“Knowledge and economic growth: a comparative analysis of three regional blocks in sub-Saharan Africa”

AUTHORS	Agyapong B. Gyekye Emmanuel K. Oseifuah https://orcid.org/0000-0002-5362-3514

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Agyapong B. Gyekye (South Africa), Emmanuel K. Oseifuah (South Africa)

Knowledge and economic growth: a comparative analysis of three regional blocks in sub-Saharan Africa

Abstract

This study attempts to make diagnosis of the progress of the three sub-regions of Saharan Africa (East and Central Africa, West Africa and Southern Africa) in the transition towards knowledge based economies, and to assess whether transition to knowledge based economy improves the sub-regions' economic performance. The authors adopt the World Bank KAM (Knowledge Assessment Methodology) developed in the institution's Knowledge for Development (K4D) and the database available on the web page of the World Bank as well as other sources. The KAM methodology was used to examine the state of knowledge in the SSA region with the view to identifying the differences among the three sub-regions in terms of their transition to knowledge economy. Using the data on knowledge economy index (KEI) it is found that compared to the rest of the world, the knowledge economy development in most SSA countries is still in its infancy. At the sub-regional level however, the Southern African sub-region outperforms the West and East & Central African sub-regions, with few countries in the Southern African sub-region, notably Mauritius and South Africa, close to being in the transitional phase of the progress towards knowledge economy. In a similar fashion, in respect of knowledge index (KI), the West African and the East and Central African sub-regions lag significantly behind their Southern African counterpart. Our statistical analysis finds that knowledge economy index is a significant predictor of GDP per capita growth. The authors finally provide recommendations on how to close the knowledge gap in the SSA region through, in particular, the development of education and skilled work force by investing in scientific research and technological development, as well as efficient innovation system and information and communications strategy, and by strengthening the economic and institutional regimes in the SSA region.

Keywords: knowledge based economy, knowledge assessment methodology, knowledge index, knowledge economy index, economic growth.
JEL Classification: O31.

Introduction

The phenomenon of globalization and its concomitant changing of the world economy are driving a transition to knowledge based economies (UNESCO, 2005). A knowledge based economy, according to the World Bank (2007), is one that uses knowledge as the primary engine of economic growth. Essentially, it is an economy in which knowledge is acquired, created, disseminated, and used effectively to enhance economic development. In particular, developing countries need knowledge based economies, not only to build more efficient domestic economies, but to take advantage of economic opportunities outside their own borders. The application of knowledge, as manifested in areas such as entrepreneurship and innovation, research and development and in peoples' education and skills levels, is now recognized to be one of the key sources of growth and competitiveness in the global economy (World Bank Institute, 2007). However, many developing countries, in particular, sub-Saharan African countries are yet to tap into the vast and growing stock of global knowledge largely due to their limited awareness, poor economic incentives, and weak institutions (Anyawu, 2012). By building their strengths and by carefully planning appropriate investment in human capital, effective institutions, relevant technologies and innovation and competitive enterprises, sub-Saharan African countries can benefit from the knowledge revolution and make the transition to a knowledge economy.

Knowledge economy is regarded as an economy where knowledge is the main engine of growth. A knowledge based economy can be described in more broad terms as the creation of any new knowledge and use of existing knowledge to do things better. The OECD (1996) defines knowledge economy as economies which are directly based on the production, distribution and use of knowledge and information. A knowledge based economy also has been defined as one that encourages its organizations and peoples to acquire, create, disseminate and use (codified and tacit) knowledge more effectively for greater economic and social development (Dahlman and Anderson, 2000; Dahlman and Utz, 2005; World Bank Institute, 2007). Others refer to a knowledge based economy as one in which the production, distribution, and use of knowledge is the main driver of growth, wealth creation, and employment across all industries (UNESCO, 2004).

Objectives and scope

Despite the acknowledged importance of the development of knowledge based economy on economic ad-

Agyapong B. Gyekye, Professor Emeritus, Department of Economics, School of Management Sciences, University of Venda, South Africa.
Emmanuel K. Oseifuah, Associate Professor, Department of Accounting and Auditing, School of Management Sciences, University of Venda, South Africa.

vancement of countries, there have not been many studies that link knowledge, in its broadest definition, to economic performance of sub-Sahara Africa. Furthermore, with the current push for inter-regional cooperation for African development, an assessment of the relative strengths among the regions with regard to the state of knowledge index becomes imperative. The purpose of this study therefore is to undertake an analysis on the utilization of knowledge as a catalyst for improved performance in the economies of the sub-Saharan African regions. The specific objectives are:

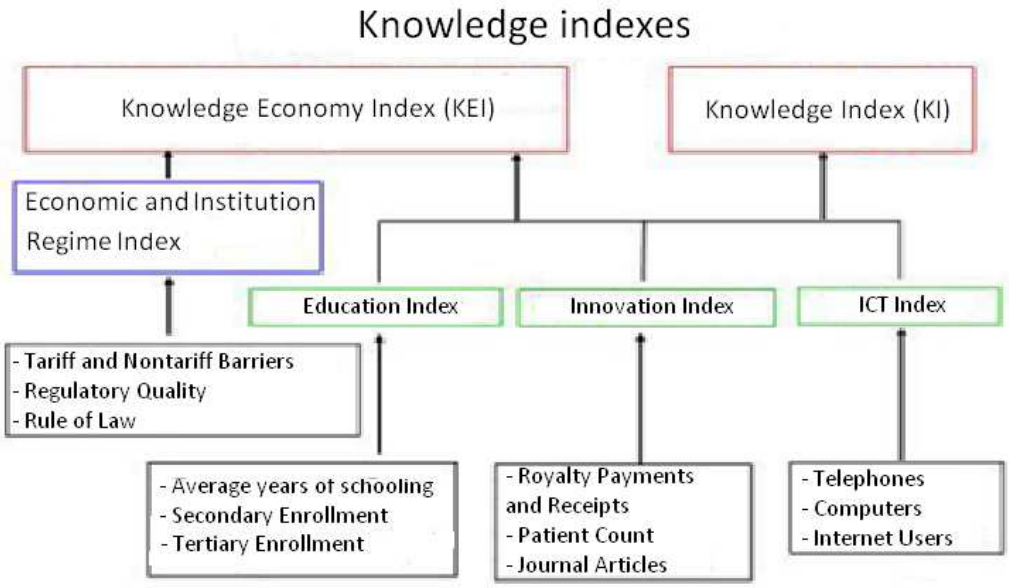
1. To analyze the performance of sub-Saharan African countries on the critical pillars of knowledge index.
2. To undertake comparative analysis of the impact of knowledge on 3 sub-Saharan African regional groupings of countries i.e. Southern Africa, West Africa, Eastern and Central African regions.
3. Empirically assess the impact of knowledge on economic growth.
4. To provide recommendations from the findings.

Based on the objectives above, the hypotheses for the study were as follows:

- Regions with high knowledge index perform better than those with low knowledge index.
- There is a positive relationship between knowledge and economic growth.

1. Literature review

The definition of knowledge for this study and the subsequent comparative analysis among the regions in sub-Saharan Africa thereof, is adopted from the World Bank (2007) knowledge economy framework which categorizes knowledge into three knowledge pillars – education, innovation, and information and communications technology, which together with the economic and institutional regime of a country constitute a knowledge economy of the country (Figure 1).



Source: Adapted from World Bank Institute (2007).

Fig. 1. Knowledge indexes

There is significant body of theoretical and empirical literature on the link between economic growth and effective innovation system, an educated and skilled labor force, information and communications technology infrastructure, conducive economic and institutional regime. We elaborate in detail on each of the knowledge economy pillars in this section. We also briefly review empirical literature that shows that all of the pillars are important determinants of long-term economic growth, thereby lending empirical support to the knowledge economy framework.

1.1. An effective innovation system. For a long time economists have been interested in the role of innovation in the economic development or growth. In the neoclassical framework, the impact of innovation is treated as Solow residual and hence a key contributing factor to economic progress (Solow, 1957; Fagerberg, 1994). An innovation system refers to the network of institutions, rules and procedures that influences the way by which a country acquires, creates, disseminates and uses knowledge. Institutions in the innovation system include universities, public and private research centers and policy think tanks. Nongovernmental organizations and the government are also part of the innovation system to the extent that they also produce new knowledge. An effective innovation system is one that provides an environment that nurtures research and development (R&D), which results in new goods, new

processes and new knowledge, and hence is a major source of technical progress. There is by now a substantial empirical literature on the impact of innovation or the generation of technical knowledge on economic growth or productivity growth. For example, Lichtenberg (1992) examined the macroeconomic effect of R&D using national level data. Using cross-sectional data from 98 countries, Lichtenberg estimated directly a non-linear production function that included the rates of investment in labor, physical capital and research as regressors. The results showed that privately-funded R&D investment has positive significant effects on the level and growth rate of productivity. Additionally, it was found that the rate of return to private R&D investment is seven times larger than the return to investment in equipment and structures. In another econometric study, Coe, Helpman, and Hoffmaister (2008) concluded that "there is robust evidence that total factor productivity, domestic R&D capital and foreign R&D capital are integrated (i.e. share a common trend) and that both measures of R&D capital are significant determinants of TFP". From R&D perspective, four factors were found to make a difference among nations: 1) the ease of doing business; 2) the quality of the tertiary education system; 3) intellectual property protection; and 4) the historical origins of the legal system. Gerryts and Buy (2008) studied the link between R&D and innovation in South Africa based on data from the South African Innovation Survey on 2001. The findings suggest that South African enterprises had a relatively high level of innovation with very low innovation costs. In addition, a cross tabulation analysis of the data revealed a significant positive link between innovation and R&D.

1.2. Educated and skilled labor force. A well-educated and skilled population is essential to the efficient creation, acquisition, dissemination and utilization of relevant knowledge, which tends to increase total factor productivity and hence economic growth. Basic education is necessary to increase the peoples' capacity to learn and use information. On the other hand, technical secondary-level education, and higher education in engineering and scientific areas is necessary for technological innovation. Note that the production of new knowledge and its adaptation to a particular economic setting is generally associated with higher-level teaching and research. For example, in the industrial economies, university research accounts for a large share of domestic R&D. Technical secondary-level education is also required for the process of technological adaptation of foreign technologies for use in domestic production processes. Such training is necessary to monitor technological trends, assess what is relevant for the firm or economy, and assimilate new technologies. A more educated population also tends to be relatively more technologically sophisticated. This generates local quality sensitive demand for advanced goods, which in turns tends to stimulate local firms to innovate and design technologically sophisticated goods and production techniques.

More recent theories of economic growth draw attention to endogenous technological change to explain growth patterns in world economies. According to these so-called endogenous growth models championed by Romer (1986), Grossman and Helpman (1991), technological innovation is created by research and development using human capital which is used then in the production of final goods and leads to increase in growth rate of output. At the heart of these endogenous growth models *is the view that differences in innovation capacity and potential are largely responsible for persistent variations in economic performance and hence wealth among nations of the world.* Thus the advent of endogenous growth models with human capital providing externalities have enhanced the role of human capital as a leading factor in explaining economic growth. A variety of empirical cross country studies show a positive relationship between human capital and economic growth. For example, Barro (1991), using crosssection data from 98 countries for the period 1960 to 1985 and 1960 values of school enrollment rates at the secondary and primary levels as proxies for initial human capital, found that both school enrollment rates had statistically significant positive effects on growth of per capita real GDP. Sachs and Warner (1997) also noted that a rapid increase in human capital development results in a rapid transitional growth. Becker et al. (1990) state that higher rates of investment in human and physical capital can result in higher per capita growth. This is because well-developed human capital leads to improvement in productivity and in growth rate and investment ratio. According to Barro (1997) investment in human capital in the form of secondary and higher education are highly significant in their effects on potential rates of growth. The better and more highly trained the workforce, the more productive it will be in helping to enhance the rate of annual real output in a society. At the same time, the lower the rate of population increase relative to the rate of growth in the capital supply, the more capital can be invested per worker to increase the average output of each member of the work force. Other studies that support Barro's assertion include Mankiw et al. (1992) and Agiomirgianakis et al. (2002).

1.3. An adequate information and communications technologies (ICT) infrastructure. Information and communications technologies (ICT) infrastructure in

an economy refers to the accessibility, reliability and efficiency of computers, phones, television and radio sets, and the various networks that link them. The World Bank Group defines ICT to consist of hardware, software, networks, and media for collection, storage, processing transmission, and presentation of information in the form of voice, data, text, and images. They range from the telephone, radio and television to the Internet (World Bank, 2007). ICTs are the backbone of the knowledge economy and in recent years have been recognized as an effective tool for promoting economic growth and sustainable development. With relatively low usage costs and the ability to overcome distance, ICTs have revolutionized the transfer of information and knowledge around the world. Over the past decade, there has been a series of studies that show that both ICT production and ICT usage have contributed to economic growth (Oliner et al., 2000).

ICT producing sectors have experienced major technological advancements, which have showed up as large gains in total factor productivity at the level of the economy. As for the non-ICT producing sectors, investment in ICT has resulted in capital deepening, and hence increases in labor productivity (Dalhman and Utz, 2005). More importantly, various studies have produced empirical evidence suggesting that substantial productivity gains have been experienced from ICT usage (Oliner et al., 2000). One of the most obvious benefits associated with ICT usage is the increased flow of information and knowledge. ICTs allow information to be transmitted relatively inexpensively and efficiently (in terms of cost), ICT usage tends to reduce uncertainty and transactions costs of participating in economic transactions. This, in turn, tends to lead to an increase in the volume of transactions leading to a higher level of output and productivity. Moreover, with the increased flow of information, technologies can be acquired and adapted more easily again leading to increased innovation and productivity (Karagiannis, 2007; Piatkowski and Ark, 2005). Apart from increasing the supply of information and knowledge, ICTs are able to overcome geographic boundaries. Therefore, international buyers and sellers are increasingly able to share information, reduce uncertainty, reduce transactions costs, and increase competitiveness across borders, all of which results in a more efficient global marketplace. Also, production processes can be outsourced, based on comparative advantage, across national boundaries resulting in further global efficiency gains. Market access and coverage also tend to expand, along with increased access to global supply chains.

1.4. A conductive economic and institutional regime. The final pillar of the knowledge economy is the economic and institutional regime of the country. The economic and institutional regime of the country should to be such that economic agents have incentives for the efficient use and creation of knowledge, and thus should have well-grounded and transparent macroeconomic, competition and regulatory policies (Dalhman et al., 2005).

A "knowledge-conducive" economic regime should be in general one that has the minimal number of the price distortions. For example, it should be open to international trade and be free from various protectionist policies in order to foster competition, which in turn will encourage entrepreneurship (Sachs et al., 2007). Government expenditures and budget deficits should be sustainable, and inflation should be stable and low (Barro, 1991). Domestic prices should also be largely free from controls and the exchange rate should be stable and reflect the true value of the currency. The financial system should be one that is able to allocate resources to sound investment opportunities and redeploy assets from failed enterprises to more promising ones (Barro, 1995).

The features of a conducive institutional regime include an effective, accountable and corrupt-free government and a legal system that supports and enforces the basic rules of commerce and protects property rights. Intellectual property rights should be also protected and strongly enforced. If intellectual property rights are not adequately protected and enforced, then researchers will have fewer incentives to create new technological knowledge and even in the event that knowledge is created, the lack of intellectual property rights protection will greatly hamper dissemination of such new knowledge (Cohen et al., 2000; Levin, 1987).

This study sought to establish the impact of education and skilled labor force (human capital), innovation, information and communication infrastructure as well as economic and institutional environment, in the context of knowledge economy framework, on the economic performance on sub-Saharan African countries.

2. Methodology

The study employed a number of methodologies to achieve its objectives stated above. First, the study adopted the World Bank's Knowledge Assessment Methodology (KAM), a methodology that is used to generate reports that reveal how an economy compares with other countries/regions on various aspects of the knowledge economy. The KAM methodology is rooted in the knowledge economy frame-

work which maintains that, sustained investments in education, innovation, information and communication technologies, and a conducive economic and institutional environment (the four knowledge economy pillars) will lead to an increase in the use and creation of knowledge in economic production, and consequently result in sustained economic growth (Chen and Dahlman, 2005). The KAM was developed by the World Bank Institute to provide a basic assessment of countries and regions readiness for knowledge economy, and identifies sectors or areas where policy makers may need to focus more attention or further investment.

The KAM is a user-friendly interactive diagnostic tool, designed to help countries and regions understand their strengths and weaknesses by comparing themselves with neighbors, competitors or other countries or regions that they may wish to benchmark themselves against, on the four knowledge economy pillars. The data on which KAM is based are all published by reputable institutions that are at the fore-front of gathering and producing country statistics that are reliable and internationally consistent (World Bank Institute, 2007).

Comparisons in the KAM are made on the basis of 80 structural and qualitative variables that serve as proxies for the four knowledge economy pillars. As the 80 variables contained in the KAM span over different range of values, all variables are normalized from 0 (weakest) to 10 (strongest) and countries or regions are ranked on ordinal scale. The normalization procedure for the KAM is presented in Appendix 1. Comparisons are presented in a variety of charts and figures that show similarities and differences across countries or regions, as presented and discussed in detail below.

2.1. The basic scorecard. One of the more frequently used modes of the KAM is the basic scorecard. The KAM basic scorecard provides an overview of the performance of a specific country or region in terms of all 4 pillars of the knowledge economy. It includes 12 standard variables: 3 Conducive Economic and Institutional Regime variables and 9 (knowledge) Education, Innovation, and Information and Communications Technology variables, with 3 variables representing each of the 3 pillars of the knowledge economy (see Figure 1). The Scorecard is constructed as the simple average of the normalized[1] values of the 12 indicator variables from 0 to 10. A score of 10 implies relatively good development of the four knowledge economic pillars as compared to other countries while a score close to 0 indicates relatively poor development.

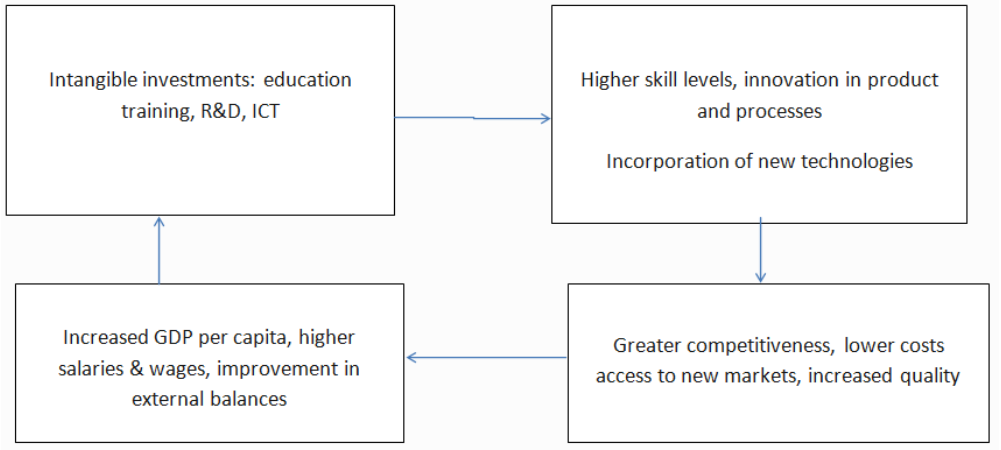
[1] The methodology for constructing normalized values of the variables is found in Appendix 1.

2.2. Knowledge index (KI) versus knowledge economy index (KEI). Knowledge Index (KI) is the simple average of the normalized country scores on the three Knowledge pillars – Education, Innovation, and Information and Communications Technology, while Knowledge Economy Index (KEI) measures performance on all four pillars. The comparisons for the 12 basic scorecard variables can be made for a given year, or for two or more different years, in order to show the movement over time. If a country performs badly over time on a certain normalized variable, this may be attributable to either the country in question has deteriorated in its readiness for the knowledge economy; or the country's improved preparedness for knowledge economy proceeded at a slower pace than the comparison group.

The KAM basic score card can be illustrated in various ways including the spider, diamond, and bar charts. The center of the chart denotes the minimum normalized value of 0, while the outer perimeter of the chart denotes the maximum normalized value of 10. Thus, a "bigger" or "fuller" spider chart implies that the country or region is better positioned in terms of the knowledge economy. The KAM also allows for the basic scorecard of up to 3 countries or 3 regions to be plotted on one chart. Knowledge economy comparisons, among countries and regions can be made by plotting them in a scatter plot based on their relative performance in the KEI for two points in time. Countries or regions appearing above the diagonal line have made an improvement in KEI between the two points in time, and countries or regions appearing below the diagonal line have experienced deterioration in terms of KEI. In this study the KAM methodology was used to compare sub-Saharan African countries grouped by regions (i.e. Southern Africa, West Africa, and Eastern and Central African regions). The list of the countries that made up the three sub-regions are found in Appendix 2.

2.3. Knowledge-based economic growth model. The second methodology employed in the analyzes in the study is estimation of a model based on theoretical and empirical literature and on the hypotheses we presented above. The basic underlying objective of developing knowledge-based economic growth model is to understand the means through which the four pillars of knowledge economy interact to transform knowledge into economic growth. Knowledge is prerequisite for rapid economic advancement in today's global knowledge economy. Knowledge has been variously described as both the foundation and heart and mind of economic advancement (OECD, 1996). Any nation that fails to position itself properly in this global knowledge-based market place, will be

increasingly unable to compete and harness the power of knowledge. Knowledge contributes to economic advancement by serving as the driver of productivity, competitiveness and economic growth through investments in education, training, R&D and ICT, all known as "intangible" investments. Figure 2 illustrates how knowledge manifests itself in economic advancement of a country.



Source: World Bank Institute (2007).

Fig. 2. Knowledge and economic growth

3. Results and interpretations

In this section, we employ the KAM to conduct a benchmarking exercise to compare the three regions of sub-Saharan Africa (SSA) in respect of preparedness for knowledge economy. The section also presents and discusses the results of the statistical estimation of the model on the impact of knowledge on economic growth in sub-Saharan Africa.

3.1. Knowledge readiness of sub-Saharan Africa.

Basic scorecard. As indicated, the KAM basic scorecard provides an overview of the performance of a specific country or region in terms of all 4 pillars of the knowledge economy. The basic scorecard includes 12 standard variables (indicators). Each of the 12 indicators in the scorecard corresponds to one of the 4 pillars. Figure 3 presents the basic scorecard for the three sub-regions of sub-Saharan Africa in a spider web visual representation for 2012.

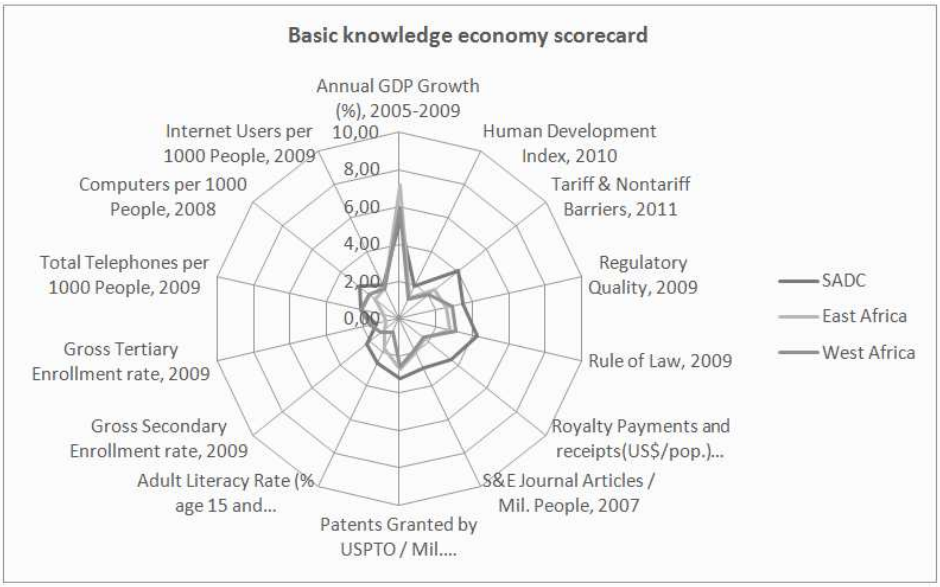


Fig. 3. Basic knowledge scorecard

The centre of the chart denotes the minimum normalized value of 0 while the perimeter of the chart denotes the maximum value of 10. The bigger the value, the better the sub-region is positioned in terms of knowledge economy development. Overall the sub-Saharan African countries performed poorly on all knowledge indicators with the region's performance well below the 50th percentile level in all knowledge economy indicators. On the basis of sub-regional comparisons, the Southern African sub-region outperforms the other two sub-regions (West Africa and East and Central Africa), with the notable exception of

Gross Tertiary enrolment where the West African sub-region fared marginally better than the Southern African sub-region. The highest normalized value of knowledge economy indicator among all the three sub-regions is 4.2 for rule of Law indicator for the Southern African sub-region which implies that SADC as a sub-region ranks in the 42nd percentile among the 128 countries in the KAM database.

Table 1. Selected basic scorecard variables sub-regions in 2012

Variable	West Africa (regional average)	East and Central Africa (regional average)	Southern Africa (regional average)
Average years of schooling	4.42	5.54	6.87
Gross secondary enrollment rate	37.04	34.53	51.5
Gross tertiary enrollment rate	7.32	3.34	7.09
Public spending on education as a percent of GDP	4.38	4.75	5.88
Total telephones per 1000 people	526	258	550
Mobile phones per 1000 people	503	250	494
Computers per 1000 people	40	26	65
Internet users per 1000 people	83	55	70
Royalty payments and receipts (US$/pop)	0.42	0.35	18.34
Technical journal articles/mil people	2.67	4.36	11.2
Tariff and non-tariff barriers (normalized)	2.01	2.73	4.22
Regulatory quality (normalized)	2.88	2.65	3.53
Rule of law (normalised)	3.07	2.73	4.25

Source: Authors' own computations from the World Bank KAM database.

Knowledge Economy Index (KEI). The KEI is the average of the performance scores for a country (or region) in the four pillars of knowledge economy. The KEI as presented in Figure 4 is usually used to visualize and compare countries in terms of their development towards knowledge economy overtime by plotting them (the countries' KEI's) in a scatter diagram based on their performance in KEI for two points in time e.g. 2000 and 2012 years.

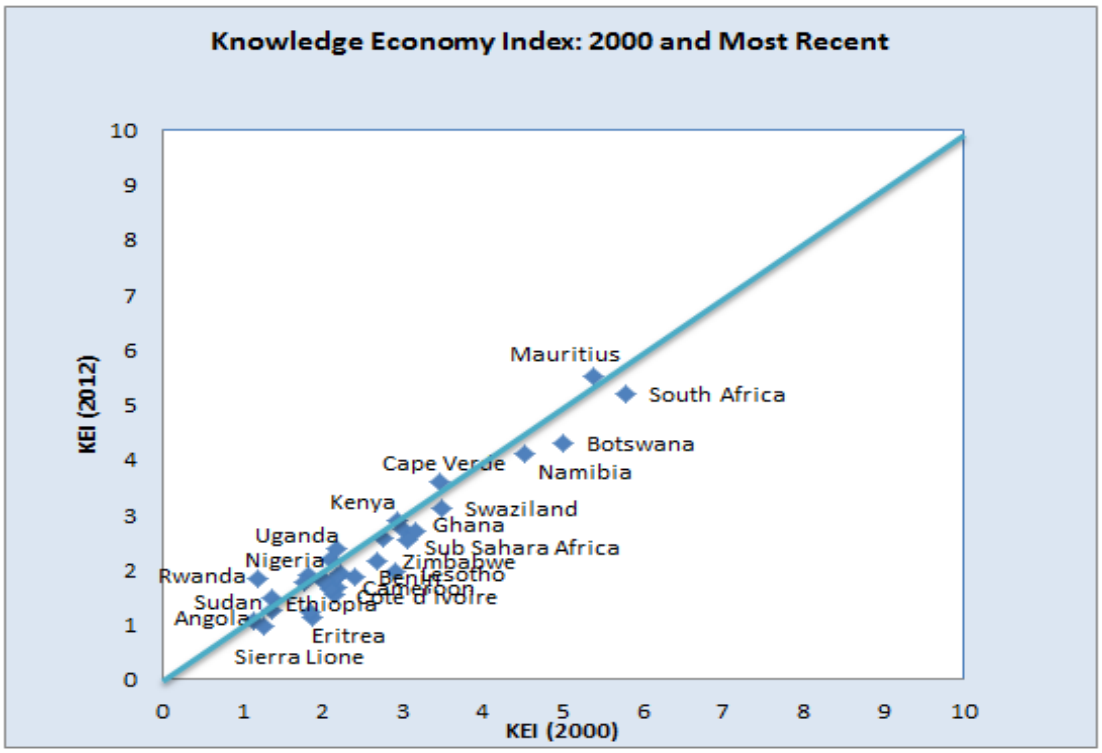


Fig 4. Knowledge Economy Index, 2000 versus 2012

The diagonal line of the diagram represents the locus of points where the KEI values in 2000 and 2012 are equal, and countries that appear above the diagonal line have made improvements in the KE since 2000. On the other hand, countries falling below the diagonal have deteriorated in their KEI over time. Furthermore, countries appearing towards the upper right hand corner of the scatter

diagram are in advanced stages of development of knowledge economy. Countries around the centre of the diagram are midway in the transition to knowledge economy; while countries located in the bottom left portion of the diagram have just embarked on the path to becoming a knowledge economy.

It can be seen from Figure 4 that all sub-Saharan African countries fall between the 10th and 60th percentile for 2000, and between 10th and 55th percentile in 2012. This result implies two things; first, compared to the rest of the world knowledge economy development most SSA countries are still in their infancy, with few countries, notably Mauritius and South Africa close to being in the transitional phase of the journey towards knowledge economy. Second, as alluded to earlier, there was a relative deterioration in sub-Saharan Africa region's development towards a knowledge economy between 2000 and 2012.

Performance of sub-regions on individual knowledge pillars. Figure 5 introduces sub-regional comparisons on the four knowledge economy pillars (economic and institutional regime, education, innovation, and ICT) for the sub-regions of SSA. From the figure, it is evident that the Southern African sub-region dominated the Western and Eastern & Central African sub-regions on all the four knowledge pillars in 2012.

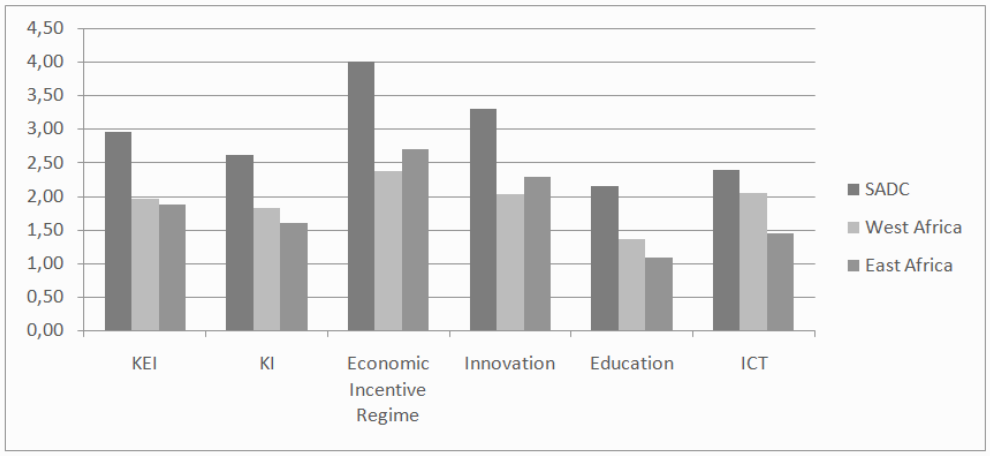


Fig. 5. Sub-regional comparison of knowledge pillars in 2012

In terms of the four individual pillars of the knowledge economy, the three sub-regions comparative performances are as follows.

Education. Figure 5 shows that education is the weakest of the three Knowledge Index (KI) pillars in 2012. This is largely indicative of the poor access to education and training compared to more advanced economies. Among the three sub-regions, the average years of schooling are found to be 4.4 for West Africa, 5.5 for East and Central Africa and 6.8 years for Southern Africa. These figures contrast with an average of 12.2 years for advanced economies. In a similar vein, while secondary enrollment rates are 37, 34, and 51 for Western, Eastern and Central, and Southern Africa respectively, secondary enrolment rate is about 94 for advanced economies. The sub-Saharan sub-regions also trail behind other regions with respect to tertiary enrollment. Although regarded as critical for the development of knowledge economy, tertiary education enrollment in the sub-region is abysmal, with West Africa with enrolment rate of 7.3, followed by Southern Africa with 7.1 and Eastern and Central with tertiary enrollment of 3.3%. In more advanced countries the average tertiary enrolment rate is about 85%. It is also noted that the performance on the education pillar was in retreat between 2000 and 2012 for the Southern African sub-region, while the other sub-regions gained. As stated elsewhere a well-educated and skilled population is essential to the efficient creation, acquisition, dissemination and utilization of relevant knowledge, which tends to increase total factor productivity and hence economic growth.

3.2. ICT. The ICT pillar is the second weakest of the knowledge index pillars. Despite the recent significant telecommunications technology penetration in sub-Saharan Africa, the majority of the region's economies lag behind the rest of the world with the notable exception of the Southern African countries of Mauritius, South Africa and Botswana. The performance of the region is particularly poor with respect to total telephone per 1000 people. While on the average, total telephone per 1000 people is 1470 for advanced countries, the figures for the three sub-regions are 526 for West Africa, 258 for Eastern and Central Africa, and 550 for Southern Africa. The figures for the Southern African countries of Mauritius, Botswana and South Africa are 1150, 1030 and 1030 respectively. To achieve the avowed objective of integrating the economies of the sub-regions, it requires a modern and adequate information infrastructure which aims at

facilitating effective communication, dissemination and processing of information, and knowledge. This is because ICTs play a significant role in the knowledge economies through the reduction of time, distance and transactions costs, as well as widening the market base for those countries' products (Anyawu, 2012)

Innovation. The innovation pillar is the best among the knowledge index pillars for the sub-Saharan African region. Innovation is regarded as the means by which new goods and services are produced to advance economic development. Innovation can be illustrated through scientific and technical journal articles published, royalty payments, or high technology's share in total exports.

On comparative basis, the West African and East and Central African sub-regions lag significantly behind their South African counterpart, as regards innovation. As Table 1 shows, while royalty payments and receipts per capita is less than half US dollar for West Africa ($0.42) and Eastern and Central Africa ($0.35), the corresponding figure for the Southern African sub-region is substantially higher at $18.34 per capita. With respect to scientific and technical journal articles published, the picture remains the same with the South African sub-region outperforming its Western and Eastern and Central African sub-regions. While on the average, technical and journal articles published per million people in the Southern African sub-region is 11.2, the corresponding figures for the Western and Eastern and Central African sub-regions are 2.07 and 4.36 respectively. In comparison to more advanced countries the average royalty payments and receipts per capita are $374.65, while scientific and technical journals articles are 695.99. This indicates that while the South African region is doing well comparatively, the sub-Saharan region still has a long way to go with respect to innovation.

Economic and institutional regime. The economic and institutional regime of an economy needs to be such that it enables the most effective use of resources for the three knowledge index pillars (education, ICT and innovation). In other words, knowledge intensive economic and institutional regime permits economic agents to have incentives for efficient use and creation of knowledge for economic advancement. Among the important measures that characterize conducive economic and institutional regime, and for which data were available for the countries in sub-Saharan Africa, are minimizing tariff and non-tariff barriers for investing in a country or region; reforming and/or strengthening the judicial and legal systems for the protection of investment and to keep law and order; and putting in place transparent regulatory framework.

Table 1 indicates that the South African sub-region again outperforms the Western and Eastern and Central African sub-regions in terms of ranking based on the normalized values of the economic and institutional regime variables in 2012. Thus while the Southern African region ranks in the 40th percentile of world ranking on minimizing tariff and non-tariff barriers, the West an East and Central sub-regions ranked in the 20th percentile in world ranking. In a similar fashion the Southern African sub-region performs better than its counterparts in terms of rule of law characterized by the strength of the judicial and legal systems; as well as transparent regulatory framework.

Knowledge economy and economic performance in the sub-regions of sub-Saharan Africa. A major research question that this study sought to answer is whether knowledge index is a good predictor of economic growth in sub-Saharan African regions. Figure 6 depicts KEI's positive correlation with GDP per capita. The positive correlation however does not establish a causal relationship between the KEI and economic growth.

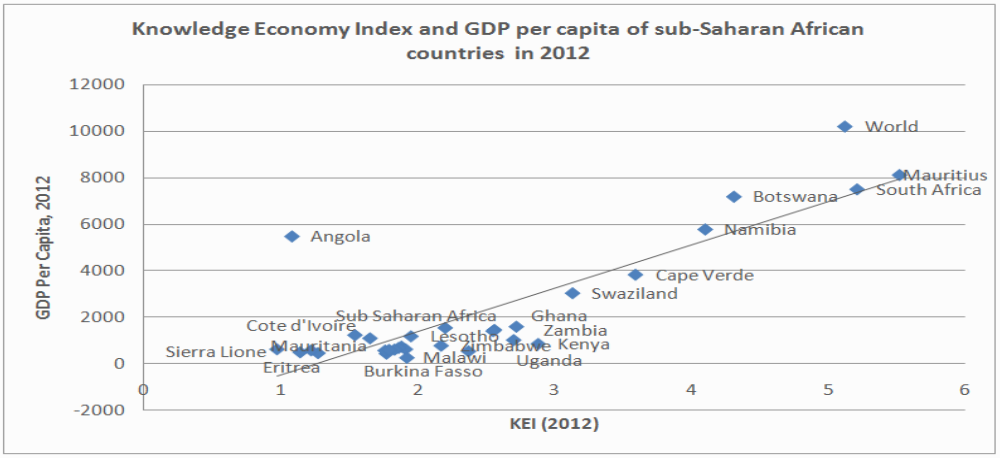


Fig 6. Knowledge Economy Index and economic growth

As shown in Figures 7 and 8, sub-Saharan African countries that score higher on the KEI have higher levels of income (Mauritius, South Africa and Botswana). However as opined elsewhere (World Bank Institute, 2007), it is plausible that relatively high income countries in sub-Saharan Africa, due to their being more affluent, are able to afford more investment in knowledge, although such investment may not necessarily produce the skills level and innovations required to bolster a country's competitiveness and enhance economic growth. Thus correlation by itself does not permit us to predict with any degree of certainty that building certain forms of knowledge in a poor country will produce economic growth anytime very soon.

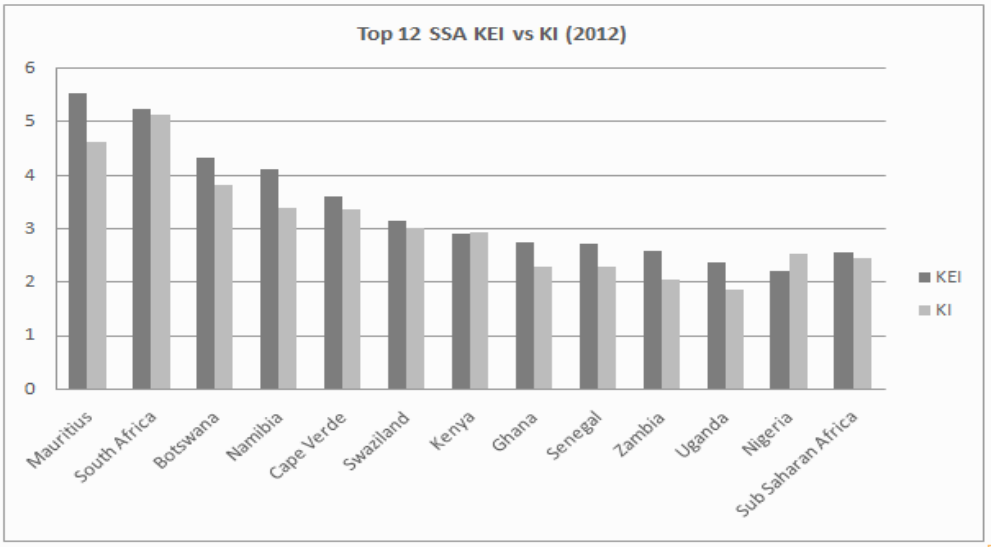


Fig. 7. Top 12 SSA KEI and KI

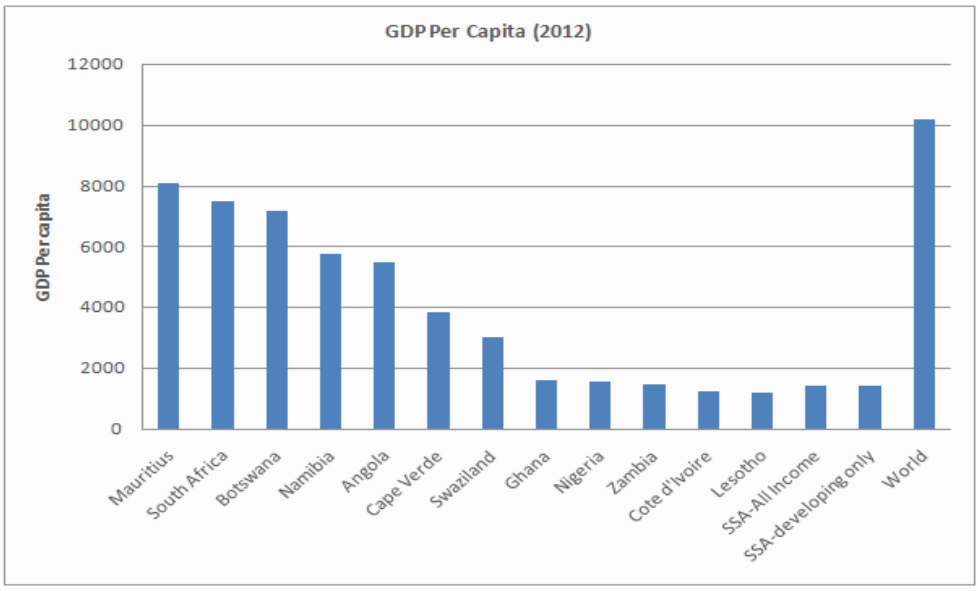


Fig. 8. Top 12 SSA GDP per capita

Rather, it is through statistical tests that we can establish a statistically significant causal relationship from the level of knowledge accumulation as measured by KEI and its components, to GDP growth rates. Table 2 presents the results of the regression analysis to assess the importance of knowledge as measured by KEI (in 2000), and other variables on the future growth of real GDP per capita for the sub-Saharan African countries in the World Bank KAM database and other databases. The data comprise panel data for the period from 2000 to 2012 for the 31 sub-Saharan African countries. The Table indicates that a unit improvement in KEI results in 0.33 percentage increase in future per capita GDP. Other variables whose improvement may lead to future economic performance in the region includes investment rate and degree of urbanization.

Table 2. Regression analysis of the effect of knowledge on future per capita GDP in sub-Saharan Africa, dependent variable is per capita GDP for 2000-2012

Variable	Coefficient	Standard error	t-statistic
Constant	0.022	0.0232	0.95
KEI (2000)	0.326	0.0600	5.43**
Gross fixed capita	0.236	0.0918	2.57**
Formation (investment) rate			
Trade openness	0.366	0.2752	1.33
Degree of urbanization	0.148	0.0382	3.87**
Inflation rate	0.126	0.3818	0.33
R^2 = 0.904, Adjusted R^2 = 0.901, Durbin Watson = 2.128.			

Note: ** Significance at 5% level.

4. Conclusion and recommendations

4.1. Conclusions

Overall the sub-Saharan African countries performed poorly on all knowledge indicators with the region's performance well below the 50th percentile (of Global) level, in all knowledge economy indicators. On the basis of sub-regional comparisons, the Southern African sub-region outperforms the other two sub-regions (West Africa and East and Central Africa). With respect to the development of the knowledge economy, the index (KEI) for most sub-Saharan African (SSA) countries falls between 19th and 60th percentile of the global level, between 2000 and 2012. This result implies that compared to the rest of the world, knowledge economy development in most SSA countries, is still in their infancy, with few countries, notably Mauritius and South Africa close to being in the transitional phase of the journey towards knowledge economy.

Our analysis indicates that education is the weakest of the three Knowledge Index (KI) pillars in 2012. This is largely indicative of the poor access to education and training compared to more advanced economies. As stated elsewhere a well-educated and skilled population is essential to the efficient creation, acquisition, dissemination and utilization of relevant knowledge, which tends to increase total factor productivity and hence economic growth.

The ICT pillar is the second weakest of the knowledge index pillars. Despite the recent significant telecommunications technology penetration in sub-Saharan Africa, the majority of the region's economies lag behind the rest of the world with the notable exception of the Southern African countries of Mauritius, South Africa and Botswana. To achieve the avowed objective of integrating the economies of the sub-regions, it requires a modern and adequate information infrastructure which aims at facilitating effective communication, dissemination and processing of information, and knowledge.

In comparison with the other knowledge indices, the innovation pillar is the best among the knowledge index pillars for the sub-Saharan African region. Innovation is regarded as the means by which new goods and services are produced to advance economic development. Innovation can be illustrated through scientific and technical journal articles published, royalty payments, or high technology's share in total exports. On sub-regional comparison basis however, the West African and East and Central African sub-regions lag significantly behind their Southern African counterpart.

The economic and institutional regime of an economy needs to be such that it enables the most effective use of resources for the three knowledge index pillars (education, ICT and innovation). In other words, knowledge intensive economic and institutional regime permits economic agents to have incentives for efficient use and creation of knowledge for economic advancement. Our analysis showed that the Southern African sub-region again outperforms the Western and Eastern and Central African sub-regions in terms of ranking based on the normalized values of the economic and institutional regime variables in 2012.

Sub-Saharan African countries that scored higher on the KEI in our analysis have higher levels of income (Mauritius, South Africa and Botswana). However as opined elsewhere (World Bank Institute, 2007), it is plausible that relatively high income countries in sub-Saharan Africa, due to their being more affluent, are able to afford more investment in knowledge, although such investment may not necessarily produce the skills level and innovations required to bolster a country's competitiveness and enhance economic growth. Our regression analysis however, established a statistically significant causal relationship from the level of knowledge accumulation as measured by KEI and its components, to GDP growth rates indicating that a unit improvement in KEI results in 0.33 percentage increase in future per capita GDP for the sub-Saharan African region as a whole, confirming that knowledge-based economy is what is needed to bolster the growth performance of sub-Saharan Africa.

4.2. Recommendations

We present below some recommendations for narrowing the knowledge gap in sub-Saharan African region:

1. The importance of education in creating and using knowledge is a generally accepted world-wide norm. Although most countries in the SSA region generally allocate a large proportion of their budgets on education, higher education enrolment, as we found in this research, remains pathetically low by world standards. In particular the low enrolment in Science, Engineering and Technology (SET) creates a situation where many university graduates remain unemployed in the face of shortage of skilled labor. To mitigate this, there is need to forge better university-industry cooperation by appointing private sector/industry representatives on national education and training bodies, as well as on academic advisory councils in universities for curriculum development.
2. The push for accelerated production of new innovation has to be intensified in the SSA region. This can be achieved by collaboration and linkages among universities, research institutions both in the region and other regions of the world, will enable SSA countries to leverage global technological development, to build requisite knowledge. Incentivizing research output by research institutions and universities through research publication output as practiced in South Africa in SAPSE subsidies to research institutions is a step in the right direction.
3. While SSA has witnessed impressive growth in telecommunications, especially in the usage of cellular phone device, the need for more information technologies such as broad band technology to improve internet access becomes imperative. In the world of today, internet technology is required for education, health care, improved productivity, efficient delivery of public services, etc.
4. Finally, in order to narrow the knowledge gap in SSA region, through the pursuance of the above recommendations, countries in the region should improve general governance, and minimize regulatory bottlenecks including laws that hamper investment in innovation and information and communication infrastructure, and attract foreign investment in the knowledge sector.

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Appendix 1. Procedure for constructing the normalized values of variables in KAM

The KAM consists of data from 128 countries for 80 variables, describing the four pillars of knowledge economy. The normalization procedure used in the KAM is as follows (see Chen and Hu, 2006):

1. The raw data (*u*) is collected from World Bank datasets and international literature for 80 variables and 128 countries.
2. Ranks are allocated to countries on the basis of the absolute values (raw data) that describe each and every one of the 80 variables (rank *u*). Countries with the same performance are allocated the same rank. Thus the rank equals 1 for a country that performs the best among the 128 countries, on a particular variable; the rank equals 2 for a country that performs second best, etc.
3. For each country, the number of countries that ranks below it (*Nw*) is calculated.
4. The following formula is employed to normalize the scores for every country on every variable according to their ranking relative to the total number of countries in the sample *(Nc)* with available data:

   Normalized (u) = 10{Nw/Nc}

5. The formula above allocates a normalized score of between 0 and 10 for each of the 128 countries with available data on the 80 variables. 10 is the top score for the top performers and 0 for the worst performers. The top 10% of performers get a normalized score of between 9 and 10, the second best 10% get allocated normalized scores of between 8 and 9, and so on. The 0-10 scale describes the performance of each country on each variable, relative to the performance of the rest of the country sample.

Appendix 2. Countries of sub-Saharan Africa in the KAM database

West Africa: Benin, Burkina Faso, Cape Verde, Cote d'Ivoire, Ghana, Guinea, Mali, Mauritania, Nigeria, Senegal and Sierra Leone.
East and Central Africa: Cameroon, Eritrea, Ethiopia, Kenya, Rwanda, Sudan, Tanzania, Uganda.
Southern Africa: Angola, Botswana, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, South Africa, Swaziland, Zambia, Zimbabwe.