
1990 – 2010								
Sub-Saharan Africa	0.812	0.007	0.86	109.38	0.247	0.011	0.77	58.44
	(98.49)	(10.46)			(14.45)	(7.65)		
CEMAC	0.474	0.001	0.15	0.28	0.301	-0.003	0.05	0.92
	(21.45)	(0.53)			(7.30)	(-0.96)		
UEMOA	0.540	**-0.003***	0.41	12.67	0.144	0.020	0.69	39.2
	(60.10)	**(-3.56)**			(3.69)	(6.26)		
EAC	0.248	0.006	0.37	10.51	0.133	0.016	0.72	45.9
	(10.88)	(3.21)			(4.71)	(6.77)		
SACU	0.809	0.012	0.44	14.19	0.041	0.019	0.70	41.94
	(20.66)	(3.77)			(1.13)	(6.48)		
COMESA	1.191	0.010	0.57	23.92	0.103	0.006	0.24	5.73
	(47.77)	(4.89)			(3.70)	(2.39)		
2000 – 2010								
Sub-Saharan Africa	0.779	0.010	0.93	117.98	0.246	0.011	0.78	32.08
	(58.06)	(10.86)			(8.36)	(5.66)		
CEMAC	0.543	**-0.004***	0.59	12.70	0.403	**-0.011***	0.82	40.18
	(32.52)	**(-3.56)**			(15.61)	**(-6.34)**		
UEMOA	0.555	**-0.004***	0.43	6.64	0.416	0.004	0.06	0.59
	(24.88)	**(-2.58)**			(5.40)	(0.77)		
EAC	0.308	0.003	0.03	0.26	0.203	0.12	0.78	32.44
	(3.73)	(0.51)			(6.22)	(5.70)		
SACU	0.859	0.010	0.22	2.51	-0.136	0.031	0.60	13.51
	(9.07)	(1.58)			(-1.05)	(3.69)		
COMESA	1.059	0.019	0.78	31.77	-0.100	0.018	0.57	12.12
	(20.52)	(5.64)			(-1.24)	(3.48)		

Note: Figures in parentheses are t-value of associated regression coefficients
* imply σ-convergence is established at $p<0.01$

Table 7: Panel Unit Root test of Labor Productivity Convergence, 1995 - 2010

Method	DLNLP-SSAMax		DLNLP-SSAMean		DLNLP-EIGMax		DLNLP-EIGMean	
	Stat.	Prob.**	Stat.	Prob.**	Stat.	Prob.**	Stat.	Prob.**
PP - Fisher Chi-square	212.94	0.00	151.11	0.00	243.97	0.00	149.03	0.00
PP - Choi Z-stat	-5.97	0.00	-2.99	0.00	-5.49	0.00	-3.33	0.00
Country	Intermediate Phillips-Perron test results							
	Prob.	B.W.	Prob.	B.W.	Prob.	B.W.	Prob.	B.W.
Angola	0.03*	2	0.39	2	0.04*	2	0.16	2
Benin	0.03*	5	0.03*	4	0.34	0	0.47	1
Botswana	0.38	5	0.47	0	0.57	9	0.05	1
Burkina Faso	0.03*	8	0.91	16	0.94	18	0.98	18
Burundi	0.46	17	0.57	3	0.53	1	0.55	1
Cameroon	0.00*	16	0.98	15	0.00*	0	0.66	1
Cape Verde	0.04*	2	0.28	1	0.67	0	0.28	4
Central African Rep.	0.29	4	0.08	0	0.96	1	0.78	1
Chad	0.17	4	0.01*	1	0.39	2	0.59	0
Congo	0.04*	18	0.71	1	0.17	0	0.44	2
Côte d'Ivoire	0.31	8	0.04*	0	0.00*	0	0.01*	1
Dem. Rep. of Congo	0.62	12	0.59	11	0.62	18	0.71	11
Equatorial Guinea	0.35	1	0.28	2	0.62	2	0.76	2
Ethiopia	0.29	1	0.04*	2	0.24	0	0.02*	2
Gabon	0.00*	10	0.16	1	0.00*	9	0.01*	1
Gambia	0.16	1	0.09	1	0.15	1	0.09	1
Ghana	0.10	8	0.35	2	0.25	0	0.06	0
Guinea	0.73	4	0.66	0	0.49	1	0.73	1
Guinea-Bissau	0.74	6	0.90	2	0.77	0	0.77	2
Kenya	0.60	15	0.85	2	0.00*	18	0.07	1
Lesotho	0.58	0	0.29	2	0.59	1	0.41	0
Liberia	0.29	2	0.40	2	0.27	2	0.44	2
Madagascar	0.93	14	1.00	1	0.93	14	0.55	0
Malawi	0.49	1	0.36	1	0.49	1	0.27	0
Mali	0.04*	4	0.01*	2	0.05	2	0.05	1
Mauritania	0.95	18	0.90	1	0.86	2	0.91	1
Mauritius	0.00*	1	0.14	6	0.00*	1	0.50	2
Mozambique	0.00*	11	0.87	1	0.00*	11	0.98	8
Namibia	0.55	4	0.54	2	0.92	2	0.21	2
Niger	0.06	11	0.01*	3	0.05	2	0.04*	6
Nigeria	0.83	18	0.90	0	0.83	0	0.87	0
Rwanda	0.09	18	0.00*	13	0.05	1	0.06	1
Senegal	0.59	2	0.37	1	0.26	0	0.48	5
Sierra Leone	0.25	5	0.51	2	0.44	1	0.55	2
Somalia	0.16	11	0.00*	6	0.12	6	0.00*	10
South Africa	0.00*	7	0.47	8	0.00*	2	0.20	1
Swaziland	0.01*	4	0.01*	2	0.60*	12	0.00*	3
Tanzania	0.08	5	0.12	2	0.43	0	0.32	4
Togo	0.26	5	0.16	0	0.01*	1	0.37	0
Uganda	0.61	6	0.66	2	0.03*	1	0.20	3
Zambia	0.05	1	0.00*	2	0.05	1	0.00*	0
Zimbabwe	0.83	2	0.77	1	0.83	2	0.68	0

Note: **Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.
B.W. implies bandwidth
* imply long-run convergence is rejected at $p<0.05$

Table 8: Panel Unit Root test of Total Factor Productivity Convergence, 1995 - 2010

Method	DLNATFP-SSAMax		DLNATFP-SSAMean		DLNATFP-EIGMax		DLNATFP-EIGMean	
	Stat.	Prob.**	Stat.	Prob.**	Stat.	Prob.**	Stat.	Prob.**
PP - Fisher Chi-square	241.47	0.00	152.53	0.00	148.85	0.00	128.76	0.00
PP - Choi Z-stat	-9.05	0.00	-4.07	0.00	-4.21	0.00	-2.81	0.00
Country	Intermediate Phillips-Perron test results							
	Prob.	BW	Prob.	BW	Prob.	BW	Prob.	BW
Angola	0.05	2	0.57	1	0.18	2	0.29	2
Benin	0.12	0	0.58	1	0.12	2	0.57	1
Botswana	0.15	3	0.49	0	0.25	2	0.54	2
Burkina Faso	0.06	1	0.37	4	0.02*	1	0.37	3
Burundi	0.06	4	0.15	3	0.22	1	0.10	4
Cameroon	0.01*	2	1.00	18	0.33	2	0.61	1
Cape Verde	0.04*	10	0.11	4	0.18	1	0.18	5
Central African Rep.	0.21	3	0.00*	9	0.00*	4	0.08	0
Chad	0.10	1	0.02*	2	0.19	0	0.48	0
Congo	0.01*	3	0.08	1	0.20	1	0.24	2
Côte d'Ivoire	0.08	1	0.40	2	0.39	1	0.25	2
Dem. Rep. of Congo	0.10	3	0.06	2	0.19	1	0.06	1
Equatorial Guinea	0.06	0	0.23	0	0.00*	1	0.17	2
Ethiopia	0.32	4	0.00*	2	0.50	1	0.00*	1
Gabon	0.16	2	0.04*	1	0.14	1	0.44	0
Gambia	0.06	4	0.09	1	0.42	2	0.05	2
Ghana	0.07	2	0.18	0	0.50	1	0.10	1
Guinea	0.57	2	0.76	2	0.73	1	0.79	2
Guinea-Bissau	0.23	4	0.50	0	0.72	2	0.60	0
Kenya	0.01*	1	0.23	3	0.03*	2	0.41	3
Lesotho	0.33	0	0.13	2	0.52	0	0.02*	0
Liberia	0.25	2	0.52	2	0.32	2	0.54	2
Madagascar	0.01*	7	0.10	0	0.33	1	0.08	1
Malawi	0.24	0	0.60	0	0.72	1	0.85	4
Mali	0.08	4	0.21	1	0.32	1	0.06	1
Mauritania	0.53	4	0.80	2	0.80	1	0.77	2
Mauritius	0.02*	3	0.05	2	0.10	4	0.21	0
Mozambique	0.01*	0	0.88	2	0.79	2	0.95	2
Namibia	0.91	3	0.99	3	1.00	2	1.00	4
Niger	0.00*	3	0.03*	2	0.04*	3	0.03*	1
Nigeria	0.53	2	0.82	0	0.45	0	0.76	1
Rwanda	0.04*	1	0.07	2	0.20	0	0.11	1
Senegal	0.06	2	0.16	1	0.22	1	0.10	2
Sierra Leone	0.00*	10	0.23	2	0.00*	6	0.27	3
Somalia	0.01	8	0.03*	2	0.06	2	0.05	7
South Africa	0.00*	1	0.63	14	0.29	0	0.97	18
Swaziland	0.00*	3	0.03*	2	0.24	1	0.64	1
Tanzania	0.02*	1	0.44	2	0.25	2	0.43	2
Togo	0.10	0	0.07	2	0.34	2	0.07	1
Uganda	0.42	0	0.46	0	0.54	0	0.62	1
Zambia	0.00*	2	0.02*	1	0.01*	2	0.03*	0
Zimbabwe	0.48	0	0.69	1	0.73	1	0.83	2

Note: **Probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. All other tests assume asymptotic normality.
BW implies bandwidth
* imply long-run convergence is rejected at $p<0.05$

4.5 Determinants of Agricultural Productivity Growths

The central interest in this study has been to examine the roles of investment (public and private), governance quality and trade as well as economic integration in explaining recent trends in agricultural productivity and productivity in sub-Saharan Africa. The analysis was undertaken within the framework of panel data econometrics with a view to controlling possible influences of country specific unobserved heterogeneity in the search for robust estimates. The results are summarized on Table 9. The evidences were provided on the influence of various hypothesized determinants on Agricultural - Labor Productivity (LP) and Total Factor Productivity Index (TFPI) as well as the component Efficiency Change Index (EFFCHI) and Technical Change Index (TECHCHI). All the outcome variables in the model were expressed in log form as to allow the coefficients of explanatory variables to be interpreted as growth rates.

A number of specification tests were conducted before arriving at the final results on Table 9. First, the appropriateness of accommodating country specific effects in the model was examined by conducting the Breusch-Pagan Lagrange Multiplier (LM). The null hypothesis in the LM test is that variances of the country specific effects (c_i in equation 11) are jointly zero across countries, implying that a pooled OLS regression without country specific effects is the appropriate specification of the problem. As shown in the fourth to the last row in Table 9, this hypothesis was strongly rejected for all the productivity indicators, given that the calculated Ch-square values (d.f. = 21) were all greater than the critical values at $p<0.01$. The choice between random effects (RE) and fixed effects (FE) frameworks for analysis of the problem was also based on the well known Hausman Test. As shown in the third to the last row of Table 9, the hypothesis that RE framework is the appropriate specification of the problem, implying that the unobserved country specific effect is uncorrelated with other explanatory variables in the model, could not be rejected even at $p<0.10$ for LP, TFPI and TECHCHI random effect frame. The hypothesis was however rejected in favor of the FE framework for EFFCHI analysis, given that the calculated Chi-square value (d.f. =1) was greater than the critical value at $p<0.01$. In addition, a test for time-fixed effects - implying that coefficients of time dummies were jointly zero in the FE framework for analysis of EFFCHI was also rejected. The results showed that coefficients of time dummy variables for 1998 and 2005 – 2010, were all significantly greater than zero at $p<0.01$. Therefore, the models for LP, TFPI and TECHCHI were estimated within the RE framework, while that of EFFCHI was estimated within the FE framework allowing also for time fixed effect. The results showing coefficients for only the relevant variables/model of interest, for brevity, are summarized in Table 9. The evidences are discussed in the following sub-sections.

4.5.1 The Role of Structural Transformation of African Agricultural Economy

Two variables relating to the structure of agricultural sector in SSA were included as explanatory variables in various versions of the agricultural productivity model estimated. These include share of agriculture in national GDPs, and share of women in national agricultural workforces. It is instructive to note that FAOSTAT data suggest that share of agriculture in national GDPs in SSA had declined steadily from an average of 30.2% in 1995 to an average of 26.4% in 2010, while women's share of the agricultural workforce increased slightly from an average of 47.7% in 1990 to an average of 48.3% in 2010. Results on Table 9, however, revealed that coefficients of agriculture's share of the GDP were all positive and significant at $p<0.01$ in the LP, TFPI and EFFCHI equations, while that of women share of the workforce was weakly significant ($p<0.10$) and positive only in TFPI equation. This shows that various efforts geared towards industrialization and diversification of national economies in SSA away from agriculture over the past decades, have been exerting negative impacts on agricultural productivity in the sub-region; while the growing female labor participation have been exerting positive, but weak impact on ATFP.

Table 9: Determinants of Agricultural Productivity Growth, 1995 – 2010 (N=416)

Variables	Descriptive Stat.		ln(ALP)		ln(ATFPI)		ln(EFFCHI)		ln(TECHCHI)	
	Mean	Std. Dev	Coef.	t-value	Coef.	t-value	Coef.	t-value	Coef.	t-value
Agric. Share of GDP	0.248	0.145	2.022	(3.85)**	1.819	(3.73)**	2.306	(3.88)**	0.251	(0.64)
Female Share of Agric Workers	0.478	0.092	-0.553	(0.29)	1.329	(1.89)	0.173	(0.07)	1.349	(1.49)
NCS/Worker in Agric.	3602.064	5276.073	0.7E-4	(3.06)**	0.2E-4	(2.20)*	-0.2E-4	(1.22)	0.3E-4	(2.38)*
Livestock Share of NCS	0.543	0.165	0.367	(0.56)	-0.360	(1.00)	-1.590	(1.42)	-0.758	(1.35)
Plantation Crop Share of NCS	0.091	0.134	-0.110	(0.08)	-0.645	(1.36)	-2.178	(1.22)	-0.237	(0.37)
Public Agric. Expense/Worker	116.197	237.381	0.2E-3	(5.51)**	0.3E-3	(3.29)**	-0.2E-4	(0.32)	0.8E-4	(1.41)
Road Density	19.690	19.171	0.002	(0.58)	-0.001	(0.40)	0.002	(0.59)	-0.001	(0.58)
Water Access rate	68.304	16.880	0.014	(4.14)**	0.006	(1.31)	-0.006	(0.94)	0.4E-3	(0.14)
Sanitation Access rate	33.526	19.867	0.004	(0.66)	-0.001	(0.21)	-0.018	(1.92)	0.008	(1.58)
Index of Political Stability	-0.443	0.873	0.012	(0.38)	-0.015	(0.47)	0.027	(0.74)	-0.030	(1.13)
Adult Literacy Rate	61.612	19.487	0.2E-3	(0.05)	0.004	(1.15)	0.001	(0.09)	-0.002	(0.63)
Agric Export/GDP	0.3028	0.386	0.036	(0.65)	0.115	(1.68)	0.157	(2.89)**	0.006	(0.16)
Agric Import/GDP	0.426	0.473	-0.165	(5.37)**	-0.055	(0.67)	-0.192	(4.82)**	0.076	(1.16)
Openness to CMKs	0.014	0.036	-0.016	(0.03)	0.698	(0.81)	0.484	(0.39)	0.349	(0.62)
Openness to CMU	0.058	0.055	0.346	(1.11)	0.422	(0.78)	-0.321	(0.60)	-0.095	(0.20)
Openness to CUN	0.137	0.208	-0.155	(1.03)	-0.546	(1.63)	-0.776	(3.92)**	-0.088	(0.34)
Openness to EMU	0.142	0.102	0.211	(0.61)	-0.119	(0.26)	0.606	(1.71)	-1.040	(4.41)**
Openness to MFT-DC	0.115	0.100	-0.198	(1.10)	0.376	(1.37)	-0.484	(1.77)	0.319	(1.62)
Openness to MFT-DN	0.052	0.070	0.545	(0.72)	0.272	(0.49)	0.705	(2.37)*	-0.320	(2.08)*
Openness to MFT-DS	0.004	0.012	0.610	(1.04)	2.007	(2.12)*	0.363	(0.74)	1.391	(1.59)
Openness to Others	0.039	0.053	0.353	(2.08)*	0.278	(0.99)	0.118	(0.24)	0.081	(0.32)
Constant			4.496	(4.02)**	3.104	(6.35)**	6.106	(4.08)**	3.978	(8.26)**
LM Test for RE			959.61**		873.09**		221.21**		1204.68**	
Hausman Test (RE Vs FE)			22.13		9.64		45.59**		9.13	
Test of Time Fixed Effect, F							22.54**			
Test of goodness of fit – χ^2(F)			443.97**		152.57**		(6.24**)		117.64**	

* $p<0.05$; ** $p<0.01$

The negative link between structural transformation cum diversification of SSA economies away from agriculture and agricultural productivity is most likely because industrialization efforts in the sub-region over the past five decades were often pursued to the neglect of agriculture and the rural sector (de Janvry and Sadoulet, 2010; Bazemar, 2008; Epstein and Jezeph, 2001). The urban bias in national development efforts have been linked to massive migration of the youths and educated members of the agricultural workforce away from agriculture (Todaro, 1997; DFID, 2004; Shittu, 2011), thus leaving agricultural production in most countries in SSA in the hand of the relatively old and less educated people than the average in the population with far reaching implications on agricultural productivity growth.

4.5.2 The Role of Investment and Asset Structure

Roles of private and public investment in agriculture on productivity growth were examined via the influence of Net Capital Stock (NCS) in agriculture per worker and public agricultural expenditure per worker, while the roles of the type/structure of agricultural production Assets were examined via the influence of shares of livestock assets and plantation crops assets in the NCS. Results on Table 9 show that capital deepening as well as public agricultural support (expenditure) have positive and significant influence on both ALP ($p<0.01$) and ATFP ($p<0.05$) in SSA. There is however, no evidence to support increased emphasis on either plantation crops or livestock to enhance productivity. It is perhaps instructive to note that all estimated coefficients associated with share of plantation crops in the estimated productivity equations were negative suggesting that some investment bias towards commercial (plantation) crops, as commonly pursued by many countries in SSA in pursuit of foreign exchange, tend to weaken agricultural productivity in a typical country in the sub-region.

The very strong and positive influence of public agricultural expenditure on productivity is a clear pointer to the fact that some aspects of the Structural Adjustment Programs (SAP) that have been the main thrust of the development strategies of many countries in SSA since mid 1980s must have been wrongly advised. Notable among these is the advice by donor agencies that African governments should remove subsidies from agricultural inputs and reduce direct participation (spending) in agriculture. The fact that many SSA countries embraced this advice has been blamed as a reason why many agricultural inputs have become too expensive and unaffordable to the predominantly resource poor farmers in SSA (Gladwin, 1991), and is no doubt a factor in the rapid erosion of agricultural Research and Development (R&D) infrastructure and capacity in Africa over the pasts decades (Benin *et al.*, 2011).

Focusing on the magnitude of the estimated coefficients, results on Table 9 in respect of public and private agricultural investments is in agreement with suggestion by Benin *et al.*, (2011) that "*large incremental agriculture expenditure and investments are required to raise and maintain high level of agricultural productivity and growth in Africa*". Our estimates suggests that the net capital stock in agriculture needs to be increased by about US$14,000/worker to raise annual ALP growth by 1%, while an increase in annual public agricultural expenditure by about US$3,000/worker (25 times the present level) is required to raise agricultural ATFP by 1%, all other things being equal. Considering that the average annual ALP and ATFP growth rates achieved by an average country in SSA over the past two decades were barely 0.9% and 1.7% respectively (Table 5), this level of investment would translate to doubling average annual LP growth rate and raising ATFP growth rates by about 60.

4.5.3 Role of Trade and Economic Integration

Results on Table 9 in respect of the influence of international trade on agricultural productive conform largely to *a-priori* expectations based on theory and evidences (e.g. Nirodha, 2013; El-Agraa, 1997). As expected, coefficients associated with the share of agricultural GDP that were exported were all positive, though only strongly significant ($p<0.01$) in terms of the influence on Efficiency Change (EFFCH) and weakly significant ($p<0.10$) in reference to ATFP. Agricultural import penetration (import/GDP) was also found to have exercised strongly significant ($p<0.01$) and negative influence on ALP and EFFCH but have no significant influence on aggregate agricultural TFP and Technical Change (TECHCH). Hence, the results support the notion that agricultural export in SSA significantly enhances EFFCH, and in the process enhance agricultural TFP, in the exporting countries while agricultural import harms Agricultural LP and EFFCH in the importing countries.

The net welfare impact of agricultural trade on the domestic economy may be assessed by comparing the magnitudes of the two impacts (that is, coefficients of import and export) in each of the estimated model with a test of the null hypothesis that the sum of the two coefficients is zero. While the hypothesis could not be rejected with reference to ATFPI ($\chi^2 = 0.26$; p=0.61) and EFFCH (F=0.22; p = 0.64), it was rejected at $p<0.05$ with reference to LP ($\chi^2 = 4.60$; p=0.03). The evidences therefore, show that while pattern of international trade in agricultural commodities adopted by a typical country in SSA over the period 1995 – 2010 has had neutral net effect on agricultural TFP, it impacted negatively on ALP over the period, suggesting that some level of protection of the domestic agriculture against strong foreign competition is crucial in the struggle to significantly reduce poverty in SSA via increased agricultural Labor productivity.

Focusing on agricultural productivity growth outcomes associated with the overall integration of SSA countries' economies with various regions of the World, we find the evidence to mixed, but quite illuminating. With reference to ALP, it is only the coefficient associated with openness to others (that is, integration into developing countries that are currently not members of some regional economic cooperation or trade pact) that is significant at $p<0.05$, and the impact was found to be positive. Likewise, it is only the coefficient of openness to MFT-DS (i.e. Australia & New Zealand) that is significant at $p<0.05$, and found to exercise positive impact on agricultural TFP. However, most (11 out of 16) coefficients associated with variables measuring level of integration into various economic blocks were positive, except for openness to CUNs (including EAC and SACU) and EU's EMU in ATFP equation, and openness to CMKs (largely, Russia), the CUNs and MFT-DC (including COMESA) in LP equation. If we focus on the ATFP components, we found however, that EFFCH was negatively and significantly impacted by increased economic integration into the CUNs and the MFT-DC, but positively and significantly enhanced by increased integration into the EU's EMU and North & Central America's MFT (MFT-DN). Ironically, however increased integration into EMU and MFT-DN were found to be associated with negative impact on TECHCH.

One major conclusion that may be drawn from the study evidences on agricultural productivity impacts of trade and economic integration in SSA is that, while strengthening existing trade blocks have neutral (mostly positive but insignificant) impacts on agricultural productivity growth, eliminating/reducing trade barriers between existing trade blocks and the "stand alone" economies would significantly enhance ALP growth, and therefore impact positively on poverty reduction. The "stand alone" economies include Nigeria & other Anglophone West Africa, Ethiopia & Eritrea in East Africa, Democratic Republic of Congo & Angola in Central Africa, as well as Mauritania. Ironically, these are the relatively large economies against which most of the existing trade blocks (CEMAC, UEMOA, COMESA, EAC and SACU) were possibly formed to compete with. Hence, the on-going efforts by the African Union (AU) to harmonize policies of the regional economic cooperation into forming an African Economic Community and enhancing Africa's self sufficiency with a view to reducing vulnerability of Africa's economies to World-wide economic shocks, might go a long way in the struggle to raise agricultural productivity and thereby reduce poverty in Africa.

4.5.4 Role of Governance Quality

Virtually all coefficients associated with variables introduced into various versions of the productivity growth model were not significant even at $p<0.10$ except for the coefficient associated Water Access rate, which was significant at 1% level and positive in ALP equation. The coefficient is also positive in ATFP equation. It is likely that most of these variables are not good proxies for governance quality, on which unfortunately data are not readily available on countries in SSA. It is also surprising that coefficients of adult literacy rates are also not significant, even though they are positive in both ALP and ATFP equations. This might be because the statistic relates to the entire population and is not specific to the agricultural population that is the subject of this study.

The positive and strongly significant impact of increased rate of access to portable water is an indication that efforts aimed at achieving the Millennium Development Goal (MDG) in this respect would contribute significantly to raising agricultural productivity, and thereby reducing poverty, in SSA. Portable water access has important implication on health of both the agricultural population and their livestock as well as for agro-processing and other value-adding enterprises in the rural sector. Moreover, obtaining water often involve great expense of time and energy for those who have no water sources in or near their homes (Sorenson *et al.* 2011), and this in turn, may impact negatively on time available for agricultural production and other livelihood activities.

5. Summary and Conclusion

This study was undertaken to examine the veracity, and appropriateness for sub-Saharan Africa, of the suggestions in the 2013 Human Development Report that solution to the low productivity and widespread poverty in Africa could be found in strengthening of regional integration and South–South cooperation in a bid to harness the wealth of knowledge, expertise, and development thinking in the South, in addition to increased investment in people's capabilities, through health, education and other public services, among others. The study was considered necessary given that past experiences of many African countries with trade liberalization were reported to have failed to achieve the targeted goals (see: for example, Skarstein, 2005), which contrast with recent experiences of many developing countries including China, Brazil, Ghana and South Africa, in which trade liberalization seems to have worked. Noting therefore, that trade impacts could vary widely, and might be influenced by many non-trade factors, the study examined the role of international trade and economic integration as well as governance and public/private investment in explaining the wide differences in agricultural productivity and productivity growth among countries in SSA in recent times (1990 - 2010).

The study was based on a panel data on 42 countries in SSA covering the period 1990 – 2010 for most indicators, and 1995 – 2010 for some indicators/countries. The data were on agricultural resource (land, labor, capital stock & fertilizer) use and value-added, agricultural & total merchandize trade with other countries in the World, and various indicators of public agricultural investment and governance qualities. The data were analyzed within the combined framework of neo-classical and endogenous growth theories including tests of neo-classical productivity convergence hypothesis and examination of the role of capital deepening, human capital and public investment in institutions and infrastructure. In addition to measuring agricultural labor productivity as agricultural value-added per economically active person in agriculture, Data Envelopment Analysis technique was used to construct the SSA agricultural production frontier and distance functions, following Fare *et al*. (1994), and estimate Malmquist index of Agricultural TFP Change as well as the component - index of Technical Change and index of Efficiency Change. Influence of various factors – trade, economic integration, investment and governance, among others – on agricultural productivity growth were assessed within the framework of panel data econometrics in which influences of country specific unobserved heterogeneity were controlled.

The main evidences from the study may be summarized thus: First, very wide differences exist among countries in sub-Saharan Africa in the level and structure of agricultural capital stock and public investment, trade and quality of governance measured by access to infrastructure and political stability. On the average, however, the mean agricultural capital per farmer (US$3,300.7) and rate of access to infrastructure (adult literacy, 58.5%; access to safe water, 61.2%; and access to sanitation, 31%) as well as level of public agricultural expenditure to improve the infrastructure

(US$100.82/farmer/year) are rather too low. As a result, the net agricultural value-added per farmer (US$1,104.42 ± 231.84 in 2010) is also very low and varied widely.

Second, many countries in SSA achieved some growth in their Agricultural Labor Productivity (ALP) and Total Factor Productivity (ATFP) between 1990 and 2010, with ALP haven grown by an average of 0.9% per annum and ATFP by an average of 1.7% per annum over the period. These growth performances were however found as being accompanied by a widening disparity (gap) in agricultural productivity among the countries, and the performances were largely driven by efficiency change that was due largely to the countries enjoying economies of scale, rather than technical change.

Third, there is no evidence to support existence of σ-convergence in either ALP or ATFP among countries in SSA as a whole. However, σ-convergence exists in both ALP and ATFP among countries in the East Africa's Custom and Monetary Union (CEMAC) between 2000 and 2010, among countries in the West Africa's Custom and Monetary Union (UEMOA) over the two decades: 1990 – 2010. Similarly, evidences from panel unit root (long-run convergence) tests do not support existence of long-run productivity convergence among all countries in SSA. Rather, the results are consistent with cases where countries in various economic integration groups (EIGs) have different steady states that may be conditioned by factors other than membership of an EIG

Fourth, the growth in ALP and/or ATFP (as well as the differences across countries) were found to be significantly enhanced by capital deepening, increased public expenditure in building agricultural institutions/infrastructure, and increased integration of economies of countries in various trade blocks in SSA (CEMAC, UEMOA, EAC, COMESA and SACU) with those of Australia & New Zealand as well as the "stand alone" developing countries – including, Nigeria & other Anglophone West Africa, Ethiopia & Eritrea in East Africa, Democratic Republic of Congo & Angola in Central Africa, and Mauritania. SSA's economies integration into other trade blocks around the World were found to have exercised neutral (though, mostly positive but insignificant) impacts on agricultural productivity growth. However, while agricultural trade by an average country in SSA between 1995 and 2010 was found to have had neutral net effect on agricultural TFP, it impacted negatively on ALP. This suggests that some level of protection of the domestic agriculture against strong foreign competition is crucial in the struggle to significantly reduce poverty in SSA via increased agricultural Labor productivity

In view of these evidences, the study concluded that concerted efforts are required in all countries in SSA to significantly enhance agricultural capital deepening, raise level of public agricultural expenditure to enhance access to infrastructure and strengthen agricultural institutions, and promote good governance. In addition to these, the on-going efforts by the African Union (AU) to harmonize policies of various regional economic groups in Africa into forming an African Economic Community with unified trade policies among member states would be beneficial to the struggle to raise agricultural labor productivity and thereby reduce poverty in Africa. Also, strengthening of SSA countries' trade/cooperation with Australia and New Zealand should be more aggressively pursued given its positive and significant impact on agricultural TFP growth, unlike trade with other economic blocks that were found to have neutral impact on agricultural productivity. Measures to protect domestic agriculture in SSA against unduly stiff competition from better supported and sometimes subsidized agricultural products from the more developed nations is also considered necessary as short-medium term policy measures to enhance the ongoing recovery from past neglects.

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