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# Total Factor Productivity Dynamics in Sub-Saharan Africa: Malmquist Index Approach

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## Abstract

A panel dataset of 30 countries in Sub-Saharan Africa (SSA) is used to analyze the total factor productivity (TFP) growth pedigree over the period 1999-2011. We initially compute the output-oriented Malmquist productivity indexes and their decomposition using data envelopment analysis approach. The curiosity is to ascertain whether Malmquist indexes are catching-up or lagging behind. The results indicate that the marginal source of TFP growth is technical progress and that the regional disparities in TFP growth deteriorated over time. Fourteen countries representing 46.7% of the number under study have positive trend in both pure technical efficiency and scale efficiency each (53.3% lagging behind negatively). Also the efficiency change component (catch-up effect) result shown that only six countries representing 20% of the number under study have positive trend with 80% lagging behind negatively in the sub-region. The second-stage regression results using tobit model show that the eleven (12) identified GCI pillars globally advocated by the World Economic Forum Report 2011/2012 be the policy priorities for improving efficiency in particular and TFP in general for the SSA to optimally harvest the opportunities of the 21st century.

**Key words:** Total factor productivity; SSA; Malmquist productivity indexes and Tobit Model

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## INTRODUCTION

Since the full democratization of African continent and the Sub-Saharan Africa (SSA) in particular in 1999, the quest for total factor productivity (TFP) growth has assumed the top burning issue. This justify the fact that quantifying productivity and economic performance of Nations is essentially not an academic rhetoric, but of policy and practical concern. Assessing the level of productivity, production efficiency and technical progress are crucial elements in analyzing the country's growth trends, international competitiveness which is the ultimate determinant of welfare improvement. Essentially productivity is one of the key measures of revealed competitiveness of a country. It is one of the conventional indicators of national and regional per capital GDP. Competitiveness in this perspective means the set of institutions, policies, and factors that determine the level of productivity of a country. The level of productivity in turn determines the rate of return obtained on investment and sets the level of propriety that can be earned by an economy, which in turn are the fundamental drivers of growth rates (Adewumi, 2011).

A competitive economy is one that is likely to grow faster over time. Without economic growth there can be no long-term poverty reduction. A nation's standard of living, sustained expansion of the economy, increased demand for labour and higher real wages are determined by the productivity of its economy, which is measured by the value of its goods and services produced per unit of the nation's human, capital and natural resources. Productivity depends both on the value of a nation's products and services, measured by the price command in open markets and the efficiency in production process (Porter & Ketels, 2003).

The role of productivity in accelerating the pace of economic growth is well recognized in the literature on growth. In the neo-classical growth accounting framework, the growth of output is the sum total of the growth of capital accumulation, growth of labour and the growth of productivity or efficiency. Thus, for a given combination of factor inputs (capital and labour), the shifts in the production frontier are engendered by the improvements in productivity or efficiency.

Essentially, the pro-cyclical growth that cannot be explained through capital_accumulation or the accumulation of other traditional factors, such as land or labour is sometimes called the rate of growth of total factor productivity (TFP) or Solow Residual. TFP advancement has been a major source to economic growth in the rapidly growing economies and the catalyst in shaping technological progress, scale efficiency and pure technical efficiency largely. TFP constitutes the output per unit of combined inputs foregone during the course of production.

$TFP=\frac{U}{F}$ where TFP : Total factor productivity ; u : Observed output ; F : Input index

But, technical change refers to advances in knowledge in relation to art of production. The chief tool to measure technical change is the production frontier, which relates inputs with outputs subject to best practice technology. Changes in technology are due course of time bring about changes in productivity. An increase in productivity may come through changes in the quality of inputs or via through such changes like improvements in marketing, increased managerial efficiency etc. Shifts of production frontier are attributed to technical change. Thus, failure to accommodate new technology is reflected in the lack of frontier shift over time.

As the world becomes more populous and unequal, globalization will continue to enlarge and develop the emerging market. The multinationals are growing in size and with global reach. Significantly, an in-depth research into what led to obvious growing disparities of wealth among developed, developing and underdeveloped countries and within them, with its attendant socio-economic cost is not only necessary but timely. This work seeks to provide lens understanding for policy makers, how the sub Saharan African economies will be shaped in future.

The idea gap of most empirical country specifics and cross-country studies that focus on determinants of GDP or GDP growth rate is that, they fail to distinguish explicitly between inputs used in production and conditions that facilitates production. Essentially, physical capital, human capital and labour are production inputs, whereas the quality of institutions, macroeconomic stability, the market quality (trade openness inclusive), population growth rate, research and development (R&D), the depth of financial markets and saving rates are conditions that determine competitiveness, sustained productivity and economic development. From the macroeconomic environment perspective, inflation rate, and to a lesser extent the black market premium, are widely used as proxies for macroeconomic conditions (Briault, 1995; Temple, 2001).

Among others, it is important to look at this study in the context of the fact that Africa has already learnt the important lessons of the debt and financial crises of the 1970s, 80s and 90s. Africa economies learnt through bitter experience, the importance of sound macroeconomic management, and have come to appreciate that, robust institutions and the market needed to work in partnership, as natural endowment, economic liberalization of capital account and market was not a panacea for growth (Ramos, 2011). Essentially measurement of the extent of productivity and the determinants of efficiency has the capacity to indicate which aspect of the economic characteristics should be addressed to improve growth and competitiveness of the economy. Thus the results of this study are expected to give appropriate policy recommendations designed to increase the sub region productivity by identifying key characteristics anchored on the region's potentials. An attempt is noble therefore, to carry out a research of this magnitude on the performance of the sub-Saharan African economies to forestall impending crises, in order to propel and sustain growth levels in the future beyond the conventional wisdom so as to assume the dominant players in the world economy. The main purpose of this study among others is to measure TFP of SSA over the last one decade using the Malmquist index and to investigate the factors that might explain the shift in technology and relative efficiency. The data used in this study consist of panel data for 30 countries within SSA over the period 1999-2011. Data envelopment analysis (DEA) approach is used to decompose the TFP component and to assess or rule out the possibility of technical regress. Then, maximum likelihood estimation method of tobit model is further applied to identify the major determinants of TFP growth in the sub-region.

## 1. OVERVIEW OF SUB-SAHARA AFRICAN ECONOMIES

There are many determinants driving productivity and competitiveness. Understanding the factors behind the process of productivity growth has occupied the minds of economist for hundreds of years, ranging from Adam Smith's focus on specialization and division of labour to neoclassical economists' emphasis on investment in physical capital and infrastructure. More so interest has been shifted to other mechanism such as education and training, technology progress, macroeconomic stability, good governance, firm sophistication, and market efficiency, among others. While all of these ideas are likely to be important, they are not mutually exclusive as two or more of them can be true at the same time and that is what has been in the literature (WEF, 2011).

In order to identify the priority areas requiring urgent and sustained policy attention to improve TFP growth, efficiency and competitiveness in Sub-Saharan Africa, we provide a birds eye view of the competitive landscape in Sub-Saharan Africa and an overview of where the sub-region stands vis-à-vis international benchmarks. We base this analysis on the World Economic Forum's Global Competitiveness Report 2011-2012. The competitiveness of a country from the standing point of the Global Competitiveness Index (GCI), is a compendium of the set of institutions, policies, and factors that determine the level of productivity of a country. To this end, the GCI comprehensively captures all the elements and variables that matters for competitiveness and best practice efficiency in productivity of Nations. These variables are systematically and technically decomposed and classified into 12 distinct pillars which are adopted as the crux fulcrum for this analysis. These distinct pillars are: institutions (public and private), infrastructure, the macroeconomic environment, health and primary education, higher education and training, goods market efficiency, labour market efficiency, financial market development, technological readiness, market size, business sophistication, and innovation.

The solid underpinning characteristic of the GCI that is crucial to this analysis is that, it explicitly takes into account the fact that countries around the world are at different stages of economic development. Accordingly, the GCI distinguishes three stages of development. In its first stage, economies are factor-driven and countries compete based on their factor endowments—primarily unskilled labour and natural resources. As wages rise with advancing development, countries move into the efficiency-driven stage of development (the second stage), when they must begin to develop more efficient production processes and increase product quality in order to continue to be competitive. Finally, as countries move into the innovation-driven stage, they are able to sustain higher wages and the associated standard of living only if their businesses are able to compete with new and unique products. At this third stage, companies must compete by producing new and different goods and services using the most sophisticated production processes. Hence we assess the overall competitiveness of Sub-Saharan Africa economies as well as the performance of individual countries compared with international standards. To put the analysis into a global context, we also include a number of comparator economies and regions.

Sub-Saharan Africa's competitiveness, which is an indicator of productive efficiency that could propel TFP in an international context, has not been on a smooth trend. Taking a global comparative analysis, both North Africa and sub-Saharan Africa are outperformed by Southeast Asia and by all of the BRIC economies. North Africa is ahead of Latin America, and also scores significantly higher than sub-Saharan Africa. Analytically only two countries from the Sub-Saharan African sub region features in the top half of the overall global rankings: South Africa (54th), and Mauritius (55th) (appendix 1). South Africa and Mauritius are behind China and as well behind Southeast Asia and India, but ahead of Brazil, Russia, and the other regional averages. The remaining sub-Saharan African countries that do better than the regional average are Rwanda, Gambia, Benin, Senegal, Kenya, Cameroon, Tanzania, Ghana, and Zambia (WEF, 2011).

North Africa outperforms sub-Saharan Africa in 10 of the 12 pillars, namely institutions, infrastructure, macroeconomic stability, health and primary education (by a large margin), higher education and training, goods market efficiency, technological readiness, market size, business sophistication, and innovation. Sub-Saharan Africa outperforms North Africa on average in only two pillars: labour market efficiency and financial market sophistication. Nevertheless, vast differences in the sophistication of financial sectors exist even within sub-Saharan Africa, with financial sectors in low-income countries with the region being among the world least developed. In contrast, financial sectors in several sub-Saharan African middle-income countries/emerging markets (e.g., Mauritius and South Africa) and a few frontier markets (e.g., Kenya) show much greater sophistication than the rest of the continent. Sub-Saharan Africa's middle-income countries also fare well relative to those in other regions of the world.

In comparison with other regions and countries highlights Sub-Saharan Africa's exhibits relative strengths and weaknesses. Sub-Saharan Africa's institutions are better assessed than those of the Latin America and Caribbean region, Russia, and Brazil. Further, sub-Saharan Africa's labour markets are on average more efficient than those of Latin America and the Caribbean on average, as well as those of both India and Brazil (WEF, 2011). More generally, this analysis demonstrates the significant diversity among individual country performances within the sub region in the various pillars. Appendix (1) shows the rankings of Sub-Saharan African countries in the 12 pillars of the Index, highlighting the three best performers in each case. As the table shows, Mauritius and South Africa are both among the top three in 6 pillars. Namibia, Morocco, and Rwanda are among the top three in 2 pillars. Botswana, Rwanda, and Tunisia have notably strong institutional environments, ranked 32nd, 19th, and 23rd, respectively, on a par with such countries as Japan and France. Nine other countries from Sub-Saharan Africa are in the top half of the institutional rankings: Gambia, Namibia, Mauritius, South Africa, Malawi, Cape Verde, Ethiopia, Zambia, and Ghana. Having built up strong institutional environments by international standards, these countries provide examples to follow for other countries in Sub-Saharan Africa. The large number of Sub-Saharan African countries at the bottom of the rankings in this area demonstrates the extent to which positive examples are critical for the region.

Mauritius and Namibia are the top-ranked Sub-Saharan African countries for infrastructure, placing at 58th and 54th, respectively. These countries have built good transportation infrastructures by regional standards, particularly their roads and ports. They are joined in the top half of the rankings by South Africa (63rd) and Gambia (69th). Yet even the ranks of these best regional performers remain middling, and the sheer underdevelopment of infrastructure in most of the continent is reflected by the much lower ranks of most Sub-Saharan African countries in this pillar.

Looking at the macroeconomic environment pillar, six (6) Sub-Saharan countries are in the top half of the rankings (Namibia, South Africa, Cameroon, Algeria, Mauritius and Mali). However, it's obvious that most Sub-Saharan African countries receive a poor assessment, which is often related to the management of the government finances. Although this is clearly a problem that is not specific to Sub-Saharan Africa, even better fiscal and monetary management are needed in most countries, the improvements achieved in the run-up to the global financial crisis notwithstanding.

Health and primary education remains among the greatest concerns for Sub-Saharan Africa, given that Mauritius is ranked in the top half of countries in this pillar. In fact, all but five countries are in the bottom third of the rankings, with many rounding out the very bottom group (indeed, all but one of the bottom-10 ranked countries hail from Africa). Poor health indicators related in large part to high rates of communicable diseases, low primary education enrolment, and poor assessments of most national primary educational systems explain this poor result. This is arguably the area requiring the most urgent attention for improving Sub-Saharan Africa's competitiveness in the aggregate.

In terms of higher education and training, although the spread between the most and least successful countries in this area is smaller than it is for some of the other pillars, the overall performances are relatively weak. The top two ranked countries are Mauritius and South Africa. However, of these two, none attains the top half of all countries, illustrating the quite low rankings for countries from the region overall in this pillar. It is perhaps not surprising that secondary education and university enrolment rates and the assessment of the quality of higher education remain weak in the region, given that the primary educational base on which to build has not yet been put in place in most countries. This will be a critical area for attention as countries move up the value chain toward more complex production.

The situation is somewhat more positive when turning to the functioning of markets in Africa. The top two countries in the goods market efficiency pillar—Mauritius and South Africa—have goods markets that are similar to those of countries such as Chile and Korea in their efficiency, although all remain below the average of OECD countries (WEF, 2011). South Africa, in particular, is characterized by strong competition in the market, a taxation system that is not distortive to business decisions, and an agricultural sector that is not very costly to the economy (unlike in many industrialized countries). Yet it is clear that most countries in Sub-Saharan Africa remain hobbled by regulations and other obstacles that diminish the efficiency with which goods and services are traded in their economies. Only four other countries are in the top half of the rankings in this pillar: Namibia, Botswana, Zambia, and Gambia. Eighteen Sub-Saharan African countries are in the bottom third of the rankings. Much can be done in the region to inject more competition into markets and make starting a business in the region less difficult.

Labour markets constitute another area where a few countries stand out for their comparatively good performance while most lag behind, and where we see some strong differences between North African and sub-Saharan African countries. Rwanda, Gambia, and Uganda receive the highest assessments, ranked 9th, 16th, and 27th, respectively, in this pillar. They are joined at the top half of the rankings by six other Sub-Saharan African countries: Kenya, Malawi, Namibia, Mauritius, Botswana, and Madagascar. These countries, to varying degrees, can count on flexible hiring and firing practices and relatively low non-wage labour costs. However, despite these relatively good performers, the table also shows that the labour markets in most Sub-Saharan African countries are among the least flexible and least efficient in the world, as also evidenced by high levels of unemployment in middle-income countries such as South Africa, Tunisia, and Botswana, as well as very high "working poverty" levels in many of the poorest countries in the region. Such labour market inefficiencies have been among the key factors setting off the political unrest and criminality in some Sub-Saharan Africa in recent time. Much must be done on the continent to free Sub-Saharan Africa's labour markets and unleash the potential of the region's workforce.

Financial markets provide a somewhat more positive picture, although significant disparities in terms of financial development remain. South Africa, ranked 1st in the region and an impressive 9th overall, has highly developed financial markets on a par with Switzerland and Canada, with relatively easy access to capital from various sources, sound banks, and a well-regulated securities market. Although their financial markets are less developed than that of South Africa, Namibia, Kenya, and Mauritius also are ranked in the top third in this pillar, well ahead of most other countries in the region. Five other countries have financial markets that are placed in the top half of the rankings: Botswana, Zambia, Ghana, Malawi, and Rwanda. Yet, particularly given the turbulence seen in recent years in global financial markets, efforts to further develop and deepen Sub-Saharan Africa's financial markets, including additional strengthening of regulatory and supervisory frameworks are necessary to ensure that financial resources in these countries are both available and allocated to their best use. It is notable that eight of the bottom-ten ranked countries in this pillar are from Africa, including countries from both North Africa and sub-Saharan Africa (See GCI, 2011).

Technological readiness is an area where Sub-Saharan African countries performed quite poorly as a group and where they are well behind the OECD average. As shown in appendix (1) the highest-ranked country in this area is Tunisia (outside sub-Saharan Africa), at a relatively low 55th, and it is joined in the top half of the rankings only by Mauritius (61st). In fact, 28 of the 35 African countries are in the bottom third, and occupy eight of the bottom ten places overall (WEF, 2011). This is a reflection of the very low penetration rates of most ICT tools on the continent, related in part to the low prioritization given by many governments to encouraging information communication technologies (ICT) and other new technology adoption, as well as to low educational attainment. Other bottlenecks, such as the vast gap in energy supply and hence its relatively high cost, impede more widespread use of the Internet. Nevertheless, there are areas where Sub-Saharan Africa can be proud of its achievements—such as the innovative applications of m-banking (Kenya); m-agriculture (Niger and Senegal); and, in general, the rapid adoption of the mobile technology. In fact, several Sub-Saharan African frontier markets (e.g., Ghana, Kenya and Senegal) are ahead of major emerging market economies such as India in the usage of mobile phones, demonstrating that in an enabling environment Sub-Saharan Africa can rapidly adopt modern technology. Moreover, in recent years Africa has been the fastest-growing market for mobile phones in the world. Despite the recent significant uptake of some technologies, however, ICT overall is an area where, in many cases, countries in other regions are simply moving faster. Given the significant potential of new technologies for information exchange and productivity enhancement, this is another clear area requiring urgent and sustained attention.

The size of markets also varies greatly among Sub-Saharan African countries. Appendix (1) highlights the three largest markets: those of South Africa and Nigeria. These two countries benefit from economies of scale afforded by significant domestic and foreign (trade) markets. While many Sub-Saharan African countries clearly cannot simply enlarge their domestic market size, they could do more to open their markets to trade and thus benefit from an enlarged foreign market size. There are many overlapping regional trade arrangements currently in place on the continent, most of which have met with mixed success at best. Trade barriers remain endemic in the region despite the great benefits that could be reaped by greater regional integration.

Turning to the most complex areas measured by the GCI, business sophistication is not yet an area of critical concern for most Sub-Saharan African countries, since they can still greatly enhance their productivity and competitiveness by improving on the more basic areas discussed above. However, for the few Sub-Saharan African countries that are nearing the transition to the most advanced stage of development, this area will become increasingly important. As luck would have it, the top two countries in this pillar—Mauritius and South Africa—are classified in the efficiency-driven stage and therefore are nearing the stage when these more complex factors will become very important.

Finally, Kenya, Senegal and South Africa are the top regional performers with respect to innovation, on a par with such innovative countries as India and Italy. These countries have high-quality scientific research institutions, invest strongly in research and development, and are characterized by a significant level of collaboration between business and universities in research. The low rankings of the other countries from the region should not be of significant concern at this stage, given the importance of focusing on the more basic areas for improvement first. The overall picture is that strong area-specific performances are concentrated among a relatively small group of Sub-Saharan African countries, although pockets of excellence exist in a number of others. This demonstrates that Sub-Saharan Africa is home to a number of countries that provide strong best practice examples in various areas for the other Sub-Saharan African countries struggling to improve their competitiveness.

Sub-Saharan Africa's international competitiveness in individual industries, especially in manufacturing and agro-processing, has seen little improvement over the last two decades. Its exports remained undiversified and their growth was overwhelmingly accounted for by natural resources.

Sub-Saharan Africa's world market share in processing industries is not only low but has remained virtually unchanged. The region exports just 0.9 and 0.3 percent of world light and heavy manufacturing exports, respectively, while developing countries in the aggregate saw their share of world exports increase dramatically, from 19 percent in 1995 to 33 percent in 2008 (appendix 2). Of the US$140 billion growth in sub-Saharan African exports between 1995 and 2008, 73 percent were mining-related commodities. By comparison, the export growth that spurred the Asian economies has increasingly relied on an expanding list of manufactures. By the 2000s, East Asia Pacific was already going through its second wave of export diversification, moving from relying mainly on light manufacturing into higher value-added heavy manufactures. In 2006–08, about 80 percent of East Asian exports came from manufacturing industries.

As seen earlier, Sub-Saharan African countries rank particularly low on innovation and technology adoption. Because of their generally low savings rates (especially among sub-Saharan African oil importers), underdeveloped domestic financial sectors, and often inadequate access to borrowing on international capital markets, their investment is constrained by available resources or their ability to attract FDI. In this concluding section we (1) discuss trends in FDI inflows to Africa, including during the crisis years of 2009 and 2010; (2) examine the impact of FDI on growth, through both investment in physical capital (factor accumulation) and total factor productivity (TFP) channels; and (3) look ahead and discuss how, in the future, African countries can attract growth-enhancing FDI, especially FDI that raises innovation and hence TFP (WEF, 2011).

In addition to providing capital, FDI can stimulate growth by helping improve the TFP of Sub-Saharan African countries by advancing their technological capacities. Besides the transfer of managerial skills, technological spill over from FDI can occur through the transfer of more advanced technologies and the demonstration of their applications, as well as through technical assistance to domestic suppliers and customers. In turn, the central role of FDI has been recognized by Sub-Saharan African policy-makers: without transfer of technological capabilities and resulting home-grown innovation, the productivity gap between African countries and more advanced economies will not be reduced and could even widen further. One of the key differences between advanced economies on one hand and developing and emerging market economies on the other lies in the amount of physical (and human) capital these groups of countries possess and the level of technology they utilize. With relatively low savings rates, volatile export revenues, and substantial investment requirements, most Sub-Saharan African countries need to rely on capital inflows, in particular FDI, to finance their development needs and reduce these gaps.

## 2. LITERATURE REVIEW

The classical growth theorist believed that if real GDP rose above the subsistence level of income it would cause the population to increase and bring real GDP back down to the subsistence level. It was sort of like an equilibrium level that real GDP would always revert to in this theory. Alternatively, if the real GDP fell below the subsistence level, parts of the population would die off and real income would rise back to the subsistence level (www.investopedia.com). This analogy holds sway in the views of Adam Smith, David Richardo through Karl Max. But in the view of the neoclassical economics, the entire edifice of the theory of growth is built on a concept of decline – the concept of diminishing returns. Diminishing returns hold when one input is fixed, and the other input is increasing. Ricardo first claimed that if one has a particular fixed area of land, the addition of more and more labor will result in diminishing returns to each additional unit of labor. If both land and labor are increased at the same rate, however, there may be no diminishing returns; there may be constant returns to scale, which is a state where there is no reason for diminishing returns to operate, since all factors grow in balance, and where all economies of large-scale production have already been realized (Samuelson, 1975). When economies of scale are being realized, then an across-the-board increase in the factors of production will actually result in increasing returns to investment, not decreasing returns.

In the Sources of Growth Analysis – Robert Solow (Solow, 1957) also developed a procedure, growth accounting or sources of growth analysis, to focus directly on the contribution of each term in the production function. The objective was to determine what proportions of recorded economic growth could be attributed to growth in capital stock, growth in the labor force, and changes in overall efficiency.

Using the formula Y=F(K, L, A) where Y is output, K is capital, L is labor, and A is a parameter to capture the effects of things other than capital stock and labor supply which might influence growth (increasing technology, worker skill levels, education, health, institutions, etc.). "**A**" is generally referred to as total factor productivity (TFP). Since A captures not only efficiency gains but also the net effect of errors and omissions from economic data, the residual A is sometimes referred to as a measure of our ignorance about the growth process. Understanding the failure of convergence has been one of the key endeavours of the economics of growth.

Unsatisfied with Solow's explanation, economists in 1980s started working on growth models. They developed the endogenous growth theory that includes technological advancement which incorporated a new concept of human capital, the skills and knowledge that make workers productive. Unlike physical capital, human capital has increasing rates of return. Therefore, overall there are constant returns to capital, and economies never reach a steady state. Growth does not slow as capital accumulates, but the rate of growth depends on the types of capital a country invests in. Research done in this area has focused on what increases human capital (e.g. education) or technological change (e.g. innovation).

The endogenous theory literature can be subdivided into three branches. The first is the popular AK approach, reflecting back to the older Harrod-Domar AK formalism mentioned above. In the newer version capital K is taken to include human capital (hence population and labour force). The growth of human capital is not subject to declining returns – as in the Solow model – because of the supposed (exactly) compensating influence of factor augmentation and technology spillovers. Spillovers are, of course, externalities, which suggest that the economic system need not be in perpetual equilibrium. Of course, this undermines the use of computable general equilibrium (CGE) models.

Neo-AK models began with Paul Romer (Romer, 1986, 1987, 1990). In an effort to precisely define the attributes of economic growth, Romer (1990) stated that technological change was (1) is an economic good and is the driving force of economic growth, (2) arises due to people responding to market incentives, and (3) is inherently different from other economic goods. Romer stated that technology was a good that was neither a conventional nor a public good but instead is a non-rival, partially excludable good. This was an important distinction in that private goods are seen as provided by markets and public goods either occur naturally or are provided by governments to compensate for some type of market failure. Other contributors to this literature divide capital explicitly into two components two kinds of capital, real and human (King, Rebelo, 1991). An alternative version assumes one kind of capital but two sectors, one of which produces only capital from itself. Another approach was to allow increasing returns by preserving the distinction between cumulable and non-cumulable factors (e.g. labour, land) and modifying the production function to prevent capital productivity from vanishing even with an infinite capital/labor ratio e.g. (Jones & Manuelli, 1990).

The second approach to endogenous growth theory emphasizes active and deliberate knowledge creation. This is presumed to occur as a result of maximizing behaviour (e.g. R&D). Knowledge is assumed to be inherently subject to spillovers and dependent on the extent to which benefits of innovation can be appropriated by rent-seeking Schumpeterian innovators. Most models assume that inventors and innovators have negligible success at appropriating the benefits of their efforts. In other words, spillovers are essentially immediate and automatic. This assumption appears to be realistic (Nordhaus, 2001).

The evolutionary approach emerged as a distinct branch of economic growth theory in the 1980s, although it was inspired by Schumpeter's early work (Schumpeter, 1912, 1934). The main difference between evolutionary economics and the neo-classical was that neoclassical theory postulates representative firms operating on the boundary of a well-defined region in factor space, whereas evolutionary biology — and evolutionary economics — lays great stress on the existence of diversity (Van den Bergh, 2003), In fact, the mechanism that drives the economic system, in the evolutionary view, is a kind of conflict between diversity and selection. In biology, diversity of populations and species is assured by mutation combined with diversity of environments. In economics diversity is the result of diversity of talents and ideas among entrepreneurs, together with diversity of competitors, institutional constraints, cultures and other external circumstances.

## 3. METHODOLOGICAL FRAMEWORK

### 3.1 Data Envelopment Analysis (DEA) Framework

DEA is a non-parametric performance measurement technique, based on linear programming, for assessing the relative efficiency of DMUs. DMUs are homogeneous entities (such as sales outlets, electricity distribution companies, bank branches, schools, university departments, and a nations' economy as a whole etc.) with some decision autonomy, operating a production process that converts a set of inputs into a set of outputs. DEA models use these inputs and outputs to compute efficiency score for a given DMU when this DMU is compared with all the other DMUs. The relative efficiency of a DMU is defined as a ratio between the sums of its weighted output levels to the sum of its weighted input levels. In contrast to other parametric econometric approaches, such as stochastic frontier analysis, DEA does not assume any specific functional form, thus avoiding problems of model misspecification.

In DEA, a DMU is considered efficient if there is no other DMU, or a linear combination of inputs and outputs of several DMUs, that can improve one input or output, without worsening the value of at least another one. The frontier is defined by the observed values of the (relatively) efficient DMUs. If a DMU does not belong to this envelopment surface (the convex hull of the efficient DMUs) and lies in its interior, then that DMU is operating inefficiently. DEA models usually return an efficient projection point of operation on the frontier for each inefficient DMU, thus identifying the DMUs that can be used as performance benchmarks for the DMUs that are operating inefficiently.

DEA originated from the work by Farrell (1957), but its current popularity is largely due to the seminal paper by Charnes, Cooper and Rhodes (1978). Thousands of DEA studies have been reported in application areas such as agriculture, education, financial institutions, health care, and public sector firms, among many others. DEA's vitality, real-world relevance, diffusion and global acceptance are evident from such literature studies as Seiford (1996) and Gattoufi et al. (2004). The DEA as non-parametric approach which tend to envelopment of decision making units (DMU) can be estimated through linear programming methods to identify the "best practice" for each DMU. The efficient units are located on the frontier and the inefficient ones are enveloped by it. In our case, 30 linear programming problems (LPPs) must be solved for each DMU (i.e. each country in this study) to obtain the distances defined earlier and they are:

$$\left.\begin{aligned} & D_0^t\left[x^{t+1}, u^{t+1} / CRTS\right]^{-1} = Max\ \lambda \\ & \text{subject to} \quad \sum \lambda_i x_i^t \le x^{t+1} \\ & \sum \lambda_i u_i^t \ge \lambda u^{t+1} \\ & \lambda \ge 0 \end{aligned}\right\} \text{for country (A) ----- (1a)}$$

$$D_0^{t+1}\left[x^t, u^t / CRTS\right]^{-1} = Max\ \lambda$$
$$\text{subject to } \sum \lambda_i x_i^t \le x^t \quad \text{for country (B)----- (1b)}$$
$$\sum \lambda_i u_i^t \ge \lambda u^t$$
$$D_0^{t+1}\left[x^{t+1}, u^{t+1} / CRTS\right]^{-1} = Max\ \lambda$$
$$\text{subject to } \sum \lambda_i x_i^{t+1} \le x^{t+1} \quad \text{for Country (C) ---(1c)}$$
$$\sum \lambda_i u_i^{t+1} \ge \lambda u^{t+1}$$
$$\lambda \ge 0$$

$$D_0^t\left[x^t, u^t / CRTS\right]^{-1} = Max\ \lambda$$
$$\text{subject to } \sum \lambda_i x_i^t \le x^t \quad \text{--- to Country (Z) ---(1d)}$$
$$\sum \lambda_i u_i^t \ge \lambda u^t$$
$$\lambda \ge 0$$

Here K, N, M, and T represent the numbers of Countries, inputs, outputs and time periods in the sample respectively.

In the present study K = 30, N = 2, M = 1 and T = 11

Time Period: t = 1999, 2000, 2001………………to 2011. l's intensity parameters.

The above LP's are required for each production unit (Total number of countries in this study). Thus, suppose one has data on K DMUs and T time periods, then one must solve K x (30T-2) LP's to solve for the estimates.

### 3.2 Malmquist Index Framework

The production technology is defined as the set of all feasible input-output combinations. The production technology T in period t is

$$T_0^t(X^t, Y^t),\ t = 1,.........T \quad (2)$$

Where $X^t$ is a *K*-dimensional vector of nonnegative input, $x^t = x_1^t,......x_k^t) \in R_+^k$, $y^t$ is an $M$ — dimensional vector of nonnegative outputs $y^t \equiv y_1^t,.....y_m^t) \in R_+^m$ and $T^t$ is the production possibility set for all feasible input-output combinations in period *t*. The output distance function $D_0^t(X^t,Y^t)$ is measured as the distance of a vector of inputs and outputs in period t with respect to the technical frontier in period t:

$$D_0^t(X^t,Y^t) = \min\ \{\theta > 0, : (x^t,y^t/\theta) \in T\},\ t = 1...\ T, \quad (3)$$

Where subscript *0* refers to output orientation in compliance with this work. The output distance function satisfies the inequality $D_0^t(X^t,Y^t) \le 1$. $D_0^t(X^t, Y^t)=1$ indicates that the production unit is on the frontier of the production set and hence is technically efficient.

As earlier noted the Malmquist index measures the TFP change between two adjacent periods by calculating the ratio of the distance of each data point relative to a common technological frontier. Following Färe et al. (1994), the Malmquist index between period t and t + 1 based on the period t technology is given by

$$MI\ or\ TDFP = \frac{D_0^t(X^{t+1},Y^{t+1})}{D_0^t(X^t,Y^t)} \quad (4)$$

The Malmquist index can be greater than, equal to, or less than 1 if productivity grows, is stagnant, or declines between the two periods. Similarly, the Malmquist index between period t and t + 1 based on the period t + 1 technology is

$$MI\ or\ TDFP_0^{t+1}\ (X^t, Y^t, X^{t+1}, Y^{t+1},) = \frac{D_0^t(X^{t+1},Y^{t+1})}{D_0^{t+1}(X^t,Y^t)} \quad (5)$$

Measures of the productivity change between period t and t+1 generally change if the reference technology is different. To avoid the arbitrary choice of reference technology, Färe et al. (1994) suggestedFäre et al. (1994) suggested a geometric mean of the two Malmquist indexes:

$$MIor\ TFP_0^{t+1}(X^t,\ Y^t,\ X^{t+1},\ Y^{t+1})$$
$$= \left[\frac{D_0^t(x^{t+1},\ Y^{t+1})}{D_0^t(X^t,Y^t)} X \frac{D_0^{t+1}(X^{t+1},\ Y^{t+1})}{D_0^{t+1}(X^t,\ Y^t)}\right]^{\frac{1}{2}} \quad (6)$$

The last equation gives an interpretation that Malmquist index (MI) is geometric mean of two efficiency ratios: the first one being the efficiency change measured by the period one technology and the other, the efficiency change measured by the period two technology. As specified from the equation Malmquist index consist of four terms namely: $\delta^t(x_t, y_t)^t$, $\delta^{t+1}(x_t, y_t)^{t+1}$, $\delta^t(x_t, y_t)^{t+1}$ and $\delta^{t+1}(x_t, y_t)^t$. The first two are related to the measurement within the same time period with $\delta^t$ or $\delta^{t+1}$ while the last two are for inter-temporal comparison. (MI) > 1 indicates progress in the total factor productivity of the country from period 1 to 2, while (MI) =1 and (MI) □ 1 respectively indicate the status quo and deterioration in total factor productivity.

Balk (2001) showed that the Malmquist index can be decomposed into four components: primal technical change (TC), technical efficiency change (EC), scale efficiency change (SEC), and output-mix effect or technological change (TECH):

$$MI\ or\ TDFP = TECHCH.EFFCH.PEFFCH.SECH \quad (7)$$

Starting from the technical efficiency change give a two period analysis therefore, the frontier one, in period one is denoted by

$$\varnothing_1 = \frac{\text{eff of}(x_t,y_t)^t \text{ WRT Frontier 1}}{\text{eff of }(x_t,x_t)^{t+1} \text{ WRT Frontier 2}} \equiv \frac{\delta^t(x_t,y_t)^t}{\delta^{t+1}(x_t,y_t)^{t+1}}$$

while frontier two, period two is denoted by

$$\varnothing_2 = \frac{\text{eff of }(x_t,\ y_t)^{t+1}\text{WRT Frontier 1}}{\text{eff of }(x_t,\ x_t)^{t+1} \text{ WRT Frontier 2}} \equiv \frac{\delta^{t+1}(x_t,y_t)^{t+1}}{\delta^{t+1}(x_t,\ y_t)^{t+1s}}$$

And the entire period frontier –Shift therefore =

$\varnothing_1 \times \varnothing_2 \equiv \frac{\delta^t(x_t,y_t)^t}{\delta^{t+1}(x_t,y_t)^{t+1}} \times \frac{\delta^{t+1}(x_t,y_t)^{t+1}}{\delta^{t+1}(x_t,y_t)^{t+1}}$ Hence frontier shift $(F_C) = \sqrt{\varnothing_1 \varnothing_2}$ as their geometric mean This is finally arrived at as $\text{TECHCH} = \left[\frac{\delta^{t}(x_t, y_t)^{t}}{\delta^{t+1}(x_t, y_t)^{t+1}} \times \frac{\delta^{t+1}(x_t, y_t)^{t+1}}{\delta^{t+1}(x_t, y_t)^{t+1}}\right]^{\frac{1}{2}}$ =frontier shift effect-(8)

The magnitude of the first term, TECHCH, in general depends on the particular input-output combination. There is technical progress when TECHCH is greater than 1 and technical regress when it is less than 1. If TECHCH ($X^{t+1}$, $Y^{t+1}$)=TECHCH($X^t$, $Y^t$), the technical change is output neutral.

The technical efficiency, TE=$D^t{}_0(X^t, Y^t)$, measures the distance of the firm's position in period t relative to the period t frontier of the technology, or how far the observed production is from maximum potential production. By definition TE≤1, and the production unit is efficient if and only if TE=1. That is (Frontier-shift) > 1 indicates progress in the frontier technology around specific country from period 1 to 2, while (Frontier-shift) =1 and (Frontier-shift) 1 respectively indicate the status quo and regress in frontier technology.

$$\text{EFFCH} = \frac{D_0^{t+1}(X^{t+1}, Y^{t+1})}{D_0^{t+1}(X^t, Y^t)} = \text{catch up effect} \quad (9)$$

The second term, EC, measures technical efficiency change between period t and t + 1. If EFFCH is greater than 1, the production unit moves closer to the frontier—in other words, the production unit is catching up to the production frontier by improving efficiency. A value of less than 1 indicates efficiency regress.

$$\text{Scale Efficiency}[SECH] = \left[\frac{S_0^{t}(X^{t+1}, Y^t)}{S_0^{t}(X^t, Y^t)} \times \frac{S_0^{t+1}(X^{t+1}, Y^{t+1})}{S_0^{t+1}(X^t, Y^{t+1})}\right]^{\frac{1}{2}} \quad (10)$$

The third term, SEC, refers to scale efficiency change between two periods, which measures how the output-oriented scale efficiency changes over time conditional on a certain output mix. It is the ratio of the output-orientated measure of scale efficiency (OSE) in period t and t + 1, where

$SCE(X^t, Y^t) = \frac{D_0^t(X^t, Y^t)}{D_0^t(X^t, Y^t}$ And $D^t{}_0(X^t, Y^t)$ is the output distance function based on the cone technology $T^t=\{(\lambda X^t, \lambda X^t,)|(X^t\ Y^t)\in T^t, \lambda>0\}$ If SCE = 1, the frontier point that can be reached by proportionally expanding yt is a point of technically optimal scale. At that point, the technology exhibits constant returns to scale and scale elasticity equals 1:$\in^t{}_0(X^t, Y^t)$ =1. If SEC is greater than 1, the output bundle at period t + 1 lies closer to the point of the technically optimal than the output bundle at period t and thus scale efficiency improves. If SEC is less than 1, the scale efficiency deteriorates. The fourth term is labeled the output-mix effect, which measures how the distance of the frontier point to the frontier of the cone technology changes when the output mix changes, where the cone technology is the technology generated from the underlying observed technology.

Pure Technical Efficiency Change

$$[\text{PEFFCH}] = \left[\frac{TEC_0^{t}(X^{t+1}, Y^{t+1})}{TEC_0^{t}(X^{t+1}, Y^t)} \times \frac{TEC_0^{t+1}(X^t, Y^{t+1})}{TEC_0^{t+1}(X^t, Y^t)}\right]^{\frac{1}{2}} \quad (11)$$

That is, PEFFCH gives the change improvement in management practices and in the output-oriented scale efficiency from a change in the output mix when inputs remain constant. When the output mix changes, the scale efficiency increases if PEFFCH is greater than 1, and scale efficiency declines if PEFFCH is less than 1. In the case of a single output, PEFFCH = 1. Under global constant returns to scale technology, both SECH and PEFFCH are identically equal to 1

### 3.3 Tobit Model for TFP Determinants

As earlier noted the DEA scores falls between the interval of 0 and 1 (0<h≤1), making the dependent variable a limited dependent variable, which is the necessary and sufficient condition for the application of a Tobit model. It has been noted in literature that Tobit model can handle the features of the distribution of efficiency measures and thus on the long run provide estimates that can assist or guide policies that could improve performance. See Chilingerian, (1995), Kirjavainen and Loikkanen, (1998). DEA efficiency estimates obtained in the first stage are the dependent variables in the second stage Tobit model. James Tobit first suggested Tobit model in econometrics literature in 1956. These models are known as truncated or censored regression models where expected errors are equal to zero. It is truncated if the observations outside a specified range are totally lost and censored if one can at least observe the exogenous variables. Consequently estimation with ordinary least squares (OLS) regression of h would lead to a biased parameter estimates since OLS assumes a normal and homoscedastic distribution of the disturbance and the dependent variable (Maddala, 1983).

The standard Tobit model can be defined as follows for the 30 Sub-Saharan African Countries:

$$\left.\begin{aligned} y_0^* &= \beta, X_0^I + \varepsilon_0 \\ y_0 &= y_0^* \text{ if}, \ y_0^* > 0 \end{aligned}\right\}$$

Where $_0$**~N(0,σ²)³**,

$X^I{}_0$ and $\beta$ are vector of explanatory variables and unknown parameters, respectively. The $y^*_0$ is a latent variable which can be viewed as a threshold beyond which the explanatory variables must affect in order for $y_0$ to jump from 0 (here being efficient) to some positive value (being inefficient in various degrees). The Tobit model can be estimated by the maximum likelihood method by assuming normally distributed errors µi and $y_0$ is the DEA scores (Alilu & Ichoku, 2012). The likelihood function (L) is maximized to solve β and σ based on observations of explanatory variables and the DEA scores.

$$L = \prod_{yo=0}(1 - F_0)\prod_{yo>0}\frac{1}{(2\Pi\sigma^2)}X_e^{-[1/(2\delta^2)]}(yo - \beta_{x0})^2 \quad (13)$$

 

Where

$$L = F_0 = \int_{-x}^{\beta x0/\sigma} \frac{1}{(2\Pi 1/2)} e^{-t^2} dt \quad (14)$$

The first product is over the observations for which the banks are 100 percent efficient (y=0) and the second product is over the observations for which banks are inefficient (y>0). F0 is the distribution function of the standard normal evaluated $\beta x_0/\sigma$. Productive factors efficiency of countries is assumed to be determined by a number of factors, which are essentially country specifics. For this study, the efficiency of factor inputs used in production is modeled to depend on specific homogeneous and non-homogeneous characteristics among the selected Sub-Saharan African Countries. These factors are INST, INFRAS, MACE, HPE, HED, GME, LME, and FMD, TR, MKTS and INNO

***Ineff= f (INST, INFRAS, MACE, HPED, HEDT, GME, LME, FMD, TR, MKTS, INNO)*** (15)

Where **ineff** denotes inefficiency index estimated from the standard DEA models.

$$\begin{aligned} inff = {} & \pi_0 + \sum_{11}^{30} \pi_1 inst_t + \sum_{11}^{30} \pi_2 infras_t + \sum_{11}^{30} \pi_3 macre_t \\ & + \sum_{11}^{30} \pi_4 hped_t + \sum_{11}^{30} \pi_5 hedt_t + \sum_{11}^{30} \pi_6 gme_t \\ & + \sum_{11}^{30} \pi_7 lme_t + \sum_{11}^{30} \pi_8 fmd_t + \sum_{11}^{30} \pi_9 tr_t \\ & + \sum_{11}^{30} \pi_{10} mkts_t + \sum_{11}^{30} \pi_{11} inno_t + \mu t \end{aligned} \quad (16)$$

## 4. DATA AND VARIABLE SPECIFICATION

This section presents the definitions of inputs and outputs and the dataset used in this study. The sample consists of 30 countries within the Sub-Saharan Africa region, for eleven consecutive years, 1999-2011. Measurement of total factor productivity usually requires either data on input and output prices or the measures of inputs and output. But, it is difficult to collect data on input and output prices. Thus the measures of inputs and output are used in this study. There are two group of data set of variables. One is for the estimation of productive factors efficiency and productivity change, while the other set is for explaining country specific efficiency in producing output and convergence. Output data of the 30 Sub-Saharan African countries was obtained from the Penn World Table (PWT 7.1, 2012) in constant U.S dollars at purchasing power parity (PPP) terms (chain index, 1999 international price). PWTs real GDP measures account for and assign suitable weight for cross country price difference of various components of GDP which enables meaningful cross country comparison.

Input data on capital (K) is the standardized capital stock in year 1990 purchasing power parity equally obtained from World Productivity Database (WPD). This capital is computed from gross capital formation. The data of these variables of 30 countries included in the dataset is available at "www.wpd.org/unido/data". Capital is the most difficult production factors to measure, partly because of the controversies related to computation of initial capital stock and depreciation rates. Depreciation in this perspective is the decay of productive capacity of fixed asset and not as a reduction in value of asset. The former refers to the production process, while the latter is a wealth accounting concept. For this, the United Nations Industrial Development Organisation (UNIDO) World Productivity Database (WPD) on capital (keff) is used. It is computed using perpetual inventory method expressed in standardized efficiency uints that assumes time varying depreciation rates with the notion that an asset's productive efficiency decline with age. Other countries not available here are obtained from The Conference Board of Total Economy Database (www.conferenc.board.org/data/economydatabase, 2012) and the World Bank EAPED Database (www.worldbank.org/eaped/database, 2012).

Labour input (L) is measured as the total labour force (Han et al., 2008; Oleg et al., 2004; Sangho et al., 2010). We disregard the labour force data of the World Data on Labour Force computed by IMF and Penn Tables while opted for the that of The Conference Board of Total Economy Database and the World Bank EAPED Database because, IMF and PWT generated its data from International Labour Organisation (ILO) that defined labour force as people ages 15 and above who meet supply of labour for the production of goods and services during a given period. This constitute both employed and unemployed. Using this data will have negative effect on the estimates. However, The Conference Board of Total Economy Database and the World Bank EAPED Database use the actively employed segment of labour force. The human capital data is proxied by the life expectancy (Mathur, 2007) obtained from IMF's World Economic outlook (WEO, 2012). The data covers the time period of 1999-2010 for all 30 countries and amounts to 330 observations in total.

Other variables considered as conditions that can explain (in) efficiency differentials: These factors are: institution (INST), infrastructure (INFRAS), macroeconomic environment (MACRE), health and primary education (HPED), higher education and training (HEDT), good market efficiency (GME), labour market efficiency (LME), financial market development (FMD), technological readiness (TR), market size (MKTS) and innovation (INNO) are all generated from the World Economic Global Competitiveness index report of 2011.

 

## 5. EMPIRICAL RESULTS

### 5.1 Malmquist Index of Productivity Change

Our preferred methodology is the Malmquist Total Factor Productivity Index (MPI), which allows us to examine five different indices namely, the productivity change (TFPCH), technological change (TECHCH), efficiency change (EFFCH), pure technical efficiency change (PEFFCH) and scale efficiency change (SECH) indices. This index uses period t technology and the other period t+1 technology. TFP growth is the geometric mean of two output based malmquist-TFP indices from period (t) to period (t+1). A value less than one indicate a decrease in TFP growth or performance relative to the previous year. Efficiency change (catch-up effect) measures the efficiency change between current (t) and next (t+1) period, while the technological change (innovation) captures the shift in frontier technology. Pure technical efficiency measures the management agility and input/ outpu mix strategy in production, while scale efficiency emphasis on the scope of production via large and small scale operation.

The annual means of all the Malmquist components scores of the 30 countries for each year of the entire period 1999-2011 was not encouraging as total factor productivity [TFP] change was quite low due to poor contribution of pure technical efficiency change and the efficiency change (the catch-up effect). The mean of pure efficiency change and the catching-up effect deteriorated heavily over the period with annual mean of 0.979 and 0.967 respectively. Pure efficiency change recorded single digit improvement in 2001-2002, 2002-2003, 2006-2007 and 2007-2008 with 0.9%, 0.8%, 1.9% and 0.3% respectively. On the other hand, catch-up effect relatively improved in 2001-2002, 2003-2004, 2006-2007 and 2007-2008 with 0.5%, 0.4%, 0.7% and 0.6% respectively. However mean of technical change over the period under review is positive with1.061. This implies that in general, although Sub-Saharan economies are operating at below its maximum potential, the sub-region is amenable to technological advancement. Sources reveals that Total Factor Productivity [TFP] growth was due to technical progress [frontier – shift]. It thus infers that the sub-region was able to cause shift in their frontier due to innovation. But it must be noted that the growth index of only 1.016 (1.02%) reflects that level of technology in the region is still abysmally low and technological adoption can take place much easier. The sub-region needs an enhancement in their productivity based catching-up capability especially the effective use of human capital in the labour market, increase the number of skilled worker to operate a more sophisticated technology and the adoption of new technology.

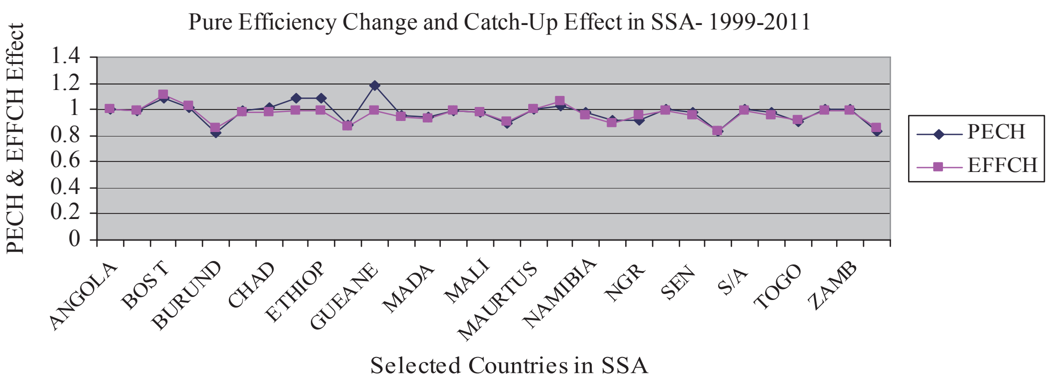


**Figure 1**
**Pure Technical Efficiency and Efficiency Change [catch-up] effect in SSA from 1999 to 2011**
Source: Authors' computation using DEA 2.1

Figure 1 presents mean pure technical efficiency change and efficiency catch-up effect of the SSA countries over the 1999-2011 periods. In this period, pure technical efficiency change and catch – up effect fluctuated and decreased on average. Catch-up effect deteriorated significantly signalling a critical area of focus for attention if the sub-region must claim the 21st century and beyond.

 

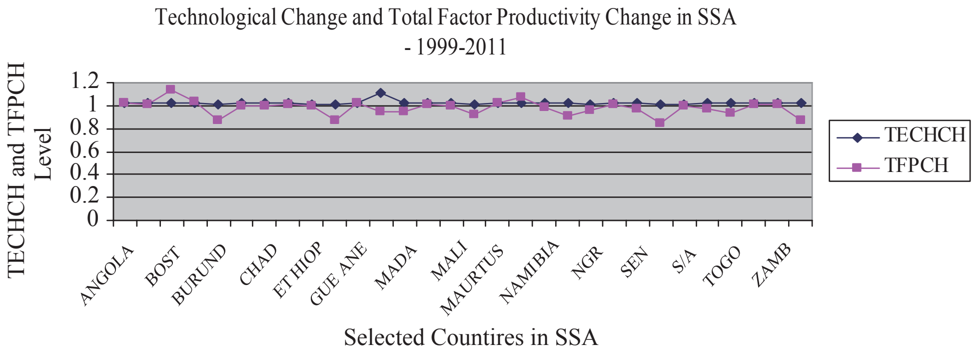


**Figure 2**
**Technological Change and TFP Change in SSA from 1999 to 2011**
Source: Authors' computation using DEA 2.1

Figure 2 presents the mean technological change and total factor productivity product [TFP] trend of the SSA economies in the study period. The average annual technological change was 1.6. That is, this period had a technical progress, on average. However, the TFP on average had 0.98. That is the period had deteriorated TFP performance generally. Evident from the graph, it was only Botswana, and Mauritius that cross the TFP frontier.

The annual averages of efficiency levels for all countries, which are given in column 2-5 of the appendix 3 evidently show that out of the 30 SSA countries, 15 recorded improvements in the total factor productivity with Mauritius and Botswana leading with double digit growth index of 37% and 14% respectively. Others are with low single digit growth. Those that appear to be efficient along with these two are Angola, Benin, Burkina Faso, Cameroun, Cote, d'Ivoir, Guinea, Ghana, Malawi, Mozambique, Rwanda, South Africa, Uganda and Zambia. Out of them Mozambique, Ghana and South Africa are relatively outstanding with 7 and 5 percent TFP growth respectively. On the other hand, Serra-Leon appears to be the least efficient countries, followed by Zimbabwe, Burundi, and Niger.

The decomposition of productivity components attributable to pure technical efficiency, efficiency change [catch up effect], technical change (movement towards or away from the frontier) and total factor productivity change [TFP] is shown in Figure 3.

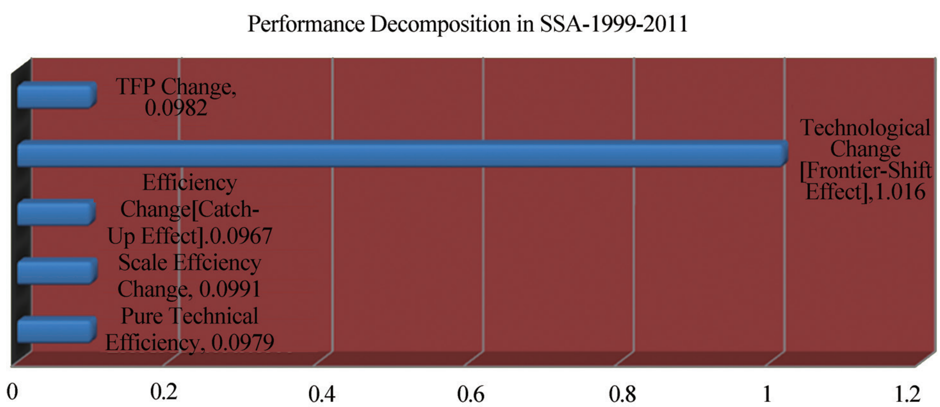


**Figure 3**
**Summary of Productivity Decomposition in SSA from 1999 to 2011**
Source: Authors' computation using DEA 2.1

Recall that a value for the Malmquist Index greate than one indicates increasing productivity and a value less than one imply diminishing productivity from period *t* to period *t*+1. It is clear that the annual TFP growth rate on average constant at 9% deterioration within 1999-2002 and then went up to approximately 3% between 2003-2008. Over the entire period, TFP experience regress by 9% per annum. If we observe the components of technological change (frontier – shift) for the entire consecutive periods, it grew marginally by 1.6%. This tells us that, from a sub-region perspective, the recorded growth of TFP mainly comes from progress in technology, whereas efficiency contributes negatively to TFP growth. Obviously technological change [frontier shift] constant return to scale [CRS], which is innovative oriented, performed better than the rest components. Meaning that the sub-region still have the potential to improve technologically while eagle eyes must be on the rest components if the region must catch up and not to lagged behind.

 

### 5.2 Result of Tobit Model for TFP Determinants

There are various reasons for the efficiency and technical change differentials among the transition economies. Socio-economic, demographic, regional, environmental, and pre-transition factors are among them. These reasons incorporate country-specific factors. However, providing a full account of efficiency differentials requires the collection of all relevant data and a careful examination of various reasons for each country. In our regression analysis, the dependent variable was the scores of TFP change, while the independent variables are the selected eleven GCI pillars that tend to determines productivity growth, global efficiency and competitiveness of nations across the world. The estimation results provide not only the effect of the explanatory variables on the mean of TFP, but also the effect on the variance of TFP as analyzed below. Therefore, in this study uses sets of inefficiency effects variables as specified in equation (16).

The overall fit of the model is quite satisfactory with a coefficient of determination (R-squared) of 0.755. The Z-statistic of the model is also significant at the 5% level. Among the 11 explanatory variables only market size (MKTS) is significant at five percent level while the rest are insignificant. All parameter estimates have the expected negative sign with inefficiency (see Table 1).

**Table 1**
**Variables Coefficient Z-value**

| Variables Coefficient Z-value |
|---|
| INST-.021800210 .1672** |
| INFRAS -.028602380 .1100** |
| MACE-.033041330.6430** |
| HPED-.060807730 .4259** |
| HEDT-.037344660 .8334** |
| GME-.035330890.4727** |
| LME-.073643800 .4372** |
| FMD-.091590380 .5898** |
| TR-.013734230.5454** |
| MKTS-.324765830-3.7093** |
| INNO-.442698840 .0898** |
| ***$R^2$=0.755*** |

*Note.* ** 5% level of significant. Authors' computation using the GCI data from the World Economic Forum Report 2011/2012

Thus, the countries that have robust quality of institutions have a strong bearing on total factor productivity growth and efficiency and thus negative relationship with TFP. It has positive influences on investment decisions and the organization of production. Good institution plays a key role in the ways in which government in SSA distribute economic benefits and bear the costs of development strategies and policies. The low coefficient of 0.0218 signifies insignificant impact of institution on efficiency. It thus implies that corporate governance strategy, intellectual properties right are weak leading to unwillingness to invest in the SSA economies by potential investors. The weak coefficient and the non-significance of the z-test value equally mean that there are no solid legal and administrative institution anchored rule of law and separation of power that can guarantee the safety of property owners of their rights. The result amplify the weak attitudes of SSA Government toward human right, freedoms and the efficiency of its operations leading to excessive bureaucracy and red tape, overregulation, corruption, dishonesty in dealing with public contracts, lack of transparency and trustworthiness. All these constitute colossal economic costs to businesses and impede the process of economic growth and development.

Equally, the weak institutions in SSA as enveloped in the GCI index reveals that the management of public finances is critical to ensuring trust in the national business environment. The weak coefficient captures the existence of corporate economic scandals emanating from the absence of good accounting and reporting standards and transparency for preventing fraud and mismanagement that can propel good governance. The negative impact of this is that it erodes investor and consumer confidence. As expected, the parameter estimates of infrastructure were negatively associated with the 30 nation's TFP. Infrastructure would improve the flow of goods and services within the entire nation and therefore improve the sub-regions' efficiency and productivity. In most SSA, infrastructure is very often neglected. Roads and telecommunications are essential for bringing about internal development. Nations that have established sound economic models and have heavily invested in infrastructure are known to have attained the efficiency enhancer level of development in the GCI classification. Maintaining sustainable growth, competitiveness and some measures of efficiency at any stage of development hinges primarily on well-developed infrastructure.

However the insignificant value of Z and the low estimate value of the coefficient speak volume of the failure of SSA economies in infrastructural development. It implies that the major infrastructures in the areas of transport (roads, air, rail and navigable water ways), telecommunication, health and the electricity are grossly inadequate hindering the expected impacts. As a matter of fact all economies depend on electricity supplies that are free of interruptions and shortages so that businesses and factories can work unimpeded. It would be almost impossible for people who do not meet their daily basic needs to help develop their nation. Therefore, leaders of nations in SSA should promote policies aimed at providing their citizens with necessary basic infrastructure to stimulate investment.

The tobit result equally indicate that macroeconomic environment gave a negative sign with TFP. It means that fiscal deficits limits the government's future ability to react to business cycles, government cannot provide services efficiently if it has to make high-interest payments on its past debts. Firms will operate inefficiently when inflation rates are out of hand. Obviously, the economy cannot grow in an efficient and sustainable manner unless the macroeconomic environment is stable.

The macroeconomic environment also captured the negative impact of tax burden on investments and on highly qualified employees, as both influence productivity growth negatively. It is noteworthy that macroeconomic environment has a positive relationship with TFP and efficiency in SSA although with negligible impact as attested to by the small magnitude of the estimated parameter as well as the insignificants value of the z-test. It thus infers that in all SSA economies under study, inflation is high with double digit, there exist perpetual fiscal deficit, high debt burden, and poor gross domestic savings. Gross domestic saving per capita increases nations' future consumption by lowering current consumption. The positive effects of savings appear to improve pure technical efficiency as countries' savings may be used to pay for projects and investments but the scenario is different in the SSA sub-region. Also with respect to debt burden, this result was interdem with the previous findings with references to technical efficiency, and technical change. In fact, results indicated that increases in external debt were positively associated with nations' productivity. The reason may be that external debt generates capital that might be used in the short run to invest more in productive sectors in order repay at a later date once benefits have resulted. This may not be so in SSA as debt portfolios are recklessly squandered with levity.

Health and primary education as estimated by tobit model equally shows a negative sign with TFP and inefficiency, which by implication has a positive relationship with efficiency. A healthy workforce is vital to a country's competitiveness and productivity. Poor health leads to significant costs to business, as sick workers are often absent or operate at lower levels of efficiency while lack of basic education is a constraint on business development, with firms finding it difficult to move up the value chain by producing more sophisticated or value-intensive products. However the insignificant value of z and the low coefficient of the parameter estimates point to the fact that its impact is significantly abysmal on the TFP and efficiency pedigree within the SSA economies during the time under study. Implying that health facilities, personnel and consumables are far below frontier standard, while it's equally suggestive that the basic education status of SSA as encapsulated in the millennium development goals (MDGs) by 2015 may not be achieved.

The quality of higher education and training is crucial for economies that want to move up the value chain beyond simple production processes and products for utmost efficiency as well as vibrant competitiveness. The tobit TFP and efficiency determinants results reveals that higher education and training has a negative sign with inefficiency. Essentially, this variable is positively related with TFP and efficiency of the SSA countries as a whole. Globalization requires countries to nurture pools of well-educated workers who are able to adapt rapidly to their changing environment and the evolving needs of the production system. It measures secondary and tertiary enrolment rates as well as the quality of education as evaluated by the business community. The extent of the impact as depicted by the coefficient of parameter estimates seems insignificants. Implying that higher education and the training capacity in SSA economies is not robust enough to exert the expected significant impact on the sub-region.

The quality of the goods market efficiency results came out with expected negative sign. It thus imply that SSA countries with efficient goods markets are well positioned to produce the right mix of products and services given their particular supply-and-demand conditions, as well as to ensure that these goods can be most effectively traded in the economy. Importantly, healthy market competition, both domestic and foreign, is crucial in driving market efficiency and business productivity, by ensuring that the most efficient firms that produce goods demanded by the market thrives. Good market efficiency thus has positive relationship with TFP and efficiency as the best possible environment for the exchange of goods requires a minimum of impediments to business activity through government intervention. Market efficiency also depends on demand conditions such as customer orientation and buyer sophistication. Disappointingly the low magnitude of the coefficient infers that productivity, efficiency and competitiveness is hindered by distortionary or burdensome taxes and by restrictive and discriminatory rules on foreign direct investment (FDI)—limiting foreign ownership—as well as on international trade. The insignificant value of Z test amplified the degree of interdependence of SSA economies and the degree to which growth depends on open markets in SSA. It further reveals that protectionist measures currently in practices in SSA are counterproductive as they reduce aggregate economic activity.

Labour market regulation has a strong positive impact on productivity growth. As indicated in the tobit model results, it has a negative sign with inefficiency. Tighter regulation can indeed increase the productivity of the working population, but at the price of reducing the participation of the population in the working process. Many regulations like minimum wages affect only the less qualified labour. Well-educated employees (with high productivity) participate in the labour market regardless of regulation, while low-skilled people (with low productivity) do not get jobs. In the long run, labour market regulations often hurt most of those whom they pretend to protect. Of course, one should not conclude that a tightening of labour market regulation is a promising strategy for growth, because its impact on productivity is only half of the story. The overall effect of regulation on GDP growth is expected to be negative. Given that all parts of the population should participate in social well being, easy access to the labour market is probably the best policy strategy to enable long-term growth in SSA. But the result obtained is disappointing, as the magnitude and the sign do not show any strong impact of labour market on efficiency in SSA during the period under consideration. It thus means that SSA labour market is far below the ideal situation that can promote efficiency, sustainable growth and competitiveness in the sub-region and beyond.

A strong financial market development mobilizes, regulates and allocates funds from the surplus unit to the deficient unit of the economy. The tobit TFP and efficiency determinants reveals a negative sign of financial market development with inefficiency. It infers that business investment is critical to productivity and as such requires sophisticated financial markets that can make capital available for private-sector investment from such sources as loans from a sound banking sector, properly regulated securities exchanges, venture capital, and other financial products. The importance of such access to capital was recently underscored by the liquidity crunch experienced by businesses and the public sector in developing economy like SSA. As relevant as the expected, the impact of the strong financial sector development is not felt in SSA sub-region given the results of the tobit model. The low magnitude of the coefficient and the insignificant value of the z test mean that t financial market activities is not robust in SSA sub-region. Meaning that the money and the capital market are not sound enough and thus characteristically weak enveloped in systemic failures.

Technological readiness equally signed negatively as expected. It means that technological readiness has positive relationship with TFP and efficiency. This is because technological readiness has increasingly become an important element for firms to compete and prosper. It captures the agility with which an economy adopts existing technologies to enhance the productivity of its industries, with specific emphasis on its capacity to fully leverage on information and communication technologies (ICT) in daily activities and production processes for increased efficiency and competitiveness. ICT has evolved into the general purpose technology of the moment, given the critical spillovers to the other economic sectors and their role as industry-wide enabling infrastructure. Therefore ICT access and usage are key enablers of countries' overall technological readiness. The disappointing concern from the Tobit result is the poor impact of technological readiness index as attested to by the magnitude of the coefficient and the insignificant value of the z. It suggest that looking at the main sources of foreign technology, either from the country's ability to innovate and expand the frontiers of knowledge or those acquired through foreign direct investment (FDI), it adoption and usage is not impactful on the SSA economy. This is a serious matter for further research.

The size of the markets determines the economies of scale. This negatively signed with TFP and inefficiency. Globalization and the policy of trade openness is positively associated with sustainable growth, efficiency and competitiveness as international markets have become a substitute for domestic markets, especially for small countries. Essentially exports are thought of as a substitute for domestic demand in determining the size of the market for the firms of a country. The size of the markets index is the only variable that stood out to be significant and with high magnitude of the coefficient. This is because SSA remains the one of the world largest market for the developed economies of the world and thus exerts significant impact on the efficiency.

Innovation strategies positively influence productivity growth and efficiency in SSA. The major indicator of innovation is the research and development expenditures as a share of the GDP. Although it has positive coefficient and significant but, somewhat surprisingly, the impact the innovation indicator on productivity growth and efficiency is low. One reason for this might be that the available innovation indicators do not reflect the more important kinds of innovation resources, e.g. less formally acquired know-how. The results clearly point out that fostering innovation is not the quick and easy policy solution to solve all growth problems, especially if the policy concentrates on the broader and less focused areas of innovation resources, which are covered by the indicators available here. Although innovation does have a positive impact on productivity growth, the road there might be longer than expected. It might thus be necessary to rethink policy with respect to innovation. Quality and efficiency controls should be an integral part of all innovation policies. Rather than drowning in the micromanagement of innovative firms, clusters and R&D expenditures, innovation policy should again put more weight on general framework conditions such as the regulatory burden and its impact on the ability of an economy to innovate.

## CONCLUSION

Measuring total factor productivity dynamic across Sub-Saharan Africa nations was the topic of this study. Efficiency measurement of Nations has been the focus of study since efficiency analysis started in the 1950s. Five measures of efficiency (i.e., pure technical, efficiency change, scale efficiency, technical efficiency change, and total factor productivity) were examined in 30 countries.

Results were presented and discussed for the beginning of the study (1999) and the ending year (2011) of the investigation. Our attention was limited to the 30 SSA economies in order to show their performance trend during these years. The findings on countries' efficiency are presented below.

The overall results indicated that over the 11-year period (1999-2011) of our study, SSA's performance is enveloped in mixed feelings. Mixed feeling in the sense that although the beginning period was characterised by poor performance, the later period of the period shows that that SSA was ready to reverse the trend judging from the stride recorded by Mauritius, South Africa, Botswana, Rwanda and Burundi with respect to the GCI ranking and the results obtained from our efficiency estimates.

The results of this study showed that 15 countries representing 50% (see Figure 1) were positive in their TFP growth trend (although at a very slow pace) while 15 (50%) of the countries are experiencing deterioration. The TFP pedigree is headed by Botswana, Mauritius and South Africa while the bottom retrogression is led by Tanzania, Togo and Zimbabwe. Pure technical efficiency, efficiency change and scale efficiency in 1999-2011 periods were all at the regressing trend as whereas technological change shows progressive trend though at slow pace too. 14 countries representing 46.7% (with 53.7% lagging negatively) of the countries each have positive trend (though positive at very slow rate) in both pure technical efficiency and scale efficiency. These justify the management failures, low capacity utilization and the undiversified mono-cultural economies currently permeating most SSA countries.

Also, the efficiency change components result shows that only 6 countries representing 20% have positive trend (80% lagging negatively) in the sub-region. This implies that the speed of catch-up within SSA was abysmally low in the 1999-2011 periods, thus the possibility for ultimate convergence in the sub-region going by this pedigree is weak. The six leading countries in the catch-up trend are Mauritius, Botswana, South Africa, Ghana, Burkina Faso, and Mozambique respectively, while the bottom catch-up regressing countries are Ethiopia, Serria Leon, and Zimbabwe.

However, technological change (innovation effect) trend seems to be positive in all the SSA economies under study within the time periods. It justifies the surge in adoption of ICT and positive impact of FDI growth as noted earlier especially between 2000 -2011. Most SSA economies have learnt to appreciate the positive impact of innovation through FDI and are succinctly leveraging on it, which accounted for the positive trend generally in the technological change component though at a marginal rate. The factors associated with nations' TFP and efficiency was determined in this study. Nations' characteristics used in this study were discussed earlier. The work technically used the current globally accepted world economic competitiveness index advocated by the World Economic Forum known as the GCI index which comprehensively cut across twelve pillars. But we choose to use eleven pillars relevant to the study. Regrettably, among the pillar-variables in the model only innovation was statistically significant, though all the variables show a positive sign with efficiency (negative with inefficiency). Variables such as institution, infrastructure, macroeconomic environment, health and primary education, higher education and training, good market efficiency, labour market efficiency, financial market development, technological readiness, and market size are all insignificants.

The bottom line of the analysis therefor is that, since all the identified variables signed positively with efficiency, the challenges before the sub-region for her to assume the epic centre of the world economy given the opportunities of the 21st century, conscious effort must be geared towards improving on the variables beyond the conventional wisdom of the fundamental macroeconomic objectives. The inference from this work totally agreed with Rodrik, 2011 which advocated that Africa (Sub-Saharan) and Asia have the potential to become the epicentre of the global economy in the current trend if they could fully unlocked these potential and turn it into historic outcomes. This could be attainable if Africa and Sub-Saharan Africa in particular can leverage on these opportunities of the 21st century to turn around the weak situation of the institution, infrastructure, macroeconomic environment, health and primary education into a viable and resilient one that can provoke sustained growth, efficiency and best practice competition. Also, the current fragile position of higher education and training, goods market efficiency, labour market efficiency, technological readiness and market size deserved conscious surgery to enhance efficiency not to talk of innovation, which remains the major driver of the economy.

Comprehensively, if these pillar-variables enveloped in basic requirement (factor driven), efficiency enhances and innovation driven are thoroughly addressed, the overall economic performance of Sub-Saharan African economy in terms of technical efficiency of factors, rate of growth in efficiency (catch-up or convergence), technical change and total factor productivity (TFP) change could witness a positive dramatic turn around and all things being equal Sub-Saharan Africa would claim the 21st century by assuming the epicentre of the global economy.

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## APPENDIX

**Appendix 1**
**African Performances in Each Pillar of the GCI for 2011**

| Country | INST | INFR | MCRE | HPE | HET | GME | LME | FMD | TR | MS | BST | INOV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rank | Rank | Rank | Rank | Rank | Rank | Rank | Rank | Rank | Rank | Rank | Rank |
| Angola | 119 | 136 | 122 | 139 | 138 | 133 | 87 | 134 | 130 | 64 | 139 | 133 |
| Benin | 87 | 113 | 82 | 108 | 112 | 100 | 85 | 95 | 122 | 124 | 99 | 60 |
| Botswana | **32** | 84 | 74 | 114 | 94 | 58 | 61 | 47 | 99 | 102 | 104 | 74 |
| Burkina | Faso | 90 | 134 | 98 | 135 | 135 | 120 | 91 | 128 | 124 | 119 | 137 |
| Burundi | 138 | 132 | 121 | 120 | 139 | 137 | 81 | 139 | 137 | 137 | 138 | 134 |
| Cameroon | 107 | 126 | 53 | 116 | 117 | 119 | 99 | 123 | 118 | **91** | 116 | 95 |
| Cape Verde | 56 | 109 | 102 | 88 | 109 | 111 | 122 | 104 | 79 | 139 | 131 | 117 |
| Chad | 135 | 137 | 134 | 138 | 136 | 138 | 95 | 137 | 138 | 120 | 133 | 115 |
| Cote d'Ivoire | 133 | 99 | 94 | 136 | 116 | 118 | 105 | 112 | 102 | 94 | 112 | 109 |
| Ethiopia | 59 | 115 | 127 | 119 | 129 | 92 | 72 | 121 | 133 | 79 | 123 | 105 |
| Gambia, | the | 37 | 69 | 117 | 124 | 103 | 66 | 16 | 76 | 97 | 138 | 65 |
| Ghana | 67 | 106 | 136 | 122 | 108 | 75 | 93 | 60 | 117 | 83 | 97 | 99 |
| Kenya | 123 | 102 | 128 | 121 | 96 | 88 | 46 | **27** | 101 | 74 | 62 | 56 |
| Lesotho | 100 | 120 | 77 | 131 | 124 | 84 | 86 | 114 | 129 | 135 | 114 | 113 |
| Madagascar | 129 | 130 | 112 | 103 | 128 | 107 | 67 | 131 | 123 | 110 | 124 | 102 |
| Malawi | 52 | 131 | 135 | 125 | 120 | 85 | 50 | 64 | 121 | 127 | 89 | 72 |
| Mali | 109 | 121 | 65 | 134 | 132 | 124 | 121 | 133 | 128 | 117 | 128 | 91 |
| Mauritania | 116 | 122 | 118 | 127 | 137 | 131 | 114 | 138 | 132 | 130 | 134 | 132 |
| Mauritius | 43 | 58 | 62 | 59 | 70 | 31 | 59 | 29 | 61 | 112 | 47 | 82 |
| Mozambique | 99 | 119 | 104 | 133 | 134 | 112 | 116 | 116 | 113 | 113 | 110 | 84 |
| Namibia | 38 | 54 | 40 | 112 | 111 | 56 | 55 | 24 | 88 | 114 | 88 | 96 |
| Nigeria | 121 | 135 | 97 | 137 | 118 | 87 | 74 | 84 | 104 | 30 | 76 | 98 |
| Rwanda | 19 | 101 | 106 | 111 | 121 | 70 | 9 | 69 | 100 | 128 | 94 | 71 |
| Senegal | 76 | 112 | 89 | 118 | 110 | 79 | 109 | 107 | 93 | 105 | 84 | 55 |
| South Africa | 47 | 63 | 43 | 129 | 75 | 40 | 97 | 9 | 76 | 25 | 38 | 44 |
| Tanzania | 83 | 128 | 115 | 113 | 133 | 108 | 77 | 90 | 131 | 81 | 98 | 86 |
| Uganda | 104 | 127 | 114 | 117 | 127 | 117 | 27 | 72 | 112 | 92 | 120 | 104 |
| Zambia | 65 | 118 | 120 | 128 | 114 | 65 | 107 | 49 | 110 | 111 | 90 | 80 |
| Zimbabwe | 105 | 129 | 139 | 126 | 115 | 130 | 129 | 105 | 135 | 134 | 119 | 122 |
| Global Leader | SGP | HKG | BRN | BEL | FIN | SGP | SGP | HKG | SWE | USA | JPN | USA |

*Note*. BEL=Belgium, BRN=Brunei Darussalam, FIN=Finland, HKG=Hongkong, JPN= Japan, SGP=Singapore, SWE=Sweden, USA= the Unites States. Adapted from World Economic Forum Report, 2011/2012.

## Appendix 2
## The Evolution of Key Sectors and Sub-Saharan Africa's Performance: World Market Shares, by Industry and Region (1995–97 and 2006–08)

| | Light Manufacturing | | Heavy Manufacturing | | Agricultural commodities | | Agribusiness | | Mining | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1995–97 | 2006–08 | 1995–97 | 2006–08 | 1995–97 | 2006–08 | 1995–97 | 2006–08 | 1995–97 | 2006–08 |
| **East Asia and Pacific** | 14.9 | 25.1 | 5.3 | 13.8 | 10.2 | 9.6 | 10.0 | 12.2 | 6.1 | 7.6 |
| **Europe and Central Asia** | 3.3 | 5.6 | 1.5 | 3.3 | 11.9 | 12.0 | 3.5 | 5.3 | 9.8 | 13.0 |
| **Latin and Central America** | 3.6 | 3.4 | 3.4 | 4.0 | 12.9 | 10.8 | 10.9 | 12.6 | 8.1 | 8.2 |
| **Middle East and North Africa** | 0.7 | 0.9 | 0.2 | 0.3 | 3.0 | 6.7 | 1.3 | 1.8 | 4.2 | 5.1 |
| **NON-OECD** | 12.3 | 7.3 | 10.8 | 11.3 | 1.7 | 9.9 | 5.6 | 3.5 | 15.4 | 19.1 |
| **OECD** | 61.6 | 53.2 | 78.1 | 66.3 | 52.4 | 45.6 | 65.5 | 60.8 | 52.1 | 41.3 |
| **South Asia** | 2.7 | 3.6 | 0.3 | 0.6 | 2.5 | 2.7 | 1.7 | 2.2 | 1.0 | 1.9 |
| **Sub-Saharan Africa** | 0.9 | 0.9 | 0.3 | 0.4 | 5.4 | 2.7 | 1.5 | 1.7 | 3.4 | 3.8 |
| **Total** | **100.0** | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |

*Note*. Adapted from UN Cimtrade database, World Bank Calculations, in World Economic Forum, 2011/2012

## Appendix 3
## Malmquist Productivity Index of the Selected SSA Country

| Country | Pure efficiency change (PEFCH)[1] | Scale efficiency change (SEFCH)[2] | Efficiency change (EFFCH) [Catch-Up Effect] [3]=[1]X[2] | Technical change (TCHACH) [Frontier-shift][4] | Total factor productivity change (TFPCH) [5]=[3]X[4] |
|---|---|---|---|---|---|
| **ANGOLA** | 0.974 | 0.997 | 0.997 | 1.021 | 1.018 |
| **BENIN** | 0.987 | 1.001 | 0.988 | 1.021 | 1.009 |
| **BOST** | 1.085 | 1.028 | 1.116 | 1.023 | 1.142 |
| **B/FASO** | 1017 | 1.003 | 1.02 | 1.021 | 1.041 |
| **BURUND** | 0.82 | 1.049 | 0.861 | 1.014 | 0.873 |
| **CAMERON** | 0.988 | 0.992 | 0.98 | 1.024 | 1.004 |
| **CHAD** | 1.017 | 0.964 | 0.981 | 1.019 | 0.999 |
| **CODT/V** | 1,088 | 0.915 | 0.995 | 1.019 | 1.014 |
| **ETHIOP** | 1.009 | 0.981 | 0.99 | 1.006 | 0.996 |
| **GHANA** | 1.083 | 0.978 | 1.05 | 1.002 | 1.052 |
| **GUEANE** | 1.182 | 0.842 | 0.995 | 1.025 | 1.02 |
| **KENYA** | 0.957 | 0.979 | 0.937 | 1.107 | 0.953 |
| **MADA** | 0.945 | 0.973 | 0.93 | 1.02 | 0.949 |
| **MALAWI** | 0.993 | 1.001 | 0.984 | 1.019 | 1.013 |
| **MALI** | 0.977 | 1.001 | 0.978 | 1.021 | 0.999 |
| **MAURIT** | 0.898 | 1.013 | 0.91 | 1.014 | 0.922 |
| **MAURTUS** | 1.12 | 1.33 | 1.35 | 1.021 | 1.371 |
| **MOZAM** | 1.031 | 1.025 | 1.057 | 1.019 | 1.077 |
| **NAMIBIA** | 0.978 | 0.98 | 0.959 | 1.022 | 0.98 |
| **NIGER** | 0.923 | 0.966 | 0.891 | 1.025 | 0.905 |
| **NGR** | 0.921 | 1.029 | 0.948 | 1.006 | 0.954 |
| **RUWANDA** | 1 | 0.991 | 0.991 | 1.02 | 1.01 |
| **SENEGAL** | 0.978 | 0.979 | 0.958 | 1.019 | 0.976 |
| **SERR/LEON** | 0.832 | 1.005 | 0.837 | 1.016 | 0.85 |
| **S/A** | 1 | 1.02 | 1.03 | 1.021 | 1.05 |
| **TANZA** | 0.976 | 0.982 | 0.958 | 1.018 | 0.975 |
| **TOGO** | 0.902 | 1.014 | 0.915 | 1.019 | 0.933 |
| **UGANADA** | 1.006 | 0.979 | 0.985 | 1.021 | 1.016 |
| **ZAMB** | 1.001 | 0.992 | 0.993 | 1.02 | 1.013 |
| **ZIMBAB** | 0.828 | 1.027 | 0.851 | 1.02 | 0.868 |
| **MEAN** | **0.0979** | **0.0991** | **0.0967** | **1.016** | **0.0982** |

*Note*. Authors' computation using DEA 2.1

### Appendix 4
### Malmquist Productivity Index Annual Mean from 1999 to 2011 of SSA

| Year | Pure efficiency change (PEFCH)[1] | Scale efficiency change (SEFCH)[2] | Efficiency change (EFFCH) [Catch-Up Effect] [3]=[1] X[2] | Technical change (TCHACH) [Frontier-shift][4] | Total factor productivity change (TFPCH) [5]=[3]X[4] |
|---|---|---|---|---|---|
| 1999-2000 | 0.0961 | 1.002 | 0.0981 | 0.922 | 0.0904 |
| 2000-2001 | 0.0873 | 0.0916 | 0.0799 | 1.18 | 0.0943 |
| 2001-2002 | 1.0095 | 0.0963 | 1.0054 | 0.944 | 0.0995 |
| 2002-2003 | 1.0080 | 0.0945 | 0.0952 | 0.974 | 0.0927 |
| 2003-2004 | 0.0981 | 1.006 | 1.004 | 0.991 | 1.003 |
| 2004-2005 | 0.0835 | 1.10 | 0.0919 | 1.084 | 0.096 |
| 2006-2007 | 1.0194 | 0.0899 | 1.0074 | 0.934 | 1.003 |
| 2007-2008 | 1.0032 | 1.0032 | 1.0067 | 0.964 | 1.029 |
| 2008-2009 | 0.0909 | 1.0045 | 0.0949 | 0.922 | 0.0942 |
| 2009-2010 | 0.0955 | 0.0886 | 0.0846 | 1.252 | 1.0059 |
| 2010-2011 | 0.0918 | 1.0047 | 0.0961 | 1.001 | 0.0962 |
| 2011-2012 | 0.0986 | 0.0978 | 0.0963 | 1.031 | 0.0994 |
| Mean | 0.0979 | 0.991 | 0.0967 | 1.016 | 0.0982 |

*Note*. Authors' computation using DEA 2.1