Innovation and Industrial Development in Africa

Hopestone Kayiska Chavula
ICT, Science and Technology Division (ISTD),
United Nations Economic Commission for Africa (UNECA), Addis Ababa, Ethiopia.
Email: hchavula@uneca.org

Victor Konde
United Nations Economic Commission for Africa (UNECA), Addis Ababa, Ethiopia.
Email: vkonde@uneca.org

Abstract

The paper attempts to explore the role of innovation in industrial and economic development of a country and tries to offer an overview of some of the challenges and key elements that may be significant in building an innovative industrial base in Africa. This is triggered by the belief that poorer developing countries do not exactly depend on innovation to remain competitive on the global market. In other words, innovation is seen as key to advanced economies with sophisticated firms that invest significant resources in research and development (R&D), which is not the case with most developing countries. Hence the processes of technical change led by innovations are usually seen as a privilege of industrialized economies. In this paper, we attempt to show that African countries that seek to develop competitive and sustainable firms or economies have to develop, implement, promote and invest in innovation policies, plans and strategies.

1. Introduction

The relationship between innovation and industrial change dates back to Schumpeter's work in various ways and specifications in several countries. He placed innovation at the center of economic change, initiating simultaneously an evolutionary process of creative destruction or as a process of creative accumulation in industrial development (Malerba, 2004). The importance of industrial development as an engine of economic growth and development cannot be overstated. Virtually all of today's industrialized countries actively supported and protected their industries through specific policies and institutions. Africa will need to design and implement similar industrial development strategies to develop a sound industrial and technological base to enable the continent successfully integrate into the global knowledge economy. The continent's ability to modernize, meet its urgent development needs and priorities, and diversify its economic activities and exports will largely depend on the development of dynamic industries (Marti and Ssenkubuge, 2009).

Currently, many African countries depend on a few low value-added primary commodities that suffer from wide fluctuations in international prices. The current rapid growth in Africa's exports, for instance, has been driven by the high demand for primary commodities on the international market that has driven prices up resulting in favourable terms of trade for many African countries. A fall in demand of primary commodities will therefore have catastrophic socioeconomic impact on the African countries that highly depend on these commodities. Therefore, it is important that Africa makes use of the capital accumulation from the commodities-boom period by investing it in the build-up of ans industrial base that enables a diversification and production f goods and services that could lead to expansion of its export base. It would reduce its dependence on low value-added products, hence create new skills, jobs, work attitudes and institutions that could drive future productivity of African economies (Lall S. and Kraemer -Mbula, 2005).

Cognizant of the critical role that industrial development plays in economic development, various initiatives to spur industrial development on the continent have been undertaken. For instance, the Conference of African Ministers of Industry (CAMI), inaugurated in 1971 under the auspices of the United Nations Industrial Development Organization (UNIDO), created a high-level forum to address industrial development issues that affect Africa. In 1980, the Lagos Plan of Action (LPA) for Economic Development (1980-2000) focused on strategies to foster collective self-reliance and sustainable development on the continent, while in 1981, proposals for an Industrial Development Decade for Africa (IDDA) were adopted at the Sixth CAMI. Under the IDDA, industrialization was observed as a means of attaining self-reliance and self-sustainability as foreseen in the LPA. In 2001, the New Partnership for Africa's Development (NEPAD) adopted a common vision and strategy for the attainment of Africa's sustainable development, and in 2005, the African Union Commission (AUC) and the New Partnership for Africa's Development (NEPAD) adopted Africa's Consolidated Science and Technology Plan of Action (CPA) 2006-2010, which articulates Africa's common objectives and commitment to collective actions to develop and use science and technology for the socio-economic transformation of the continent and its integration into the world economy. It is based on three interrelated pillars of capacity building, knowledge production and technological innovation contributing significantly to the development of the knowledge society on the continent.

In 2008, the Summit of the Heads of State and Government of the African Union was devoted to the issue of industrial development in Africa. The dedication of an entire meeting of Heads of States and Government to industrialization attested to the political will and importance accorded to industrial development. During the Summit, a "Plan of Action for the Accelerated Industrial Development of Africa (AIDA)" was adopted. The Plan was complemented by a Strategy for Implementation, adopted during the 18th CAMI in October 2008.

Notwithstanding all these initiatives and experiments with diverse trade and industrial policies, the contribution of the industrial sector to Africa's growth is well below its envisaged maximum productivity levels. Currently, the continent remains the least industrialized region of the world. For instance, the share of sub-Saharan Africa (SSA) in value-added global manufacturing actually declined in most sectors between 1990 and 2000 (Lall S. and Kraemer-Mbula, 2005) and industrial production and exports in most African economies have declined in relative importance, diversity and sophistication. Africa's share of global manufacturing production (excluding South Africa) fell from 0.4 percent in 1980 to 0.3 percent in 2005 and its share of world manufactured exports fell from 0.3 to 0.2 percent over the same period. Africa's share of manufacturing in GDP is about one third of the average for developing countries. Per capita manufactured output is less than 20 percent while exports are less than 10 percent of the average for developing countries. Currently, Bangladesh alone produces as much manufacturing value added as the whole of sub-Saharan Africa, excluding South Africa (Page, 2010).

Almost two-thirds of Africa's merchandise exports are accounted for by agricultural, fuel and mining products. The continent's post-independence leaders looked to State-led, import substitution industrialization as the key to rapid economic growth (UNECA, 2010). The industries they created, however, were frequently uncompetitive and unsustainable and efforts to spur industrial development largely vanished with the economic crises of the 1980's and 1990's. This to a greater extent is envisaged to have been due to the minimal emphasis placed on science, technology and innovation (STI) in the industries on the continent during the time.

The period between 1980 and 2000 is characterized by the implementation of very unpopular policies to liberalize African economies. In particular, the privatization and liberalization policies promoted by the World Bank and IMF under the Structural Adjustment Programmes (SAPs) which led to the collapse of many uncompetitive state-owned enterprises, relocation of foreign firms and loss of jobs and revenues in many countries. Although there are valid arguments that it could have been implemented with a 'human face', one cannot deny that it's the investments that followed these draconian policies that are now bearing fruits. For example, African exports continued to grow despite a large contraction in 2009 due to the global crisis, as they rebounded by 25 percent in dollar terms in 2010, outstripping world export growth of 21 percent (UNECA, 2012).

As stipulated earlier, one of the elements that was neglected immensely in the 1990s was the promotion of innovation. The budget for education, R&D, subsidies for innovation and technology acquisition, among others, were either eliminated or greatly reduced during the period. A host of institutions and other research centres were required to raise their own funds and expected to expand their private operations to raise funds, with minimal government support.

However, the notion of national industrial policies has made its way back to many African countries, with new and reviewed industrial strategies over recent years. This is an indication that, after swinging between two extreme positions (i.e. the import substitution and structural adjustment policy prescriptions), governments are reflecting on the policy mixes that best suit their current needs (Page, 2010). It has been suggested that the most effective policies in spurring growth seem to be the ones directed at supporting investments in education, training and innovation. This is deemed to be achieved through some selected and targeted policies encouraging experimentation and innovation as the essential ingredients of growth-oriented industrial development (Di Maio, 2008).

The main objective of this paper is to show that African countries which seek to develop competitive and sustainable firms and economies, as well as products and services have to develop, implement, promote and invest in innovation policies, plans and strategies. The paper is structured as follows: Section 2 describes the history behind innovation policy and strategies, Section 3 highlights the current status and the challenges that hinder innovation and the development of a sound industrial base in Africa. It then proceeds to provide framework elements that could be considered by policy makers seeking to promote innovation for industrial development in their countries in Section 4. Each of the elements described includes a number of examples drawn from the experiences of countries inside and outside Africa. Section 5 summarizes the main findings and conclusions.

2. Historical perspectives to innovation and industrial development

Already in the 1970s, it has been widely argued that the dismal performance of the industrial sector has, to a great extent been due to the fact that many of the African firms have been largely passive technology learners that merely focus on adoption and routine operation of externally supplied technologies, especially where technological effort developed is essentially aimed at the absorption of production capabilities. As opposed to active technology learners such as Singapore, South Korea etc., African countries have not built any significant innovation capabilities i.e. the technological effort aimed at mastering the production capability together with the improvement capability (Viotti E.B., 2002; Bell and Albu, 1999). Any domestically generated industrial technological change has been essentially minor, adaptive and routine maintenance involving little or no technological creativity and upgrading. The main technological tasks have been to acquire and learn how to operate

and use the available technologies and undertake investment and production activities. As a consequence, the improvements have been marginal hence they could not compete or keep abreast with dynamic and innovative firms that have been emerging globally.

Recognizing the significance of knowledge and technological innovations, several science and technology (S&T) initiatives have been launched in African countries that sought to use S&T as a vehicle for achieving rapid economic development. During the 1970s, many African countries established national research councils and R&D centres. This development was partly driven by the Conference of Cabinet Ministers responsible for the Application of Science and Technology (CASTAFRICA I) held in Dakar, Senegal in January 1974. Consequently, by the time the second conference was held in 1987, the number of African countries with S&T promotion bodies increased from 4 to 28. Several R&D institutions specializing in natural sciences, agricultural, medical, nuclear, industrial and environmental research also increased rapidly on the continent. Almost all of these institutions were government-funded and were predominantly geared towards agricultural and primary products research (Adeboye, 2000).

Several international organizations have played significant roles in the development of S&T policies among African countries. They have supported S&T development efforts through science, technology and innovation policy reviews, the establishment of networks of centres of excellence, promotion of transfer of technology and development of higher education and R&D institutions etc. These organizations include UNESCO, UNCTAD, IDRC, the Swedish Agency for Research Co-operation with Developing Countries (SAREC), etc. African governments have also taken strides in developing S&T in order to enhance contribution towards socio-economic development in their respective countries. In most of the countries this was envisaged to be achieved through the development and application of S&T in order to improve the people's living standards and quality of life. However, it is observed that these initiatives mostly focused on the development of science and technology without or with minimal emphasis on identification of characteristics in the public research systems that could have increased learning and innovation performance. Since the most effective policies in spurring growth seem to be the ones directed to support investment in education and innovation (Di Maio, 2008). The level of education among entails the ability of African countries to transform and integrate into the global knowledge economy in terms of human capacity development and their ability to convert knowledge and innovation into economic growth and development. 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 in this regard. 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 growth of these economies.

Educational systems, particularly higher education systems, increasingly play a critical role in the innovation system of a country. Some of the key trends that have driven this belief include the increasing collaboration between the private sector and research universities, increasing protection of knowledge generated in universities (e.g. patent applications and grants), changing mandates of research universities and commercialization of university knowledge. The performance of a research university is no longer measured just in terms of courses offered, research undertaken and numbers of students graduated or size of faculty. Instead, universities are increasingly competing in terms of patent applications and patents granted, papers published in top journals, number of licenses issues and start-ups or spin-offs seeded. It has been observed that the mandates of educational institutions have increasingly taken on board the need to perform R&D activities and entrepreneurship.

The current speed and magnitude of technical change makes the ability to innovate and use of new technologies critical to industrial development. Manufacturers or service providers have to continuously innovate to remain competitive given the short life-cycle of products on the global market and the continuously changing technological developments. This entails the need for African countries to build the necessary capacity required to continuously absorb, utilize, adapt and upgrade new and existing technologies to improve the production processes and diversify their product ranges in order to remain competitive. As such, innovation becomes a critical driver in industrial development on the continent, especially through academia-industry-government partnerships. For example, in 2006 alone, the United States Federal Government R&D support to industry and universities was about $20.9 billion and $30.1 billion, respectively. At the same time, industry supported R&D expenditure in United States universities stood at $2.4 billion. It indirectly shows the presence of university-industry-government relations in R&D projects.

Traditionally, innovation is seen as the process of combining resources in new or unusual ways to generate new or improved products (goods and services) and processes. These improvements or advancements may range from slight improvements on existing ones to major leaps in performance and changes in technology systems and economic paradigms. These technological innovations will not be possible without significant investment in R&D and education, which generate basic scientific and technological knowledge upon which the creation and dissemination of innovation are based. Innovations may also be non-technological. Non-technological innovations may refer to new and improved ways of organizing internal business practices, external relations and market approaches. In simple

terms, non-technological innovation could be viewed as changes in the way organizations undertake their activities as well as new rules that facilitate improved cooperation among stakeholders. For example, the ability of customers to book tickets and hotels, access bank accounts and apply for entry visa over the Internet is enabled by new business models and practices that permit these activities to occur via virtual contacts in addition to or instead of physical presence.

These advancements are made possible by investment in knowledge generation, supportive policies that promote experimentation, market conditions that encourage the entry of new and innovative products, business methods and entrepreneurs. Nowadays, producers of products and processes have to continuously innovate in order to remain competitive, which to a greater extent calls for an increasing role of end-users (consumers) to participate in the development of desired products and services (see Yusuf and Evenett, 2002). Innovation therefore must be regarded as a core objective of a country seeking to develop a competitive and sustainable industrial base.

3. Challenges to innovation for industrial development

In order to apply new innovative ideas and knowledge to tackle development challenges, knowledge needs to be created first. Hence, investment in education, especially in S&T is fundamental in generating ideas that stimulate or drive innovation. An assessment of Africa's current conditions reveal that primary education of many African countries has greatly expanded in the last two decades However, its secondary and tertiary education levels, which are vital in promoting technological innovations, lag behind most of the global regions. Africa, especially sub-Saharan Africa tops all the five regions of the world in terms of primary school enrolment, especially due to the emphasis placed by both African governments and donors on promoting primary education. The fact that the region is behind all other regions in terms of secondary and tertiary education (as a level or stage of studies beyond secondary education) may account for the relatively low technological outputs from Africa, especially if captured in terms of the number of scientific and technical journal articles, number of researchers in R&D, patent applications and high technology exports (see GeSCI, 2010). However, this might also have been exacerbated by the non-existence or weak innovation systems in many African countries.

Africa continues to lack the basic infrastructure and facilities that are essential in supporting an innovative knowledge economy. The skills level of its people, technological sophistication and innovative capabilities of its institutions and firms remain low on the continent. It should be emphasized that both the supply and quality of education and skill underpin the long term ability of countries to assimilate and master new technologies. Education helps to increase the S&T absorptive capacity of a nation, enabling it to benefit from S&T inputs from a multitude of sources such as capital goods imports, licensing, spill-over effects of foreign direct investment (FDI) etc. (Yusuf and Evenett, 2002). The continent has also registered limited increase in R&D expenditures by foreign affiliates, it has attracted very few R&D projects and recorded the lowest growth in foreign patent applications and trademarks registered. Existing data also suggests that Africa lacks or is still in the early stages of developing some of the key institutions needed to promote investments in STI, such as R&D centres, venture capital firms, patent offices, S&T academies etc. These institutions help in providing a clear leadership that appreciates and promotes creativity, innovation and entrepreneurship (UNECA, 2010). Very few African countries have strengthened these institutions to exploit existing opportunities and meet emerging development challenges.

With reference to technological knowledge and innovation outputs, as shown in Figure 1, Africa is the only region that spends more than 10 times on imports of capital goods than it earns in exports of similar goods. Asia's capital trade balance has increased from about US$33 billion in 1995 to US$59 billion – emerging as a net exporter. Although Latin America and the Caribbean (LAC) region is still a net importer of capital goods, its exports of capital goods have grown at the same speed as Asia (3-fold). Africa is not just behind in the production of capital goods and other high-technology products, it also has the lowest number of researchers and least number of authors of peer-reviewed scientific and technical journal articles in comparison to other regions (Hill, 2004 and VTT, 2010). This suggests that Africa is not investing heavily in acquisition, use and generation of knowledge, and therefore may not be attracting significant R&D intensive FDI (UNTAD 2005).

AU-NEPAD (2010) has shown that funding levels for scientific research remain low in sub-Saharan Africa. It showed that only three – Malawi, Uganda and South Africa – topped the 1 percent spending threshold in 2007. The report also reveals that apart from funding problems, many scientific labs are poorly equipped and science students get little practical research training because research centres are often separated from universities, with most of the countries relying intermittently on foreign funding. Sometimes even when research is successful, it is difficult to bring the developments or outputs to the marketplace, due to lack of coordination between research institutions and the industries, signifying lack of strong and effective national innovation systems on the continent.

Africa is, however, not short of talented innovators and entrepreneurs as demonstrated recently in some sectors such as ICT and education. The growth of the mobile telecommunication industry in Africa was led by firms that were born on the continent. Some of the leading firms, such as Vodacom, MTN, Orascom, were all headquartered on African soil while CelTel (now Airtel) had mainly African investors (Kelly, 2004). Similarly, entrepreneurs are driving growth in the African education sector. In countries such as Ethiopia and Kenya, private colleges and universities are starting to rival those run by the government at least in terms of number of establishments. A study by UNCTAD stated that domestic investment growth in Africa was truly remark-

able especially over the period 2000-2007, during which Africa outpaced even Asia (UNCTAD, 2008).

The role of innovation in industrial and economic development could also be assessed through technology transfer. For example, UNECA (2010) has shown that Botswana, Korea, Mauritius and Tunisia had a GDP per capita of less than $300 in 1970. Today, all these countries are regarded as successful examples in their own rights. By 2007, the GDP per capita of Korea had increased nearly 70 times (from $280 to $19,500) while that of Botswana, Mauritius and Tunisia stood at $5,200, $6000 and $3,300 in 2007, respectively. Today, Korea is home to some of the world's largest transnational corporations such as Hyundai, LG and Samsung. One of the major differences is the rate at which these countries acquired and adapted foreign technologies.

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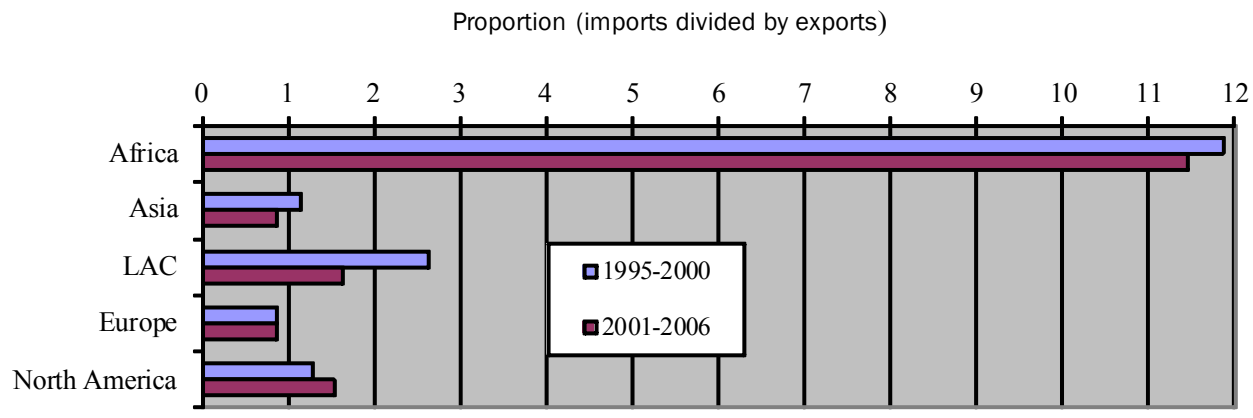
Figure 2 shows that despite Korea leading the selected African countries over the period under consideration, all the countries experienced on average an increasing trend in royalty and licensing fee payments. Also it is observed that Botswana bypassed Korea over the period 1989-1993 before dropping between 1993 and 1996. These increasing tends may entail to some extent the increasing trend in transfer of technology to these countries, while some of these assets such as trade marks, who do not necessarily represent technology transfer, may signal the existence of the growing confidence and trust in domestic industrial processing cooperation. In 1978 Korea's royalty and licensing fee payments (about $2,000,000) were about 17 times higher than that of Botswana ($121,000). As of 2007, Botswana paid $11 million while Korea paid about $5 billion (about 450 times) in royalties and licensing fees (UNECA, 2010). This indirectly reflects the differences in the industrial and technological base of the countries. Specifically, it reflects the fact that Korea has developed firms that produce sophisticated products while Botswana has not yet developed a sophisticated industrial base. It also indirectly shows that African countries are largely relying on basic knowledge and technologies for which no or little technology transfer related transactions are required (e.g. tractors, seed driers and cleaners). In order to produce cars, computers and cellular phones, a company will need to use technology developed by others to remain competitive as technology evolves very fast.

In terms of patent applications, it has been observed that Africa is the only region where patent applications have fallen between 1990 and 2004. Based on national reports to WIPO, the number of patent appli-

Figure 1. Annual average imports of capital goods as a proportion capital goods exports



Source: UNCTAD Handbook of Statistics

cations granted worldwide grew rapidly after 1990 and 1996. Since then the number of patents granted per year have grown only marginally during the period 1997 to 2004. The number of patent applications has grown rapidly in Asia, LAC and industrialized nations but only marginally in Africa (See Figure 3). However, the drop in Africa's data after 1995 are due to the missing data from Sudan and South Africa, as they have not reported their resident patenting activities since these dates. The number of patents filed by foreign firms indicate the presence of foreign affiliated firms that undertake R&D activities in the country (UNECA, 2010).

Studies have shown that political commitment to the development of STI for development is a challenge. This is evidenced through the analysis of the synoptic review of the national Poverty Reduction Strategy Papers (PRSPs), which reveal that the incorporation of S&T issues in PRSP is weak (Warren-Rodriguez, 2007) . This is further exacerbated by poor governance ranging from corruption to ineffective bureaucracy, which stymies progress in many countries. This signifies, to a greater extent, the lack of appreciation by policy makers with regard to the significance of innovation in economic growth and development.

Countries such as Thailand have successfully transformed their economic structure from being agricultural to industrial based, with the share of agriculture in gross domestic product (GDP) declining from an average of 32.2 percent in the 1960's to an average of 10.4 percent over the period 2000-2010 while manufacturing sector contribution to merchandise exports increased from an average of 2.5 percent in the 1960's to an average of 75.4 percent over the period 2000-2010. African countries seeking to achieve similar transformation in their socio-economic development have to pay significant attention to current trends in innovation, emerging industrial trends, business practices and value chains. This entails harnessing innovation capability of individuals and institutions to build industries that could help transform Africa from an agrarian continent to a producer of value-added goods and services. This could be achieved by putting emphasis on supporting innovators and entrepreneurs seeking to bring new and improved goods, services and processes to the market. This could be done through the provision of financial as well as technical support by exposing the innovators to emerging technological developments and initiatives.

Despite the many problems confronting scientists in Africa, there are signs that they are starting to build momentum. After a relatively slow growth during the 1990s and 2000s, the output of publications is now rising rapidly. In 1996, sub-Saharan researchers produced roughly 0.8% of the total papers in the Scopus database. By 2009, that fraction had reached 1%. This to some extent due to the increasing joint collaborations with researchers in Africa and between those in Africa the developed world (Nature, 2011). Africa's royalties and licensing fee payments have risen from a ltle over $250 million in 1990 to about $2.45 billion 2008 before dropping marginally to $2.37 billion in 2009, due to the financial and economic crisis. This pace of growth is comparable to that of Europe and Central Asia but lower than that of East Asia and the Pacific.

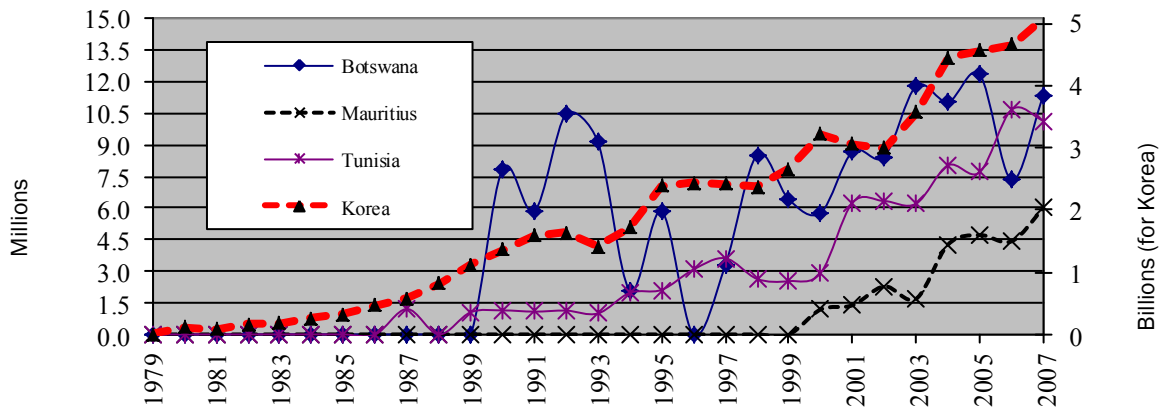
4 Strategies for building an innovative industrial sector

The issues raised in the previous section could be achieved, among others, if there exists a conducive economic and institutional environment; relevant skills and education; infrastructure; and political leadership and support.

4.1 Economic environment

Although it is difficult to define an economic environment that favours growth in innovation, it is generally seen as one which ensures that competition, procurement, financial and intellectual policies, among others, are supportive and facilitative to innovation and industrial development. Such an environment will enhance

Figure 2. Royalty and licensing fee payments



Source: UNECA, 2010

knowledge and technology transfer, generation and diffusion in industry and society in general. For example, increasing innovation financing through provision of special grants, loans and guarantees, subsidies and tax incentives for R&D could promote innovation by encouraging individuals, start-ups and existing firms to invest in innovation and bring their products to the market. Similarly, procurement and competition policies could be used to encourage firms to improve the quality of their products and meet international standards.

There is need to have an effective legal and regulatory framework that encourages fair competition, promotes innovative firms, attracts foreign innovative investors and removes administrative entry barriers. In addition, countries may also need to develop clear technology commercialization rules, including ownership of intellectual property rights on products of publicly funded research. In general, the main goal is to reduce the costs of innovation and entrepreneurship related activities to the individual and the business in a country.

4.2 Human capital development

Advanced skills development and higher education play a complementary role to technological advances in a knowledge economy if the educational institutions respond to the needs in the private sector and the prevailing technological challenges. Improved higher education allows workers to use existing physical capital more efficiently. However, 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. In a global economy where technology literacy is becoming important, increasing and improving higher education will lead to a rapid development and dissemination of knowledge, and in turn advancements in technological innovation which is a critical element of the countries' competitiveness. There may be a need to reshape higher education to introduce entrepreneurial training and internships into their curricula as well as encouraging students to commercialize university research. This could be accomplished by ensuring that national development plans incorporate platforms which strengthen the linkages between universities, industry and government (Juma, 2005) in order to promote industry-academia dialogue and exchange. For instance, making it compulsory for higher education students to serve as interns in industrial institutions and academic staff to keep up with developments in innovative companies through exchange programmes as is the case in some highly developed economies. Government financial support is necessary to enable these exchange programmes to work efficiently. This academia-industry-government partnering arrangement, often referred to as the Triple Helix, needs to be operationalized and promoted to function well in Africa. African countries should put in place mechanisms that will encourage them to refrain from relying on intermittent foreign financial and logistical support, so that they are able to develop innovations that are designed to tackle the prevalent challenges on the continent without the interference of donor interests.

As stated earlier, human capital is needed not only to undertake R&D but also to navigate complex regulatory requirements and to successfully nurture and manage start-ups. In particular, Africa needs R&D managers capable of identifying potentially useful and marketable research. In a way, countries need to develop not only science and engineering talents but also technology entrepreneurs and S&T managers to ensure a complete and effective innovation value chain from idea generation to research output commercialization. The availability of experienced S&T managers helps to ensure that the limited human, financial and institutional resources are efficiently mobilized and allocated and potentially useful research outputs are well-protected and exploited to obtain their full potential benefits.

For instance, Africa accounts for about 2.4% of the global researchers – slightly higher than the number of researchers in India. Yet, India was granted three times more patents than Africa, by the United States Patent Office in 2008. More importantly, India is an established information technology powerhouse with software exports in excess of US$48 billion. While it is difficult to make conclusions on such scanty information, it however begs the question on the efficiency of Africa's innovation system and entrepreneurship.

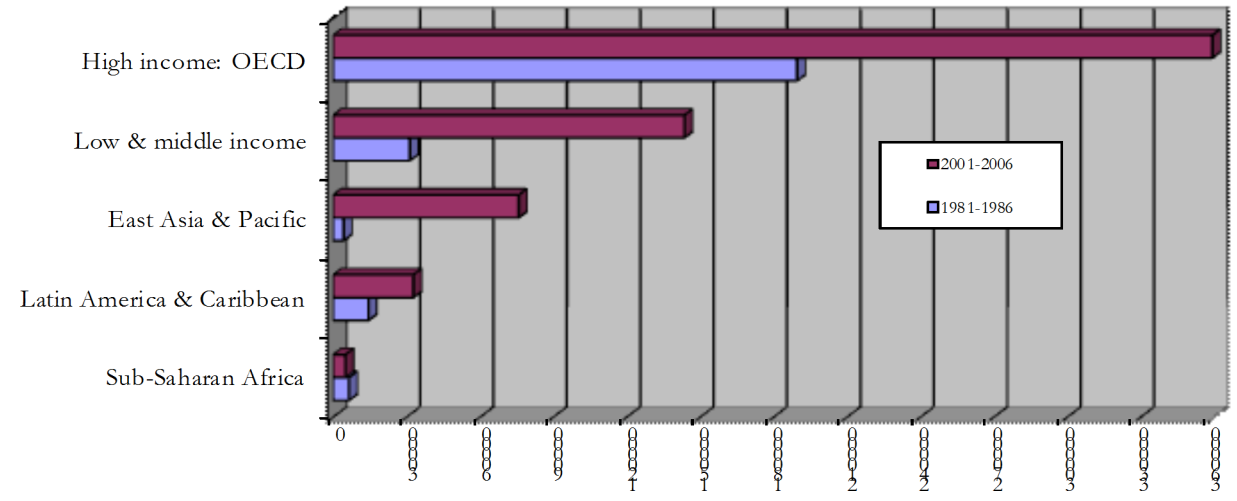
In the United States, it was observed that many of the technology clusters are in regions with most of the critical skills needed to develop the industry. For example, the biotechnology clusters of California and New England (Boston area) have generated a number of biotechnology firms due to the high concentration of top life science research universities which are rich in qualified and experienced scientists, managers and service providers that have been involved in the development of biotechnology firms over the last three decades (Konde, 2009). Their success seems to partly lie in the presence of human capital with the necessary skills to undertake and manage research groups as well as entrepreneurial talent to bring research outputs to the market.

4.3 Academia-industry-government cooperation

In Africa, the private sector is still relatively small and is largely not technologically sophisticated (e.g. most of the SMEs are in the informal sector facing a lot of financial and technological challenges to upscale their businesses). However, promoting cooperation through joint projects and programmes of mutual interest to R&D centres and SMEs/large firms could stimulate generation of research ideas and products/services that are demand-driven. Over time, such cooperation will demonstrate the importance of R&D, especially to SMEs and encourage joint funding and implementation of projects. This relationship would also develop a private sector that can influence training and research agenda of technical colleges, universities and R&D centres and fuel investment in R&D and technology acquisition, enabling African firms to become competitive.

Governments could also require ministries to reserve a fraction of their budgets for promoting STI joint initiatives between their R&D centres and SMEs. For ex-

Figure 3. Average annual patent applications by non-residents



Source: WIPO, 2009

ample, United States agencies with external budgets (for R&D) in excess of $100 million per year are required to set aside 2.5% of that budget for contracts with small businesses. Those with external budgets for R&D that exceed $1 billion per year are required to set aside 0.3% of that budget for cooperative research between small businesses and a federal laboratory or a non-profit laboratory under the Small Business Innovation Research (SBIR) and the Small Business Technology Transfer (STTR) programmes, respectively.

4.4 Innovation infrastructure

STI infrastructure is critical in addressing the financial and knowledge gaps mentioned above. Infrastructure, on one hand, includes networks and information technology which could provide access to management, intellectual and R&D resources as well as key information on sources of knowledge, technologies, market opportunities and potential partners in the sector within and across national borders. On the other, infrastructure, such as well-equipped centres, science and technology parks, technology and business incubators in the vicinity of higher education and research institutions, among other common facilities, could reduce the costs for innovators and entrepreneurs in the process of taking research and new products to the market, increase cross fertilization of knowledge, improve chances of being funded and encourage entrepreneurship. These could include cluster-based industrial development focusing on SMEs which offer a good learning and knowledge exchange avenues, as well as promoting technological innovation. It should be noted that the development scope of STI infrastructure should not be limited to laboratories in universities and R&D centres

There is no single definition of a centre of excellence, but it is often described as one capable of undertaking and producing comprehensive high-quality R&D activities relevant to its mandate and with high economic impact. They possess sufficient scientific critical mass, infrastructure, steady or broad-based funding portfolio and skilled managers. Often, they are focused on one or few areas of specialization such as a single problem or technology field and are expected to generate useful solutions (Araoz, A. (1996). Therefore, centres of excellence in industrial innovation consist of those centres that conduct research and development and provide innovative solutions to industrial development.

For example, the stated aim of the Korea Institute of Industrial Technology (KITECH), a fully government-funded research institute, is to support industrial technology development of SMEs. Since 1989, KITECH has focused on technology commercialization, SME support and development of the nation's strategic industrial technology. KITECH is one of the major research institutes in Korea that helps SMEs acquire industrial technologies and penetrate international markets.

Many African countries invested significant proportions of their meager resources in developing R&D centres whose mandates were to turn natural resources and primary commodities into high-value industrial products through the application of technology. Overtime, some of these centres have transformed into self-sustaining service providers while others are largely dependent on development partners for survival. If industrial development is to be attained, Africa may wish to revitalize its R&D centres to work closely with emerging firms in the various industries. Countries such as South Africa and their R&D centres, such as the Council for Scientific and Industrial Research (CSIR) could help serve as models as well as offer leadership to this regard.

For all these processes to perform effectively and efficiently, an intelligent, reliable and enabling information infrastructure is needed. ICT provides essential infrastructures and tools for knowledge creation, sharing and diffusion thereby boosting innovation capacity of all sec-

tors hence contributing to productivity growth. ICTs play a critical role in organization and coordination of global production networks, and the integration of firms into the global supply chains (Dahlman, 2007). They are key enablers of business innovation and transformation and play a pivotal role in helping countries' economic sectors stay ahead and be globally competitive. To achieve this, the industrial sector as well as the countries themselves should have a vision of where they want to be with regard to 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 strategies to enhance ICT innovations and new technologies for greater productivity and economic benefits, hence contributing significantly towards growth and development.

4.5 Political leadership

The development and effective utilization of STI is an essential issue that requires political leadership. The call for political leadership to the development of STI is one of the key and persistent challenges facing the STI sector. Political leadership and support play a vital role in the mainstreaming or incorporating STI issues into the countries' national development plans and strategies. This entails the participation of high-level individuals such as Heads of States and government, cabinet ministers, parliamentarians and STI committees/taskforces with enough knowledge with regard to the role that STI plays in national development, with the core responsibility being that of promoting STI for development in the country. For instance, Thailand's national information technology board was chaired by the Prime Minister. The country carefully screened FDI projects to identify their technological contribution, its investment promotion agency linked SMEs to foreign investor firms and government provided direct support to enable SMEs become competent partners to foreign firms in the electronics industry. As a result, Thailand is a major manufacturer and the electronics industry accounts for about 40 percent of the country's exports.

5. Conclusion

The historical and empirical evidence reviewed shows that industrial policies are necessary for economic growth and development in Africa. However, despite the several initiatives taken by African countries, these economies have remained sluggish and uncompetitive on the global market. Research studies have shown that Africa has performed poorly in the acquisition, adoption, dissemination and utilization of new and emerging knowledge in the past few years in relation to other regions. This has mostly been attributed to the lack of support on elements that are regarded to be the foundations of innovative economic activities such as investments in education, science and technology as well as linkages between the government, industries and research institutions, mainly due to lack of vibrant national learning and innovation systems among African countries. Finally the paper suggests strategies that African countries could take into consideration in designing their innovation policies and strategies in order to remain competitive. The different countries and their institutions should be able to acquire, assimilate, use, adapt, change and even create technologies by putting in place strong national learning and innovation systems. Macro-economic, industrial and educational policies should be appropriate for the generation of an environment suitable for the development of active learning systems in this regard. The African governments are expected to play a pivotal role both on the demand and supply side of the technological learning as was the case with Korea in the early stages of technological development. This should be coupled with the necessary infrastructure with the whole process being championed by well informed and knowledgeable strong political leaders with regard to the significance of STI in a country's development.

Notes

i. The views expressed in this paper do not necessarily reflect the views of the UNECA. The comments from colleagues in the ICT, Science and Technology Division (ISTD) on the earlier version of the paper as well as Mr Phillip Aerni are greatly acknowledged.

ii. Etzkowitz, H. and De Mello, J.M.C (2000) The endless transition: relations among social, economic and scientific development in a triple helix of university-industry-government relations, Rio 2000 Triple Helix III Conference.

iii. For details and break down, see the National Science Foundation Science and Engineering Indicators 2007

iv. Using World Bank data GeSCI, 2010 in their study observed that sub-Saharan Africa experienced the highest primary school gross enrolment rate trends over the period 1990-2008 beating Middle East and North Africa, Latin America and the Caribean, South Asia and East Asia and the Pacific regions.

v. Unless explicitly stated, the term patent as used in this paper refers to utility patents (i.e. patents for inventions) and therefore may not include design and plant patents or utility models. In the United States, utility patent applications and granted represent over 90% of all patent applications. WIPO data generally reflect utility patents.

vi. Calculations are based on the data from the World Development Indicators database.

vii. The term 'global value chain' as used here refers to firms and institutions involved in the conception, design, production, distribution, marketing and delivery of products and services until it is in the hands of the final consumer. E.g. a computer design in the US has components manufactured in Singapore, uses technology sourced from Russia, assembled in Ireland, financed by bank in Japan and sold by retailers in South Africa to end users.

viii. For more details see the upcoming UNECA (2011), African STI Report.

ix. The relationship between the university–industry–government can be considered as a triple helix of evolving networks or an evolutionary model of innovations. See Loet Leydesdorff at http://www.rvm.gatech.edu/bozeman/rp/read/31701.pdf

x. For details, see http://www.sbir.gov/

xi. See Kim, Linsu (1997) Imitation to Innovation: The Dynamics of Korea's Technological Learning, Havard Business School Press, Boston, Massachisetts.

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