The Role of Knowledge in Economic Growth
The African Perspective

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1. Introduction

In the past few decades where countries have experienced the effects of globalization and technological innovations, knowledge has become the key driver of competitiveness and is now reshaping the patterns of economic growth and development in many developed and developing countries. Knowledge and the ability to take advantage of the existing technology and innovations are at the heart of successful development in these countries, as knowledge and innovation have become more important to international competitiveness and the countries’ growth and development (Dahlman, 2007). Knowledge can contribute to economic and social development through its ability to drive competitiveness and productivity, as a facilitator of welfare and environment and as an enabler of institutions and governance. Knowledge is also crucial in the policy-making process as well as its application of best practices and experiences from elsewhere which could serve as a basis of pragmatic approaches to the design of development strategies and policies. However, knowledge will promote development faster in places that have mechanisms that enable the transfer of ideas from time to time and from place to place as well as across societies and communities (World Bank, 2007).

Despite recognizing that the term knowledge should not only be equated with science and technology, the history of knowledge society discourse has demonstrated a strong bias towards thinking of knowledge as scientific or technological knowledge (Hearn G. and Rooney D., 2008). It is because of these reasons we have knowledge-driven transformation of economic development process leading to what is called the knowledge economy. Knowledge is an important part of the economic activities due to its increasing speed in creation and dissemination and the increasing share of knowledge related activities in production, utilisation and trade. The knowledge economy is based on the creation, dissemination and utilization of knowledge, in which case knowledge assets are deliberately accorded more importance than capital and labour assets and the economy relies on knowledge as the key engine of economic growth. It is an economy in which knowledge is acquired, created, disseminated and applied to enhance economic development. The creation and dissemination of knowledge and technological innovations have been driven by advances in science combined
with the information revolution (Dahlman, 2007). For the knowledge based development process to exist, there is need to have an educated and skilled labour force, a dense modern and intelligent information infrastructure (able to provide necessary services anytime anywhere), an efficient innovation system and an institutional regime that offers incentives for the efficient creation, dissemination and utilization of knowledge (Driouchi et al., 2006).

This paper tries to establish the status of African economies in terms of their transformation to knowledge economies and empirically examine the impact of knowledge and its related variables on economic performance in Africa. The study makes use of the variables identified under the World Bank’s four knowledge economy index (KEI) components which include the economic environment, innovation, education and information infrastructure. These are deemed significant in the development of the knowledge economy, this also takes into consideration the availability of data on these variables on the continent. The next section looks at the theoretical concepts behind the relationship between knowledge and economic growth. After the theoretical underpinnings are explained, we look at the status of African economies in terms of nurturing the foundations that could make them become knowledge economies in relation to other regions and countries such as Korea and China and Singapore. This is done by looking at different policy domains that might be considered core to the knowledge economy. Section 4 delves into the methodology and data used for the analysis in assessing the impact of knowledge on economic growth. Section 5 dwells on the explanation of the econometric results and the last section presents conclusions and policy prescriptions for Africa as well as areas of further research.

2. Theoretical Perspectives to Growth, Trade, Knowledge and Technological Transfer

Traditional theories of international trade have explained trade patterns by appealing to differences in the factor endowments found in various countries or to cross country differences in industry productivity. Recently the earlier models have been extended to allow for multiple industries, factors of production, with emphasis on heterogeneity of firms and imperfect competition. This has been explained through the new trade theories and the new growth theory which are also based on market imperfections. In these theories trade openness leads to gains in trade and productivity, mainly through what are termed static, once-and-for-all gains (which arise as the misallocation of resources under protection and import substitution are corrected) and as the resources are shifted from inefficient to efficient sectors, activities and even firms (Deraniyagala et al., 2001). It is
argued that freer trade by leading to more efficient allocation and use of resources, which is a result of the knowledge and technological gains from trade, permits countries to specialize in production of goods and services in which they possess a comparative advantage and hence resulting in the production of maximum level of output for a given level of inputs, implying higher degree of productivity and economic growth. Most of the countries have achieved this through trade liberalisation policies and this has been supported by the findings of most studies where a significant impact of trade openness on technical efficiency at plant, firm or industrial levels has been observed (Houssain and Karunaratne, 2004; and Karunaratne and Bandara, 2004)

2.1 The New Trade Theory

The economic transition effects from autarky (the closed economy) to the open economy is that exposure to trade induces an increase in productivity levels and average profits per firm. This process is mostly associated with the new trade theory, whose models in general attempt to address the short comings of standard or traditional trade theory by dealing with some of the realities of trade in a more complicated and sophisticated manner by incorporating a fuller number of factors. New trade models incorporate innovations like market imperfections, strategic behaviour and the new industrial economics, new growth theory and political economy arguments.

New trade theory involves informational asymmetries and imperfections which inform so much of the recent innovations within mainstream microeconomics, which is itself usually seamlessly transformed into understandings of the economy as a whole. It also draws upon the new industrial economics, with models incorporating the strategic behaviour of all agents, firms as well as governments. Information asymmetries and adjustment costs are dealt with in models that consider optimal technology choice over time and issues of research and development (R&D) rivalry.

In models involving heterogeneous firms, international trade is found to be a catalyst for inter-firm resource reallocations within an industry, and how these reallocations affect industry performance. Through these models it is argued that trade has both enhanced the growth opportunities of some firms while simultaneously contributing to the downfall and even exit of other firms in the same industry. As protection is reported to shelter inefficient firms, these models reveal that due to exposure to trade, firms that are less productive are forced to exit the industry, and those that are more efficient and productive, self-select
themselves into the export market and become even more efficient as they get exposed to competitive pressure from foreign firms (Tybout, 2001; Melitz, 2003).

This is in line with the trade theory which postulates that export market selection effect and the domestic market selection effect (of exiters) both reallocate market shares towards more efficient firms and contribute to an aggregate productivity gain (Melitz, 2003). The models show also that on the firm level the impact of trade is that trade benefits are not equally spread across firms, and also show that exposure to trade generates the Darwinian evolution\(^2\), in which the most efficient firms thrive and grow as they export and increase both their market share and profits. It is believed that domestic firms enlarge the stock of domestic knowledge as they increase their interaction with foreign markets and it is also shown that exporting activities have some learning externalities that decrease through time and increase with the level of exports (Hoyos et al., 2007). It has also been observed that if foreign markets are characterized by a higher degree of competition than domestic markets, then exporters will be put under very competitive pressures than non-exporters, therefore, increasing their incentives to innovate and be more efficient in order to survive. Hence exporting firms would exhibit higher long term productivity growth than non-exporters as a result of the knowledge acquired in the process through learning by exporting.

These new trade theory models show also that another selection process would occur since only firms with higher productivity levels enter the export markets (Greenway and Kneller, 2004; Baldwin and Gu, 2004). Both of these selection effects (exit and entry to export market), obviously reallocate market shares from less productive firms to more productive ones (who export), and therefore contribute to aggregate industry productivity growth (Pavcnik, 2002). This is supported by the findings of the study by Baldwin and Gu (2004), on the Canadian manufacturing sector, in which it is revealed that as trade barriers fell during the period under consideration, more Canadian plants entered the export market which led to higher productivity growth through increases in plant specialisation, learning by exporting and exposure to international competition as firms were able to exploit economies of scale and became more efficient in production. This is evidence in support of the new trade theory in which it is explained that exporting facilitates transfer of knowledge across countries, and enhances the innovation process among exporting firms. As international trade leads to faster diffusion of technology, and hence higher productivity growth, there are also the spillover effects due to ‘learning by doing’ gains and better management practices triggered by the new technology leading the firms towards

\(^2\) Darwin emphasised the process of entry and exit of firms as they get more exposed to international trade.
the best practice technology (Krugman, 1987). This is also in line with the theoretical conventional arguments relating to trade liberalisation, which stress that through the lowering of export controls trade allows firms and industries to target the export markets, thus widening the markets for domestic products and overcoming underutilization of capacities, if any, due to deficient demand at home. This is envisaged to affect productivity growth positively since it allows producers to reap the benefits of scale and hence reduce costs. This means that firms in more open trade regimes can supposedly operate at lower costs owing to higher levels of output available through their participation in world markets. This argument, however, is based on the assumption that liberalisation necessarily expands increasing returns to scale activities which is at the heart of the new trade theory, while trade protectionist regime increases entrepreneurial slack by reducing competition and increasing relative prices in import-competing sectors (Jenkins, 1995). As trade is expected to increase competition, these increased levels of competition are also expected to generate increased innovative activity and productivity gains across all sectors as competitive pressures lead to greater entrepreneurial effort to increase x-efficiency. Hence trade and trade openness is perceived to have a positive impact on efficiency and growth in the economy.

2.2 Learning and Productivity

Knowledge also plays a key role in determining the survival of economic agents in an economy. Studies have identified two different types of entry-learning processes in the production cycle; learning by selection and by evolutionary adaptation. In the first case, entrants may physically have to be present to learn about their abilities to manage, to master technologies, to engender labour skills and to solve a myriad of other problems that are a prerequisite to success (Baldwin et al., 1995). Entrepreneurs differ in their capabilities and are unsure of their own capabilities before committing resources to new businesses, that is, they do not have very precise information and knowledge on what their costs will be relative to their competitors. It is argued that some firms will be able to master skills required for success better than others, and will start off life with lower costs, a better product and higher profits, implying more efficiency than other firms. And these will be the firms that are expected to survive, while inferior and less efficient firms will be eliminated by natural selection. This means that entry is accompanied by a selection process that will eliminate the more inefficient firms (De Hoyos, 2007; Jovanovic, 1982; Baldwin et al., 1995). As the life cycle progresses and dominant designs emerge, products become homogenous and new entrants could only achieve success by taking customers away from incumbents. Price competition should become more intense, with the less efficient firms being driven out of the market. Learning here
is accompanied by selection, i.e. firms learn about their relative abilities through the selection process after birth. It seems therefore that the effect of exit (due to competitive pressures) and market selection becomes larger as firms age and as their growth rates decline (Baptista et al., 2007).

It is also argued that the relative efficiency of entrants at the time of birth is not as important as is their ability to make progress in reducing the efficiency gap between incumbents and themselves after entry. In this case learning is said to be evolutionary or sometimes referred to as active learning (Baldwin et al., 1995; Olley and Pakes, 1992). While skills may be distributed equally upon entry, there is considerable opportunity to learn and improve performance, and it is this opportunity that leads to success. It is also argued that evolutionary learning occurs in industries where exit is more or less random, and where substantial progress is made on the part of the surviving entrants in closing the initial gap between entrants and incumbents. However, it should be noted that high growth industries are usually overpopulated by many firms with competing product designs and moderate price competition. These industries attract large waves of new entrants, some bringing new innovative and competitive products to the market. And these waves of entry lead to large waves of exits of those competitors that experience a decline in productivity due to competitive pressures.

2.3 The New Growth Theory

Apart from market imperfections and strategic behaviours, the new trade theory has an impact on productivity and growth through its integration with the new growth theory (the endogenous growth theory), which is essentially based also on market imperfections. In endogenous growth theory, the long-run growth rate can be improved by government policy to induce a higher saving rate and/or to incorporate externalities (Deraniyagala and Fine, 2001). Models linking trade and endogenous growth have examined issues of technological and knowledge spillovers, and learning as the key mechanisms through which international trade and endogenous growth have been linked to productivity and economic growth (Grossman and Helpman, 1990; Grossman and Helpman, 1991; Deraniyagala and Fine, 2001). This has been shown to be achieved through how international trade boosts a country’s R&D sector by transmitting technological information, increasing competition and entrepreneurial effort, and expanding the market size in which innovative firms operate. However, trade can also have negative effects on the R&D sector by displacing innovative activities3.

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3 See Grossman and Helpman (1991) for details.
The theory relating trade to growth, postulates that, when trade causes resources to be released from one sector, which then find their way into research activities, the rate of innovation rises, hence productivity and growth. This is supported by the study of Karunaratne (2007), in which efficiency and technology proxies such as intra-industry trade and capital deepening variables were found to be negatively correlated to inefficiency during the study period. The findings give credence to the predictions of endogenous growth theories that openness of the economy provides a conduit for accessing new knowledge and technology that promotes innovation and economic growth. However, it is stressed that, when the sectors that expand in response to trading opportunities compete with the R&D activities for factor inputs, international integration may retard growth as it retards innovation process, implying that firms could experience either increases or decreases in productivity due to international trade. But in developing countries where R&D activities as well as technological developments are very low, the impact of trade openness on growth through its effects on innovation is expected to be very minimal (Grossman and Helpman, 1991).

It is also argued that imported capital goods embody information about new technologies, and producers exposed to this information are seen as more likely to innovate, implying that increased amounts of resources will be devoted to R&D following trade openness. However, this is dependent on the absorptive capacity of countries, hence affecting both productivity and growth.

Trade may also affect productivity through its direct and indirect effects on the innovation process, through the importation or exportation of human-capital intensive goods. Trade may facilitate the transmission of technical information from foreign sources. Grossman and Helpman (1991) show in their models on the impact of trade through international knowledge flows that an integrated economy will enjoy productivity gains through R&D which spur technological progress. It is also shown that if a country imports human-capital-intensive goods after opening up, that country may experience reduction in derived demand for human capital due to international integration, and thereby lowering the cost of innovation, hence promoting efficiency and economic growth. However, it is also possible that trade may impede productivity and growth in a country that exports human capital-intensive goods because the exportable sector draws human capital away from research activities hence retarding innovation and productivity. This is envisaged to be very minimal in less developed countries as most of these countries are importers of these human capital-intensive goods.

The endogenous or new growth theories contend also that the opening of the economy to free trade facilitates the diffusion of new technology through intra-industry trade by promoting horizontal differentiation of inputs and scaling up
product quality (Grossman and Helpman, 1991; Karunaratne, 2001; Deraniyagala and Fine 2001). It is also postulated that this exposure to international competition triggers endogenous R&D and innovation (Karunaratne, 2001; Deraniyagala and Fine 2001). This is empirically supported by the findings of Driffield and Kambhampati (2003) in a study that involved for six Indian manufacturing industry groups. Analysis of the determinants of efficiency reveal that firms with higher market shares were more efficient than others, R&D significantly increased efficiency in three sectors, while higher levels of industry concentration are associated with lower efficiency levels. Due to technological diffusion through intra-industry trade under the new growth theories, it has been argued that technological progress is therefore, not exogenously determined as assumed by the neoclassical (Solow) growth theory, but springs from the inner walls of the industry. The new technology activates learning-by-doing spillover effects and accelerates the process of catch-up with best practice or efficient technology. This means that endogenous or new growth theory through trade liberalisation facilitates the transfer of new technology and knowledge through intra-industry trade and promotes domestic innovation and capital deepening bolstering productivity and technical efficiency in production (Karuranantne, 2001; Hossain et al. 2004). Hence, it has been postulated that trade acts as the conduit for the transfer of new technology and knowledge that increases productivity and growth (Deraniyagala and Fine 2001; Karunaratne, 2007). This is also evidenced by the findings of Karunaratne (2007), in which the technical efficiency dividend reaped by Australian manufacturing industries following the implementation of microeconomic reforms, showed that technical inefficiency had been brought down by the microeconomic reforms, induced trade liberalisation and technology diffusion processes.

It has also been argued that developing countries with high trade restrictions in the past and technologically backward, in such economies the potential gains from exporting as a result of the liberalisation of the economy are large. Exporting offers the maximum scope for the increased discipline of competition and contact with foreign customers, providing maximum scope of learning opportunities (Bigstern et al., 2002). Hence it is argued that if exporting induces efficiency in any environment, it should do so in such economies as well, and if such economies (with small markets for manufactured goods) are to industrialize, it will have to be through learning-by-exporting. However, the limitations of the new trade theory are particularly acute for the developing countries, given their small size, the limited scope for profit shifting, the nature of their trade, and the enhanced possibilities for the capture of trade policy by special interests. Most

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4 Although some studies have argued through the self-selection effects where they use discrete choice models for the decision to export.
studies have concluded that paradoxically, the only point of relevance of the new trade theory to developing countries that does emerge lies in the strengthening of the case for trade liberalisation and, therefore, for a reduced role for government in trade policy\textsuperscript{5}.

2.4 Education, Skills development, Innovation and ICTs

Apart from creating a conducive economic and institutional environment that will enhance knowledge diffusion through trade, there is need to have people with diverse range of skills by making more investments in education, skills development and life-long learning. Advanced skill and higher education play a complementary role to technological advances in this knowledge revolution. Theoretically, higher education allows workers to use existing physical capital more efficiently, it also drives the development and diffusion of new knowledge and technologies and also improves the capacity to imitate and adopt new knowledge and technologies. This implies that developing countries need to expand not only primary education, but also secondary and tertiary education in order to enhance the diffusion and utilization of knowledge for economic development. Increasing higher education will lead to a rapid development and dissemination of knowledge, which will lead to more advances in technological innovation as it is becoming a more critical element of countries’ competitiveness. Firms need to be at least fast imitators and adopt, use and improve new technology in order to remain competitive. Countries should develop capacities to acquire technological knowledge that already exists, be able to create relevant new knowledge and be able to disseminate and use the new knowledge throughout their economies. For all these processes to perform effectively and efficiently there is need for an intelligent, reliable and enabling information infrastructure. ICTs are a critical part of what enables the organization and coordination of global production networks and the integration of global supply chains (Dahlman, 2007). ICTs are a key enabler of business innovation and transformation and play a pivotal role in helping countries’ economic sectors stay ahead and be globally competitive. To achieve this, countries should have a vision of where they want to be as regards the challenges ahead in terms of technological changes and the countries priorities and needs. This calls for collaborative efforts with sectoral champions to enable the adoption of ICTs for greater productivity and economic benefits and for building an inclusive digital society, hence contributing significantly towards growth and development.

\textsuperscript{5} See Alam A., 1994.
3. Africa’s Status Towards the Knowledge Economy

African countries have embarked on different policy initiatives which have had direct and indirect effects on the integration of these countries into the knowledge-based economy. In this section we look at the status of African countries as they transform themselves and integrate into the global knowledge economy in terms of human capacity development to convert knowledge and innovation to growth. Education is the key element of a knowledge-based, innovation driven economy as it affects both the supply and demand for innovation (Dahlman, 2005). Human capital and skilled labour complement technological advances. New technologies cannot be adopted in production without a sufficiently educated and trained workforce. The demand side is also important since innovations may not take place in the absence of educated and therefore demanding customers and consumers. This calls for a critical look at the educational development trends in Africa in order to make sure emphasis is placed on educational levels and skills development that have a significant impact on knowledge and innovation as they contribute to the economies’ growth.

Figure 1.0: Gross Enrolment Ratio - Secondary

Figure 2.0: Gross Enrolment Ratio - Primary

Figure 1.0 shows that Sub-Saharan Africa (SSA) and South Asia regions trail behind all the regions of the world on secondary school enrolment while Latin America and the Caribbean top the regions. The data reveals that the enrolment ratio dropped significantly in all the regions with SSA experiencing a decrease at an average rate of 3.05 percent between 2000 and 2008, while South Asia experienced a drop of 20 percent in the same period.
Interestingly the Figure 2.0 shows that SSA tops all the groups in Primary school enrolment. This shows the extent of the African governments’ efforts in promoting primary education, as it increased at the average rate of 6.4 percent between 1990 and 1999, before decreasing at an average rate of 0.16 percent between 2000 and 2008.

Figure 3.0: Gross Enrolment Ratio – Tertiary Education

With reference to tertiary education, from the Figure 3.0, it is observed that SSA and South Asia again trail below the rest of the regions in terms of tertiary education enrolment which is deemed critical for the development if the knowledge economy. Tertiary enrolment ratio grew at the average rate of 1.3 percent between 2000 and 2008 in SSA. However, in all the regions it is observed that they started experiencing decreases in enrolment in all the three education indicators after 2006. SSA also shows relatively the lowest levels in terms of the number of researchers in R&D per million people, though showing a drop in all the regions especially after 2006, as depicted by Figure 4.0.

Figure 4.0: Number of Researchers in R&D per million people

Figure 5.0: Scientific and Technical Journal Articles
For African economies to remain competitive in the knowledge economy, their innovation systems should be able to convert these countries’ R&D investments and their educational capacities into industrial and export strengths in the high technology sectors (Dahlan et al., 2005). This conversion could be illustrated through the number of patent applications, high technology’s share in total exports and also through scientific and technical journal articles published. With reference to SSA, Figure 5.0 shows that the region produces the lowest number of scientific and technical journal articles in relation to the other regions in the world. Figure 6.0 shows that SSA countries performed relatively better in terms of patent applications by African countries since the early 1970s before slumping significantly in the mid 1990s, after which the SSA countries have not been able to recover. Figure 7.0 reveals that in terms of high technology exports, the SSA countries, on average, have performed relatively better than the Middle East and North Africa and the South Asia regions. However, their technological component in manufactured exports have not been able to surplus that of East Asia and the Pacific and Latin America and the Caribbean Regions.

For countries to integrate in the knowledge economy they also require a modern and adequate information infrastructure which is aimed at facilitating effective communication, dissemination and processing of information and knowledge. ICTs play a significant role in the knowledge economies through the reduction of time, distance and transaction costs as well as the widening of the market base for the countries’ products. The ability to store, share and analyse knowledge through networks and communities using ICTs allows economic agents to exploit the unique properties of knowledge to gain competitive advantage. Despite showing significant increases in mobile technology penetration in Africa, the region still rallies behind the East Asia and Latin America and the Caribbean regions.
4. The Cross-Country Knowledge Impact

4.1 Methodology and Data

In our analysis it is assumed that countries produce wealth based on three independent input aggregates which include knowledge, technology and human resources besides human capital. The knowledge aggregate variable should be able to measure the extent of knowledge acquisition, creation, utilization or use and access in a given country. These will basically encompass issues to do with the economic environment that is favorable to enhancing the above mentioned measures, innovation capabilities, education and information infrastructure, which are deemed crucial in the development of the knowledge economy.

4.1.2 Construction of Variables

With reference to the knowledge economy index developed by the World Bank Institute each of these four components is composed of specific indicators or variables. For example, the KEI components of the economic incentive regime
could include trade policy variables (such as a measure of tariff barriers, trade openness, credit to the private sector and interest rate spread), intellectual property protection regime and government regulation. Trade policy vis-a-vis the level of tariff and non-tariff barriers for a country sheds light on the openness of the economy, while property rights and regulations are two indicators of the extent of protection of intellectual property and regulation of business. Great emphasis should be placed on the degree of openness in international trade and investment for developing countries as it influences overall knowledge diffusion and technology spillovers which are deemed crucial to this study. It has been widely recognized that knowledge and innovation related policies should be at the core of national development strategies, this being the case the World Bank has identified the above mentioned four component pillars upon which these strategies should be built. The variables associated with these components allow the efficient flow of knowledge and also allow researchers to make efficient use of the knowledge base.

Another component in assessing the impact of knowledge is innovation. In order to measure the innovative capacity of a country, it is important to examine the number of R&D personnel since they discover and utilize new knowledge, and are the source of new technologies, while the percentage of manufactured trade in GDP provides an indication of the manufacturing sector (driven by innovation) in promoting a country’s economic growth. The other variable capturing innovation effects in an economy is the number of scientific articles published in technical journals per year and FDI outflows, which indicate the productivity of researchers to come up with the creative and innovative ideas. Countries are expected to have an effective innovation system which involves firms, research institutions, universities, consultants and other organizations that keep up with new emerging knowledge and technology, that are able to tap into the growing stock of global knowledge and be able to adapt and assimilate it into the needs of the local communities in Africa. For most African countries much of the knowledge and technology that nurtures innovation is imported, getting into the countries’ through FDI, imports of equipment and other goods and licensing agreements. However, these imports should not be allowed to obscure or marginalize the countries’ unique indigenous knowledge assets, such as traditional knowledge.

The education component in the knowledge economy indicates the opportunities offered by a country for its citizens to acquire knowledge, and access and utilize the knowledge base. The education component could include variables such as the adult literacy rate, the secondary school enrolment ratio, and the tertiary enrollment ratio representing university and technical education. These variables would capture the capabilities of a country to acquire and utilise knowledge. In
order for a country to remain competitive in the knowledge revolution and withstand technological and economic changes, there is need to have a labour force that is composed of educated and skilled workers who are able to continuously upgrade and adapt their skills to create and use knowledge efficiently. Hence emphasising the significance of higher education.

ICTs play a significant role in the knowledge economies through the reduction of time, distance and transaction costs as well as the widening of the market base for the countries’ products. Given the emergence of ICTs and their rapid expansion in Africa, it is crucial to measure the country’s information technology infrastructure and their role in enhancing knowledge transfer and economic growth. Telephone lines (cellular and land lines), computers, Internet hosts give an indication about the information infrastructure of a country. The rationale is that the use and expansion of these infrastructures are paramount in information transmission and therefore enhancing knowledge and technological access, acquisition and utilisation.

The success of all these components will depend on the country’s institutional regime, and economic incentives it creates. The economic regime should be able to allow the efficient mobilization, allocation and utilization of resources, stimulate entrepreneurship and be able to induce the creation, dissemination and efficient utilization of knowledge. This covers a vast array of issues, ranging from macroeconomic framework, to trade regimes, finance and banking, labour markets and governance.

### 4.2 The Model

The Barro (1991) cross-sectional endogenous growth model was employed to look at the impact of knowledge on the long term average growth rate of African economies. The period averages and initial values were used as replicated by several authors in their studies using the endogenous growth model, since it reduces the shortcomings that come with data errors and poor data availability as is the case with most developing countries in Africa and since growth is inherently a long-term phenomena, the model is envisaged to prove more successful in obtaining sensible and robust estimates. However, we are not primarily interested in examining the issue of ‘convergence’ in income levels as is the case in Barro (1991), but instead, we are interested in finding out whether knowledge acquisition, creation utilization and access (captured by economic incentive regime, innovation, education and information infrastructure variables separately) has led to an increase in economic growth among African countries.
To investigate the impact of knowledge on economic growth, the Barro (1991) model was extended to take care of the effect of knowledge component variables which has the following form:

$$\text{GDP}_i^{9007} = \alpha_0 + \alpha_1 \text{GDP}_i^{90} + \alpha_2 \text{GDI}_i^{9007} + \alpha_3 \ln \text{PS}_i^{90} + \alpha_4 \ln \text{Kv}_i^{9007} + u$$

...(1)

where GDP$_i^{9007}$ is country $i$’s average per capita GDP between 1990 and 2007; GDP$_i^{90}$ is country $i$’s per capita GDP in 1990 to capture the impact of the country’s initial wealth; GDI$_i^{9007}$ is the average of country $i$’s gross domestic investment (GDI) to GDP ratio between 1990 and 2007; PS$_i^{90}$ is country $i$’s gross primary school enrolment in 1990, which is used as a proxy for human capital stock; Kv$_i^{9007}$ is the average of the specific knowledge component variable which is captured by country $i$’s average of specific variables (within the study period) in the four identified knowledge components of economic incentive regime, innovation, education and information infrastructure. The same regression specification was applied to these knowledge components. $\alpha_0$ is a constant representing other factors of production and $\alpha_1, \alpha_2, \alpha_3$ and $\alpha_4$ are elasticities of initial per capita GDP in 1990, investment capital, human capital and knowledge component measures respectively.

Note that in our approach we use the same variables Barro (1991) used i.e. per Capita GDP as a measure of peoples’ living standards, the investment to GDP ratio to measure capital wealth, gross primary school enrolment as a measure of human capital, and the knowledge variables as defined earlier. Our main area of focus is to examine whether the increase in knowledge access, acquisition, creation and utilization have an impact on economic growth of African countries. Our hypothesis is that increased economic incentives for the economies, increased enrolment in higher education, increase in innovative technologies and information infrastructure, which are the foundations for the knowledge economy, should have a positive effect on the countries economic growth.

The Barro (1991) cross-sectional endogenous growth model is used to look at the long-term average growth rates. As regards studies pertaining to economic growth, the endogenous growth model was earlier adopted in a number of studies such as Qiang (2009), Driouch et al. (2007), Waverman, Meschi and Fuss (2005) etc. The model uses trade openness ((imports plus Exports)/GDP) as a proxy for the economic incentive regime together with the interest rate spread (lending
minus deposit rate), domestic credit to the private sector (as a percentage of GDP) and tariff barriers (simple mean tariff for all products); trade in manufactures ((import plus exports of manufacture)/GDP), FDI inflows and outflows and the number of articles in scientific and technical journals as a measure of innovation; literacy rate, gross secondary and tertiary enrolment ratios capture the role of education in the knowledge economy; and number of fixed telephone lines per 100 population, mobile users per 100 population and internet users per 1000 population to capture the impact of technology infrastructure.

Data on the selected the identified knowledge economy and economic growth variables in different African countries are used to investigate the impact of knowledge and technological developments on economic growth. The study employs data from all the African countries excluding Liberia, Eritrea, Somali and Sao Tome and Principe due to the unavailability of data on some variables used in the study. The selection was based on the availability of data on output, investment, human capital captured by school enrolment and the knowledge economy variables. The sources of data for the variables used are the World Bank’s World Development Indicators (WDI) and the Africa Development Indicators (ADI) databases, the UNESCO Institute of Statistics and the World Telecommunication/ICT Indicators Database by the International Telecommunications Union (ITU). The analysis is based on country level panel data, comprising annual series from 1990 to 2008.

5. **Empirical Results**

In the section above, the various hypotheses have been postulated on how the different knowledge components and sub-components or variables impact economic growth. In this section, we examine empirically to what extent knowledge has contributed towards growth in the selected African countries, by estimating the equation above. Based on the availability of data some of the variables that could have been very instrumental in establishing the impact of knowledge on economic growth were not included in the analysis. This was due to the fact that data was not available for most of the countries on the continent, making the model statistically flawed.

As indicated earlier the endogenous growth model is estimated for the four knowledge components, on pooled data covering all the 49 countries involved to capture the specific contributions of the knowledge components to economic growth. Different dynamic specifications, allowing for the inclusion of different
knowledge variables pertaining to the groupings were also explored. The estimated results are presented in the Table 1.0 below.

The table reports the results of the OLS regression on the four knowledge components as well as the diagnostic tests for the models which show that the models are statistically satisfactory at conventional levels of significance. In all the 4 models presented, the results show that the average GDP growth rate between 1990 and 2007 (GDP9007) was positively correlated with initial wealth per capita GDP in 1990 (GDP90), the gross domestic investment (GDI) to GDP ratio (GDI9007), and gross primary school enrolment in 1990 (PS90). Since the average GDP per capita (GDP9007) is positively correlated with the initial level of GDP per capita (GDP90), it means that the results fail to confirm the Barro’s convergence hypothesis with reference to the theoretical notion that poorer countries grow faster than richer countries, implying the absence of convergence in the economies.

Convergence in the neoclassical growth models indicates that per capita growth rate tends to be inversely related to the starting level of output or income per person. In particular if economies are similar with respect to preferences and technology, then poorer economies grow faster than rich ones. Thus there is a force that promotes convergence in levels of per capita product and income (Barro and Sala-i-Martin, 1992). However, our results indicate lack of convergence among African countries, since the convergence coefficient is found to have a positive and highly significant sign in all the four models. That is, there is a tendency for the initially richer countries in Africa to grow faster than the poor ones over the period under study. Since recent endogenous growth theories and technological approaches have argued that rapid growth is a function of both access to new technological ideas and the diffusion of those ideas through the productive structures, this result might imply lack of capital and labour mobility between countries, lack of diffusion of technology or technological transfer from richer to poorer African countries and lack of redistribution of income from relatively rich to relatively poor countries.

Looking at the impact of the economic incentive regime, the results reveal that, apart from the trade openness variable which is found to have a significant positive impact on GDP, the rest of the variables in the economic incentive regime model are found to have a negative or insignificant impact. This result suggests that despite countries experiencing a significant flow or transfer of knowledge and technology into and out of these countries due to countries’ openness, the economic environment within these countries seem not to be conducive for knowledge and technology acquisition, creation and its utilisation.
Trade openness is simply the ratio of exports plus imports to the gross domestic product (GDP). The higher the value of trade share denotes a lower degree of trade distortions, implying that firms can easily import and export, inducing more competition in the economy hence increasing efficiency and productivity. In other words this measures the country’s level of openness.

Table 1.0: Knowledge Impact on Per Capita GDP (1990-2007)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Economic Incentive Regime</th>
<th>Innovation</th>
<th>Education</th>
<th>Information Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>GDP90</td>
<td>0.881 (0.000)***</td>
<td>0.908 (0.000)***</td>
<td>0.805 (0.000)***</td>
<td>0.692 (0.000)***</td>
</tr>
<tr>
<td>GDI9007</td>
<td>0.418 (0.006)***</td>
<td>0.388 (0.007)***</td>
<td>0.44 (0.004)***</td>
<td>0.288 (0.031)***</td>
</tr>
<tr>
<td>PSE90</td>
<td>0.443 (0.010)**</td>
<td>0.348 (0.016)**</td>
<td>0.400 (0.055)**</td>
<td>0.319 (0.026)*</td>
</tr>
<tr>
<td>Interest rate spread 9007</td>
<td>-0.058 (0.410)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private sector credit 9007</td>
<td>-0.006 (0.913)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tariff barriers</td>
<td>0.031 (0.884)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trade openness</strong></td>
<td><strong>0.336 (0.019)</strong>**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Trade in manufactures</td>
<td>-0.020 (0.789)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FDI Inflows</td>
<td>0.200 (0.008)***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FDI Outflows</td>
<td>0.007 (0.872)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scientific &amp; Technical articles</td>
<td>0.012 (0.623)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Literacy rate</td>
<td></td>
<td>0.052 (0.808)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary enrolment ratio</td>
<td></td>
<td></td>
<td>-0.262 (0.055)**</td>
<td></td>
</tr>
<tr>
<td>Tertiary enrolment ratio</td>
<td></td>
<td></td>
<td>0.186 (0.079)*</td>
<td></td>
</tr>
<tr>
<td>Telephone main lines</td>
<td></td>
<td></td>
<td>0.190 (0.025)**</td>
<td></td>
</tr>
<tr>
<td>Mobile subscribers</td>
<td></td>
<td></td>
<td>0.20 (0.019)**</td>
<td></td>
</tr>
<tr>
<td>Internet users</td>
<td></td>
<td></td>
<td>-0.157 (0.080)*</td>
<td></td>
</tr>
<tr>
<td><strong>Constant</strong></td>
<td><strong>-2.222 (0.020)</strong></td>
<td><strong>-2.172 (0.001)</strong>*</td>
<td><strong>-0.491 (0.659)</strong></td>
<td><strong>-0.175 (0.830)</strong></td>
</tr>
<tr>
<td>Number of countries</td>
<td>47</td>
<td>49</td>
<td>49</td>
<td>49</td>
</tr>
<tr>
<td>R²</td>
<td>0.91</td>
<td>0.913</td>
<td>0.900</td>
<td>0.9156</td>
</tr>
<tr>
<td>F-statistic</td>
<td>79.23 (0.000)***</td>
<td>61.14 (0.000)***</td>
<td>61.82 0.000)***</td>
<td>75.94 (0.000)***</td>
</tr>
<tr>
<td>Breusch-Godfrey test</td>
<td>1.568 (0.210)**</td>
<td>0.577 (0.4475)</td>
<td>0.008 (0.9278)</td>
<td>0.363 (0.5466)</td>
</tr>
<tr>
<td>ARCH(1)</td>
<td>0.083 (0.773)</td>
<td>0.235 (0.6275)</td>
<td>0.288 (0.5914)</td>
<td>0.391 (0.5315)</td>
</tr>
<tr>
<td>RESET</td>
<td>1.360 (0.271)</td>
<td>0.900 (0.4497)</td>
<td>1.57 (0.2131)</td>
<td>0.030 (0.9941)</td>
</tr>
</tbody>
</table>

Notes: P-values in parentheses; ***= Significant at 1% level; ** = Significant at 5% level; *= Significant at 10% level.

The variables used to capture the innovation capacity of African countries seem not to have any significant impact on economic growth except for the FDI inflows. For example, trade in manufactures which was incorporated in the model to capture the contribution of the manufacturing sector (driven by innovation) in promoting growth, is found to have a negative but insignificant effect on growth,
which could imply a decimal employment of innovative knowledge and technologies in the sector. This could also be reason why the FDI outflows from these countries do not have a significant impact on growth as well. This could suggest the inability of the innovations sytems in African countries (if at all they exist) to convert R&D investments as well as imported technologies through trade openness and FDI inflows into significant innovative industrial and export outputs. This is also supported by the number of articles published in scientific and technical journals per year, which is found to be positive but statistically insignificant at conventional levels. The result also suggests the lack of researchers’ ability to come up with creative and innovative ideas that could contribute significantly to the countries’ productivity.

The results from the analysis involving variables incorporated in the model to capture the opportunities offered by African countries for their citizens to acquire education and effectively and efficiently access the knowledge base and utilize it are found to have conflicting effects on growth. Literacy rate is found to have a positive but insignificant impact on growth, and secondary school enrolment ratio is found to be negative and significant at 5 percent level, while tertiary education is found to be positive and significant at 10 percent level of significance. The results to a greater extent could be suggesting that African countries are yet to capture the gains from the development of high quality education systems and research networks. The results show that tertiary education has a weak impact on growth implying failure to fully convert or transform technology and knowledge into productive use. While the result for secondary school enrol reveal the little emphasis placed at this education level as compared to primary education.

The results from the analysis of the information infrastructure’s impact on economic growth reveal that mobile telephony and fixed telephone main lines have significant impact on per capita income in Africa, while Internet usage has a negative impact. The results also indicate that the fixed telephone main lines still play a significant role in their contribution towards economic growth in Africa, as the results indicate a highly significant impact on growth. However, the impact of Internet usage seems to have a negative and significant contribution on economic growth among African countries. The results show that continued enhancements of the information infrastructure with investments in ICTs would play a pivotal role in strengthening the countries’ innovation systems and hence knowledge access and utilization and economic growth.

All in all the results suggest that African countries are still lagging behind, and there is need for policies to improve education and the economic incentive regime in order for technological knowledge and innovations to contribute significantly
to economic growth and development. The results are in support of the findings by Driouchi et al. (2006).

6. Conclusions and Policy Prescriptions

This study employs the Barro (1991) approach using 1990-2008 data from 49 African countries to try and examine the impact of knowledge on economic growth. It uses variables associated with the countries’ economic environment, innovation, education and information infrastructure (which are the four World Bank KEI component pillars) to assess the impact of knowledge on economic growth in Africa. The assessment of the most African economies reveals that SSA lags behind most of the other regions especially in relation to variables deemed to be the foundations of the knowledge economy. The results of the econometric analysis reveal that in terms of the economic environment, the African economies are relatively open to allow the flow of knowledge and new technologies to the continent, however, the results suggest that the economic environment inside these economies is not all that conducive to acquisition, dissemination and utilization of new knowledge and technologies due to the unfavourable conditions created by, for example some macroeconomic and fiscal policy variables like interests rates and effective credit opportunities to the economic agents.

The variables incorporated in the study to capture the capability of African countries of tapping the growing stock of global knowledge, assimilating and adapting it to local needs, and creating new knowledge through the countries’ innovation systems reveal that no significant technological innovation developments occurred in Africa during the study period, despite experiencing a significant positive impact of FDI inflows. This could suggest that FDI inflows seem not to have been significantly utilised innovatively to increase production of goods and services that have an impact on growth. This to a certain extent could suggest the inability of the innovation system to transform knowledge and technological investments into productive outputs that have a significant impact on these economies. This is supported by the results from trade in manufactures, FDI outflows and scientific and technical journal articles variables which are employed to capture contributions to growth from innovative technologies developed in the economies. Thi is also supported by the impact of education variables which is the at the core of knowledge access, acquisition and utilization. Education and technological skills enable people to create, share and utilize knowledge, however, the study reveals that the human resource capacity that exists on the continent does not have the required capability to utilize technological knowledge innovatively, efficiently and effectively so that it
contributes significantly to growth. The results suggest that there is need to expand access to educational levels that are critical for knowledge acquisition, creation, dissemination and utilization such as secondary education and particularly tertiary education which are critical in carrying out activities that are crucial for the development of the knowledge economy. There is also need to improve the quality of the whole educational system as well as content and relevance of what is taught, and there is need for a shift from the formal educational system to the development of life-long learning systems, in order to keep pace with the speed in the generation and diffusion of knowledge and technologies.

The results from the information and communication infrastructure variables, (which is needed to facilitate the effective communication, dissemination and processing of information) indicate that telephone main lines and mobile telephony have a significant positive impact on the people’s living standards in carrying out the above mentioned roles in Africa, while Internet usage has a significant negative contribution towards economic growth. This means that despite the spread of fixed main lines and mobile phones on the continent, people as well as enterprises have not maximised the use of these technologies to access the Internet in their business endeavours, and hence enhance knowledge transfer and access. However, SSA still trails behind the other regions in terms of ICT penetration despite the increased penetration over the years.

In general the results show that for African countries to make their economies more productive in the knowledge economy, there is need to direct policy efforts towards restructuring economic incentives that encourage the acquisition, adaptation and utilization of knowledge into productive use. This would be achieved through expanded education and research and development through the development and strengthening of the innovation systems. There is need to put more emphasis on government policy that encourages trade which encourages or facilitates knowledge spillover effects and transfer to African countries. With the required education and skills in the domestic economies, this will lead to the development of technological innovations that will have significant impacts on productivity and growth of African economies.

7. References.


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World Bank (2009), The Little Data Book on Information and Communication Technology, from World Development Indicators, World Bank, Washington D.C.