Economic Commission for Africa

UNECA series on technology transfer
for Africa's development

A technological resurgence?
Africa in the global flows of technology

United Nations

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The terms "fold" and "times" refer to the estimated final value divided by the estimated initial value. Thus an increase from $2 to $4 is a 2-fold (2 times) increase or growth. A 2-fold growth is equivalent to 100% increase, 3-fold to a 200% and 12-fold is a 1,100% increase.

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Preface

The UNECA series on Technology Transfer for Africa's Development are designed to draw attention to the importance of technology transfer in economic development. The main objective of the studies in this series is to explore trends in technology transfer, the preferred modes and channels of technology transfer, the impact of technology transfer on industrial productivity and efficiency and the mechanisms and measures countries may use to facilitate technology transfer.

This is based on the understanding that technology transfer is vital to the attainment of economic and social development. All countries depend on technology transfer to meet some of their national aspirations and challenges. It is difficult for many countries, including many developed countries, to specialize in all fields of technology. For many developing countries, technology transfer is the mainstay of their sustained technological, industrial and economic transformation. Many of today's developed and fast growing countries relied on technology developed by others to grow.

Therefore, the series seek to understand the interplay between technology transfer and development. In particular, it unravels and highlights the contribution of technology transfer to innovation, entrepreneurship, investment, efficiency, productivity and export performance of African countries. It is believed that technology transfer could help African countries to meet their health, nutritional, sanitation, energy and communication needs, among others

To meet the goals mentioned above, the series seek to identify success factors and assess the impact of international, regional and national technology governance on technology transfer and innovation through studying emerging global, regional and national trends in technology transfer and technology transfer rule-making and case studies at national, industrial and institutional levels to. These studies improve the understanding of the mechanisms, conditions, capabilities and costs associated with different channels and modes of technology transfer and their impacts on development.

The present study highlights broad trends in cross-border flows of technology using various market and non-market-based proxies. The proxies do not necessarily measure the volume of technology flows but are helpful in identifying trends in technology transfer from one country to another, and in identifying countries that may be benefiting from such technology flows. Such information is useful in understanding the role that policies potentially play in promoting or hindering technology transfer, opportunities that countries could exploit and private sector practices they may wish to encourage or discourage. Each chapter is designed to highlight trends and practices among developed and developing regions, and among African countries. It then offers various ways in which countries can stimulate their firms and institutions to acquire new and emerging technologies.

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Glossary

BEC	Broad Economic Categories
BPT	Business, professional and technical
Comtrade	United Nations Commodity Trade Statistics Database
EU	European Union
FDI	Foreign direct investment
GDP	Gross domestic product
GNP	Gross national product
ICT	Information and communication technologies
ISTCAs	International science and technology cooperation agreements
IPR	Intellectual Property Rights
KEMRI	Kenyan Medical Research Institute
LAC	Latin America and the Caribbean
NESBPs	National Economic and Social Development Plans
NIEs	Newly industrialized economies
NITC	National Information Technology Committee
OECD	Organization of Economic Cooperation and Development
PPP	Public-Private Partnership
R&D	Research and development
S&T	Science and technology
SITC	Standard International Trade Classification
SMEs	Small and medium-sized enterprises
SSA	Sub-Saharan Africa
TNC	Transnational corporation
TOT	Transfer of technology
UN	United Nations
UNECA	United Nations Economic Commission for Africa
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Programme
USPTO	United States Patent and Trademark Office
WDI	World Development Indicators
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

Executive summary

Africa has made significant strides over the last 20 years. The economies of most African countries have been liberalized, the political systems have increasingly adopted democratic values and rule of law is becoming well established. Despite the teething challenges that the continent went through in the 1990s, Africa has posted positive and impressive growth in real gross domestic product (GDP), attracting more investment and benefiting from favourable trade terms.

Technology is one of the components recognized to be positively associated with foreign direct investment, trade and economic growth. This paper assesses the extent to which African countries are benefiting from and participating in the global technology market. The assessment is based on comparison of trends in the global flows of technology among various regions of the world and among African countries using a number of technology transfer proxies. It then recommends simple steps that African countries can easily apply within their existing institutional set-up and budgets to accelerate acquisition and use of foreign technologies. The paper focuses on the period between 1990 and 2008.

Some of the major findings include:

Africa and Asia enjoy tremendous increase in royalties and licensing fees

Royalty and licensing fee receipts and payments rose about six times between 1990 and 2008 globally. However, royalty and licensing fee payments went up about 57 times for East Asia and the Pacific, 10 times for SSA, 6 times for the OECD and 5 times for LAC between 1990 and 2008. In terms of royalty receipts, East Asia and the Pacific registered the fastest growth followed by LAC, OECD and SSA. At the continental level, royalty and licensing fee payments for Cameroon, Senegal, South Africa, Swaziland and Tunisia have increased rapidly between 1990 and 2007.

Africa posts the lowest growth in imports of capital goods but catches up in the last 5 years

The import of capital goods has increased by about 7.8-fold for LAC, 7.5-fold for Asia, 4.7-fold for North America, 3.9-fold for Europe and 3.7-fold for Africa between 1990 and 2006. However, Africa registered the fastest growth in imports of capital goods between 2001 and 2006 than any other region. In Africa, imports of capital goods increased by more than six times for Madagascar, Zambia, Niger, Nigeria, Rwanda, Guinea and Uganda over the same period.

Trade in Business, Professional and Technical (BPT) services increase rapidly

Africa recorded a 5.6-fold growth in terms of receipts by the United States for BPT services from unaffiliated firms between 1990 and 2005. It lags behind Europe (about 7.7-fold) and Asia (about 6.5-fold). However, Africa has the fastest growth in payments by United States firms to unaffiliated firms for BPT services (51-fold), followed by Asia (14.2-fold), LAC (9.5-fold), and Europe (8.7-fold) over the same period.

Africa lags behind in international, research and development investments

Asia has seen R&D expenditure by foreign affiliates and imports of R&D services by firms abroad increase rapidly while Africa and LAC have remained almost unchanged between 1994 and 2002. This trend is backed by the observation that nearly half of 588 strategic foreign R&D projects recorded in 2005 were hosted in China and India alone and not a single African country was among the top 15 host countries.

Africa paints a mixed picture in growth of intellectual property rights while Asia becomes a leading player

The number of patent applications has grown only marginally in Africa and LAC but rapidly in Asia. African trends in patent applications vary widely. In general, South Africa, Egypt, Morocco and Tunisia receive a large share of patent applications recorded in Africa. In terms of resident trademarks, Africa recorded about a 2-fold growth which was faster than the growth recorded by the OECD (1.6-fold) and LAC (1.5-fold) but was lower than Asia (8-fold) between 1990 and 2007. South Africa accounts for almost half of the total non-resident trademarks of SSA.

Overall, Africa is performing better in proxies that are closely related to trade and investment such as trade in capital goods and royalties and licensing fees than those that represent emerging knowledge such as the flow of intellectual property rights and research, development and testing services.

Ways to increase technology transfer in new and emerging knowledge

Although there are several ways in which African countries could facilitate acquisition of new and emerging technologies by their firms and institutions, the paper proposes that emphasis should be placed on the following measures:

1. Governments may wish to promote industry-academia-government (triple helix) partnerships to identify, acquire, adapt, upgrade and diffuse new and emerging technologies as well as incubate and nurture start-ups. Each of these players brings unique advantages that could reduce costs and risks associated with technology transfer.

2. Government contracts should be used to facilitate technology transfer through requirements that encourage joint ventures and projects between domestic and foreign firms, and between domestic industries and R&D centres.

3. Industrial alliances between domestic and foreign firms, especially those in which the government participates, invests or acts as guarantor could serve as a driver for technology transfer, learning and innovation.

4. International science and technology cooperation agreements (ISTCAs) between African countries and leading or emerging technology exporters could be developed with a focus on joint research projects, exchange of expertise and knowledge, pooling of resources and exchange of good practices.

Introduction

Technology plays a central role in the economic and social transformation of countries. The wide diffusion of technology in the economy is expected to lead to improvement in quality of production, generation of new knowledge, improvement in living standards, productivity or efficiency and exports, among others (Torlak, 2004; Yasar and Paul, 2005). From this perspective, efforts to acquire, adapt and use new and emerging technology could help African countries to:

1. improve productivity, attain industrial development and promote export growth
2. meet multilateral environmental, trade and developmental commitments (e.g. MDGs and climate change)
3. increase their participation and integration in global production networks and partnerships and;
4. improve the general welfare of their people (UNCTAD, 2004).

The acquisition of mobile technology and wireless technologies have greatly reduced the cost of information transfer, shortened distance, improved services and empowered more businesses and individuals to operate more efficiently in Africa. Mobile banking and other mobile money transfer services have reduced the number of people that have to travel to a bank to make financial transaction in South Africa and Zambia and enabled the transfer of about US$ 4 billion in Kenya in one year (2008/2009).[1] Most of these applications being used in Africa are created using knowledge derived from R&D investment made by other countries. Many of these business models and practices do not differ radically from those in use in the same sectors in developed countries (e.g. Western Union money transfer system and Internet banking). Similar benefits of technology acquisition in Africa have been recorded even in the traditional sectors such as agriculture, energy and mining.

Technology transfer is also key in maximizing economic and social benefits from investments made in R&D. In general, the wide diffusion and adoption of technology often leads to increased productivity and efficiency of the entire industry or economy. For example, Microsoft products generate billions of dollars for the firm because they are widely used. This would not be possible if the products were only used by Microsoft itself. The wide adoption of a technology generates greater economic value for the technology producers, owners and users.

However, technology is not exactly free to use, copy, modify and upgrade by anyone qualified in the art. It is for these reasons that technology transfer is a major component

1 Allafrica.com

of many multilateral trade agreements (e.g. Agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) and General Agreement on Trade in Services (GATS) of the World Trade Organization), multilateral environmental agreements (e.g. Montreal Protocol and UN Convention on Biological Diversity) and regional agreements (e.g. SADC and COMESA and Egypt-EU)[2]. Many of these agreements attempt to balance the interest of technology producers and users. These agreements recognise that those who develop the technology have to recoup some of their investment in order to continuously innovate and those who need the technology are not unfairly exploited or denied access by technology owners in order to encourage competition and innovation.

History has shown that countries grow faster by taking deliberate steps to learn different ways of improving performance in a variety of sectors and diversifying into different areas. Deliberate effort to learn has made some African countries, such as Ethiopia, Kenya, Uganda and Zambia, that did not export flowers and fresh vegetables a few decades ago become major producers (Norman, 2003). Some have argued that Korea's successful industrialization was largely driven by technological learning, particularly in the electronics industry (Kim, 1997).

The target in technological learning, with respect to technology transfer, is to use knowledge developed by others and master the associated production and processing systems essential to moving up the technological ladders. The goals of this learning process are to achieve a competitive position in the global economy, become producer of branded products and processes and meet other national realities.

Technological learning and innovation does not occur in a vacuum. The economic, industrial and science and technology systems need to be supportive. The liberalization and privatization processes that Africa undertook in the late 1980s and early 1990s opened up African countries to international investment and competition. Despite the teething challenges that Africa faced in the 1990s – loss of jobs, closure of factories and influx of cheap imports – foreign direct investment (FDI) and domestic investment increased, production grew and Africa's terms of trade improved. However, foreign and domestic investment in S&T has remained low and some of the links that existed between R&D centres and the privatized firms have not been re-established. Government support is needed to improve these links, mobilize resources for S&T and encourage investment in R&D.

Technology transfer and innovation could be facilitated through various partnership arrangements, FDI, trade and education, among others. For instance, FDI can be used to acquire operational, maintenance, management, and innovation skills through hands-on and handholding processes. Many of the Asian countries that have grown rapidly used foreign firms that relocated to manufacture their products

2 For details on international agreements containing technology transfer clauses, see the Compendium on International Arrangements on Technology Transfer, UNCTAD.

in Asian countries to acquire the necessary skills. Foreign firms are estimated to have accounted for over 30% and 50% of Korea's electronics production and exports in 1972, respectively (Bloom, 1992).

Recognizing the vital role of technology transfer to Africa's economic and social development, this note focuses on trends in technology transfer among the different developing regions of the world, including Africa, and similar comparisons among African countries at the regional level. The main goal is to identify global trends and which countries in Africa are attracting a relatively large proportion of technology. To achieve this goal, the paper uses several proxies to identify the trends and, various examples and cases to demonstrate how African countries could accelerate technology transfer to their firms.

The first chapter defines the common terms and proxies used in this paper, and discusses the challenges of tracking technology flows. The second chapter presents the trends in technology transfer using various proxies. The third chapter provides a brief explanation of some factors that affect technology and makes a few recommendations of measures that Africa can put in place to accelerate the pace of acquiring foreign technologies and diffusing technologies in the wider economy.

Chapter 1
Setting the scene: an explanation of key issues

This section explains some of the issues and terms used in determining what constitutes technology transfer and how it could be tracked. The section provides the operational definition of technology transfer used in this paper, explains the main channels and modes of technology transfer. It also highlights the challenges in tracking technology flows, and sets the scope and limitations of the proxies used to track technology flows.

1 Definition, channels and modes of technology transfer.

It was agreed during the negotiations of the International Code of Conduct for Transfer of Technology to define technology transfer as the "transfer of systematic knowledge for the manufacture of a product, for the application of a process or for the rendering of a service and does not extend to the transactions involving the mere sale or mere lease of goods"[3] (UNCTAD, 1985; Patel, *et al* 2001). This definition attempts to differentiate transfer of technology from diffusion of technology[4] and views technology transfer as a transfer of a system that includes hardware, software, procedures and skills, among others, as a package, rather than as a "product transfer", such as the sale of a tractor. It looks at technology transfer largely as a transaction between the supplier and user of the technology.

Therefore, technology transfer could be divided into three main categories: 1) transfer of knowledge, 2) transfer of technology products, and 3) transfer of production processes. Knowledge is transferred in its explicit form through freely accessible services such as publications on business, science and technology and education. Although there are fees for accessing some of these knowledge sources, e.g. annual subscription, the information itself is free of cost to transfer from one country to another.-

There are several channels through which technology may be transferred. The transfer of technological products may take place in the import or export of machinery/equipment embodying the technology of interest. Although data on exports or imports could be used, it does not necessarily disaggregate between simple product replacement and upgrading from the introduction of new or improved technologies. The transfer of a production process for the manufacture of a product or delivery of

3 However, it is important to keep in mind that it is a legal definition with a bias towards commercial contracts. This definition does not recognize general education and mobility of workers as technology transfer.

4 Technology diffusion is best seen as the non-commercial, sometimes involuntary or deliberate, dissemination of technology and skills or the ability of the technology importing country to learn from the acquired technology to develop its domestic capabilities.

a service is expected to take place through trade in knowledge assets and services (e.g. licensing, franchising and outsourcing), FDI (e.g. investments in new projects and joint-ventures) and turnkey projects[5]. The extent to which these activities represent actual transfer of technology may depend on the level of learning, skills development and absorptive capacity of the recipient and the technology content of the project.

In terms of modes, technology may be transferred intra-firm (internalized) or inter-firm (externalized). Intra-firm technology transfers refer to transfers between affiliated firms or subsidiaries. Inter-firm transfers occur when technology is licensed to unaffiliated parties. Though firms may not be affiliated, they may have a common origin, collaborated in the past and common advisers. Transfer of technology between such firms may not qualify as intra-firm legally. For example, transfer of technology to an independently owned contractor to enable the contract to supply services is inter-firm transfer legally speaking but does not seem to differ, in practice, from transfer of technology to an affiliate to supply goods and services.

The mode of transfer of technology is determined by several factors. In brief, the business strategy of the technology owner and buyer is often a major determinant. The owner of the technology may be interested in expanding business operation abroad to exploit its unique technology. In such a case, the firm may choose to internalize the technology and prefer greenfield investment, mergers and acquisitions (M&A), joint venture and franchising to licensing. Similarly, a technology buyer may wish to seek technology partnerships, buy out a technology owner (acquisition) or obtain access only to the technology (licensing). These motives and preferences of the technology owner and buyer may influence whether the technology will be transferred inter-firm or intra-firm.

The capacity of the technology buyer and technology seller may also influence the modes within which transfer of technology may occur. For instance, if the buyer has excellent knowledge of the technology and only needs to access and benefit from the technology, licensing may be preferred. This is also important to the technology seller as the ability of the buyer to successfully bring the technology to market, achieve economies of scale and compete favourably in the national or global market place is necessary because licence fees are often based on proportion of sales and profits generated by the buyer. The absence of an interested buyer or partner will influence the technology owner to establish a production and marketing facility in, or export the product to the target market.

The nature of the technology is another key determinant. Some technologies are sector- or industry-specific, complex, rapidly evolving or easy to copy. To remain competitive, firms may prefer to transfer such technology to affiliates or its close partners. For instance, drug producers often keep the production and process technologies within

5 A type of project that is constructed by a developer and sold or turned over to a buyer in a ready to use condition.

their networks of firms while licensing mainly the products (patents of drugs, vaccines and equipment). While every chemist knows how to make aspirin, few can produce it at a competitive market price. The difference may be in the production and process technologies.

The sophistication of a technology may either favour inter-firm transfer or intra-firm transfer depending on its application. For instance, Dolby Laboratories, specializing in innovative sound technologies makes about 78% of its revenues from licensing, 14% from product sales and 7% from services[6]. Its products are used in entertainment audio systems (headphones, computers, DVDs, movies etc.) that are produced by other firms. Indeed, firms such as Microsoft make software that has worked well with different technology operators. Indeed, Microsoft and Intel will lose a good chunk of their revenue and market share if the major original equipment manufacturers (HP, IBM, Dell, Sony etc.) sold their equipment pre-installed with other operating systems or without Intel Chips. On the other hand, Apple makes its own operating system and hardware.

The domestic policies of the country within which the technology exporter or buyer operates may influence the mode of technology transfer. For example, technology export is encouraged in order to generate revenues for the exporting country. However, countries may restrict the export of technology to a given country or control the export of specific technologies considered to be key to national competitiveness and security. A common practice is to ban the export of technology to a country. In such cases, establishing an affiliated firm abroad (intra-firm transfer) may be a way to circumvent such regulations. Likewise, the national policies of a technology importing firm could impose limit on the entry of foreign firms in sectors regarded as critical to national development and security (e.g. water, communication, energy and security). This could make intra-firm transfers of technology almost impossible. Countries may also provide incentives for import of technologies in their investment promotion that may be better than those provided to established firms. Such measures may facilitate intra-firm transfers. Other regulations such as competition policies and intellectual property rights could also influence the mode of transfer.

The domestic market size of a country, competitors and skills of the labour force may determine the mode of transfer. Keeping other factors neutral, larger markets may induce a firm to transfer the technology within the firm instead of licensing while smaller markets may not be so attractive to induce technology owner to invest abroad. Similarly, intra-firm transfers may be preferred in a competitive market. Governments, exporters and importers may prefer different modes for the transfer of technology for different reasons. Governments, for example, often see technology transfer as an integral part of their industrial, development and trade strategies.

6 See the financial report at http://investor.dolby.com/ReleaseDetail.cfm?ReleaseID=228010

However, none of these reasons determining the mode of transfer are mutually exclusive. It is possible that the market is large, the technology is simple, but the host-country policies are not optimal; or potential partners exist but a firm may still decide to enter the mark0et by establishing an independent plant to exploit its technology instead of licensing or staying out. Thus, technology transfer should be seen in the broader economic gains in both short and long term scenarios that the technology owner targets to make. In this case, the mode of technology transfer should be based on sound commercial interests of the technology owner and user. However, since technology is often one of the determinants of the economic competitiveness of firms and countries, governments generally favour inter-firm to intra-firm transfers to enable diffusion of technology to local industries and development of indigenous competitors to occur.

2 International governance of technology transfer

Given the above, there have been several attempts to govern international transfer of technology. The early efforts (1960s-1980s) were based on the premise that the market for technology was imperfect because of the acute dependency of developing countries on a limited number of technology suppliers and the absence of legal regimes to monitor technology transfer agreements in some developing countries. The main argument was that technology transfer conditions employed had economic and social consequences on the growth of developing countries. The supplier may, for example, charge an excessive price for technology or transfer bundles of unnecessary technology alongside the technology the user actually needs (i.e. technology packaging).

One of the most ambitious efforts was an attempt by governments to formulate an International Code of Conduct on the Transfer of Technology under the auspices of UNCTAD (UNCTAD 1985; Patel *et al* 2001). The main goal was to establish an international legal regime to regulate international technology transfer. The Code was designed, among others, to enable national governments to define fields of operation of foreign firms, choice of channels, mechanisms and prior or subsequent approval of technology transfer transactions and their registrations. After a decade of negotiations, the efforts were abandoned in 1985 but this particular initiative had raised many issues.

Many of these issues raised have been incorporated to form part of the World Trade Organization's (WTO) Trade Related Aspects of Intellectual Property Rights (TRIPS). The TRIPS Agreement attempts to balance the needs of developing countries to access technologies and the needs of developed countries to eliminate unauthorized use of IPR. For example, the TRIPS Agreement recognizes that technology transfer is needed to enable developing countries to build a sound technological and industrial base (Article 66.2) and meet their international commitments (TRIPS article 63). The Agreement also provides measures to control abuse by IPR holders (e.g. Articles 8.2, 31 and 40.1).

TRIPS Agreement places greater emphasis on IPRs and the conditions under which they are granted, protected and transferred or used. The TRIPS Agreement does recognise that those who own IPR could abuse their monopoly powers. As such, it permits unauthorized use of IPR if *"prior to such use, the proposed user has made efforts to obtain authorization from the right holder on reasonable commercial terms and conditions and that such efforts have not been successful within a reasonable period of time"* (Article 31(b)). Many users are unlikely to evoke this flexibility for fear of legal costs associated with the requirement to prove that the terms and period of negotiation were unreasonable.

What constitutes unfair or unreasonable terms is also difficult to prove given that IPR is often used to access technology owned by others, to secure funding for further development or to sell technology to interested parties for a fee. More importantly, IP plays a minor role at research stage, especially by public institutions, since the use of patents belonging to others in research may be allowed. However, once the product is ready to transfer to users or is ready to go to market, the interest of the IP owners have to be taken into consideration.

For instance, the development of vitamin A enriched rice, termed "Golden Rice", utilized about 70 IPRs and/or inventions belonging to 32 different companies and universities. To enable those who will acquire Golden Rice and/or its technology "freedom to operate" (i.e. to undertake further research and develop other products), the developers of Golden Rice needed to obtain free licenses from the IP holders. Whilst one acknowledges that Golden Rice would possibly have not been developed that quickly if the patented inventions were not publicly available or kept secret, negotiating through this maze of patents was tasking. In the case of Golden Rice, public pressure and the use of a private partner proved vital (Potrykus, 2001).

IP monopolies could also be used to block or discourage others in a field of interest or stifle technology development and transfer. Peter Ringrose, Chief Scientists at Bristol-Myers summed it as follows: "there are more than 50 proteins possibly involved in cancer that the company [Bristol-Myers] was not working on because the patent holders either would not allow it or were demanding unreasonable royalties" (Thompson, 2002). As stated earlier, firms may choose to avoid such products which inhibit innovation and limits technology transfer.

The TRIPS Agreement has a major impact on international technology transfer as it established a minimum global IP enforcement regime and, for the first time, ensures that IP benefits from the same dispute settlement mechanisms as other trade issues. Many have argued that TRIPS has made it harder for firms in developing countries to imitate and learn by exploiting global knowledge. Many of today's developed and emerging countries disallowed IP protection in areas where their firms were still developing e.g. Switzerland and India in the pharmaceutical sector. Recently, Brazil has lifted IP protection on anti-retrovirals to meet the HIV/AIDs emergency and there is evidence of technological learning and innovation leading to 10 patents (Cassier and Correa, 2007).

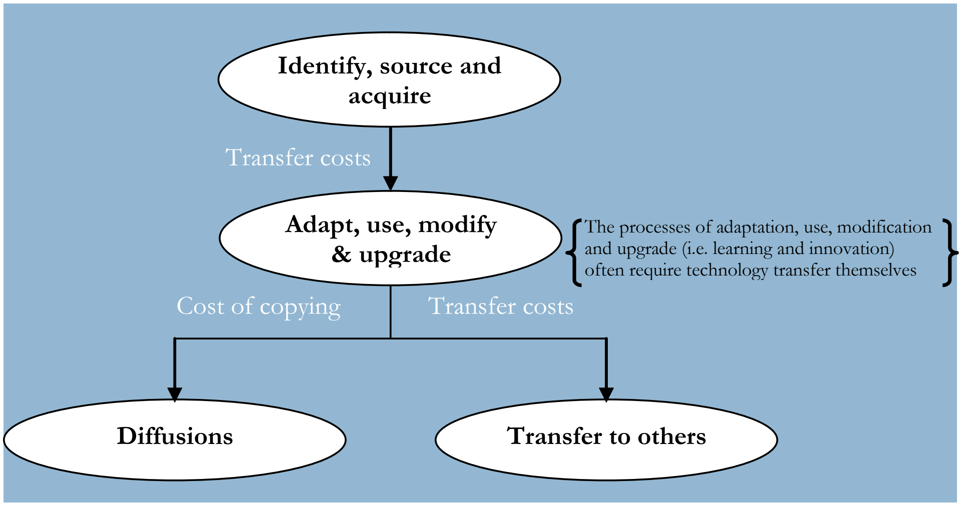
In developed countries, most IP users are potentially IP producers. In this environment, stronger IP protection does not create a major challenge as both will bear some costs and benefits of technology transfer. At a global level, developing countries are largely and potentially IP users and not producers. For example, about 1.7 million non-resident patents were filed in least developing countries (LDCs) while only 6 were filed by their residents in 2002.

3 The process of and costs associated with technology transfer

In general, the process of technology transfer starts in practice with identification of the need and possible sources of technologies (in case of the buyer) or potential users of the technology (in case of the seller). Depending on the various reasons mentioned earlier, an agreement is reached and the transfer conditions set, then the technology is transferred. In terms of individual market transactions, a technology transfer may be considered completed once the sale is finalized and the technology is put into operation by the user. From a development perspective, however, effective transfer of technology entails the outcome that the user is able to operate, maintain, upgrade and build on the acquired technology to spur further innovation.

For example, in August 1992, Tanzania appointed a committee of experts to come up with specifications for a radar system that would meet the country's requirements. The experts recommended a joint radar system for military and civilian use. In September 1997, Tanzania and BAe Systems (then SPS) agreed on the list of components to be included in the radar system. The Sales Agreement price included equipment maintenance contract, training, spare parts and wages for expatriates. In 2002, BAe Systems was issued with a license by the United Kingdom (UK) to supply the radar to Tanzania. This case demonstrates some of the key components of technology transfer agreements such as user training, system maintenance and expert support. Nevertheless, it is important to state that not all technology transactions are that complex and lengthy, and require strict government approval (e.g. import of machinery for production and research).

Figure 1. Simplified technology transfer diagram and related costs



However, as illustrated in Figure 1, technology transfer should not be seen as a one-time process but rather as a continuous process to acquire and absorb forefront technologies to remain competitive. For example, the development of the automotive industry in the Republic of Korea took several key stages. The country started with the assembly of foreign models with about 20% local content in the early 1960s. Within two decades, the country achieved mass production. A key component of this success is Korea's continuous acquisition of technology and learning to operate and further improve the acquired knowledge (Pacudan, 1998). Korea remains a net importer of technology despite its incredible achievements. Korea is not an exception. Japan, the second major technology-exporting country after the United States, only became a net-technology exporter in 2003, according to a study by the Bank of Japan (Yamaguchi, 2004; Nitta, 2005).

As seen in the case of Tanzania, there are several costs that may be associated by a single technology transfer transaction. These may take the form of licensing fees, technical and service fees and purchase price of machinery and equipment among others. These costs may be paid for directly (as in a sales price of the system or fees) or indirectly as an investment contribution to the project (paid in terms of dividends and/or in shares). For example, BioPAD, one of South Africa's biotechnology regional innovation centres and two local firms - Sekunjalo and Bioclones – have invested in the Swiss company, Solidago AG. This investment was designed to form a new company, Ribotech Pty Ltd, in South Africa, using unique technologies owned by Bioclone and Solidago AG. Under this arrangement, Solidago transferred technology from Switzerland to South Africa for production, marketing and distribution of a cancer-treating compound – a G-CSF-, Sakunjalo and BioPaD supported the cost of technology transfer to Ribotech, the new venture. In this case, some of the technology transferred to the new firm is paid for in terms of shares or dividends.

4 Defining proxies for measuring technology transfer

There are several proxies that have been used to measure technology transfer (see Kelly (1998) for a detailed discussion). The most common ones include royalties, licensing fees and imports of capital goods. In general, the proxies track the payments that are associated with technology transfer and not the technology itself. For example the transfer of intellectual property rights and provision of technical services occasion payments in the form of royalties and licensing fees. Some of these assets, such as trademarks, do not directly represent technology transfer. However, they may signal the existence of growing confidence and trust in domestic industrial processing and other activities that often indicates an increasing use of better production and service delivery techniques. By ensuring licensees meet minimum product or process standards internationally, owners of trademarks and trade names can indirectly promote technology upgrading and transfer.

Capital goods may be defined as high value and durable agricultural, industrial and commercial machinery or tools, used in the production or delivery of services. Some studies have argued that imports of capital goods are a good indicator for technology transfer or passing on R&D benefits (technology spillovers) from the exporting countries to the importing countries (Kelly, 1998). It is important to stress that the technological sophistication or knowledge content of capital goods may vary widely even within the same class of machines (e.g., engines may have varying outputs, complexities, sophistication, performance and applications) and, as a result, their validity to serve as conduits for technology transfer may differ (Navaretti *et al.*, 2003).

Services are another proxy for technology transfer. Services that play a key role in technology transfer include architecture, engineering, consulting, installation, research, management, operational leasing, financial and analytical testing services, among others. These services, termed business, professional and technical (BPT) services, are often required to upgrade skills of the technology importing partner, install, maintain and improve the efficiency of capital goods, stay abreast with the next generation of technological developments, manage technology and improve the efficiency of running a business, among a host of other reasons. More importantly, this class of services plays a role in the transfer of tacit knowledge and organizational arrangements that are not easy to buy, copy and/or acquire.

In particular, trade in R&D services is now seen as another key proxy of technology transfer. There are four broad categories related to internationalization of R&D: 1) investment in fully-owned or co-owned R&D units abroad, 2) R&D expenditure through foreign-affiliates abroad, 3) subcontracting of R&D activities to other institutions abroad and 4) indirectly passing on R&D activities to contractors. In many of these cases, the parent or contracting firm may provide requisite information, technologies and support to meet the specific requirements of their next generation of products or services. Depending on the needs, a firm may choose to use one or more of these approaches to achieve specific goals in managing the high cost of R&D effectively.

Another proxy that we use in this paper is patent applications. We consider patents as a source of valuable knowledge that the owners and the patent authorities view as possessing potential economic benefits worth the cost of protecting and hence, number of patents registered may serve as an indicator for technology development capability. Patenting activities largely reveal global flow of such knowledge and the patenting trends of inventors (i.e., favoured destinations of such knowledge). Such data may be indicative of the emergence of a technologically innovating community in a country and potential future entry of new foreign products in a market. In addition to being a source of information, an increasing trend in foreign patent applications, other than that stimulated by law (e.g. where a patents may not have been previously obtainable in a given field of technology), may indicate a growing competitive market or a rise of potential imitators or technology users likely to exploit such knowledge in a key market of interest.

Finally, the paper also considers trademarks as being indicative of activities that involve exploiting knowledge that belongs to others. Unlike patents, trademarks are issued largely on innovative and recognizable designs (words and drawings) of actual products and often associated with products (goods or services). Trademarks may also be issued on design inspired innovations that integrate the needs of consumers and may be indicative of increasing knowledge accumulation by domestic firms or trust by the owners of such marks in the users to meet the necessary quality to preserve the reputation that the mark represents.

5 Scope and limitations of the proxies in tracking technology flows

As stated earlier, the proxies are generally payments or codified knowledge associated with technology transfer. Although the channels of such transfers are well known, measuring technology transfer presents many challenges. The number of technology transfer transactions or the amount of money paid does not necessarily reflect the quantity of technology. Indeed, a technology transaction deal may not even constitute technology transfer according to the definition in this paper. A firm developing its own product may have, in the process of product development, used knowledge that is protected by a patent. It may have to pay royalty to the patent holder to fulfil legal requirements or avoid litigation (as shown earlier in the case of Golden Rice). How much of such royalty and licensing fee payments constitute technology transfer or simple fulfilment of a legal requirement is difficult to determine.

It is also important to point out that technology may not necessarily flow in one direction. For instance, a firm may seek to merge with or acquire another firm to gain access to complementary or advanced technology, especially in knowledge intensive industries such as pharmaceuticals, information technologies (IT), automobiles and biotechnology. Likewise, the establishment of an R&D facility abroad by a firm may be a strategy for technology sourcing rather than for a transfer of technology. Therefore, payment may not indicate the direction of technology flow. In other words, the paying party may be exporting technology.

Other challenges of measuring technology transfer stem from two aspects: 1) the nature of the technology, and 2) the value of the technology. The extent to which a sale or transfer of tangible or intangible assets may constitute technology transfer depends on the use and the economic and legal context. The sale, lease and licensing of intellectual assets is perhaps the most common form of technology transfer through trade and the mainstay of some industries, but certainly not the only one. A firm may take up shares in another firm in exchange for its technological, managerial and financial contributions. In this way the technology selling entity is paid in shares and dividends rather than royalties and fees.

The value of the technology may also be influenced by the stage of development of the technology, ownership (private or public institutions), relationship and knowledge base of the acquiring party, among others factors. In general, royalty payments as a proportion of sales in health-related inventions, for instance, range between 0-5% in preclinical inventions, 5-10% in phase I of clinical trials and more than 20% at the product launch stage (Finch, 2005).

Services perhaps present a unique challenge. For example, software and related services exports of India grew from about US $12.8 billion in 2004 to US $17.2 billion in 2005. The total amount of royalties earned by India in all sectors of the economy in 2004 was $25 million. There is little doubt that software can be seen as a kind of technology and that its export as transfer of technology that is to be used in service delivery or production of a product (e.g. software for billing, customer relationship management (CRM), transport management and accounting services, etc). However, one cannot use the sales figures to represent technology transfer, and royalties may not capture the technological component of services.

Perhaps a major challenge in tracking technology transfer relates to the lack of data at national level. This is particularly problematic in Africa where basic data on intellectual property rights, royalties and licensing fees and technology related-service fees are often unavailable. Even where such data are available and accurate, transfer of knowledge and skills would be difficult to trace because data are rarely disaggregated (e.g. royalty payments for accessing minerals may be lumped together with that of technology exports). In this paper, we use data of a major technology market (e.g. United States) that often disaggregates data between affiliated and unaffiliated firms. It is also assumed that inter-firm payments are more likely to reflect true market value of a technology than intra-firm payments (NSF, 2006).

Chapter 2
Trends in technology flows

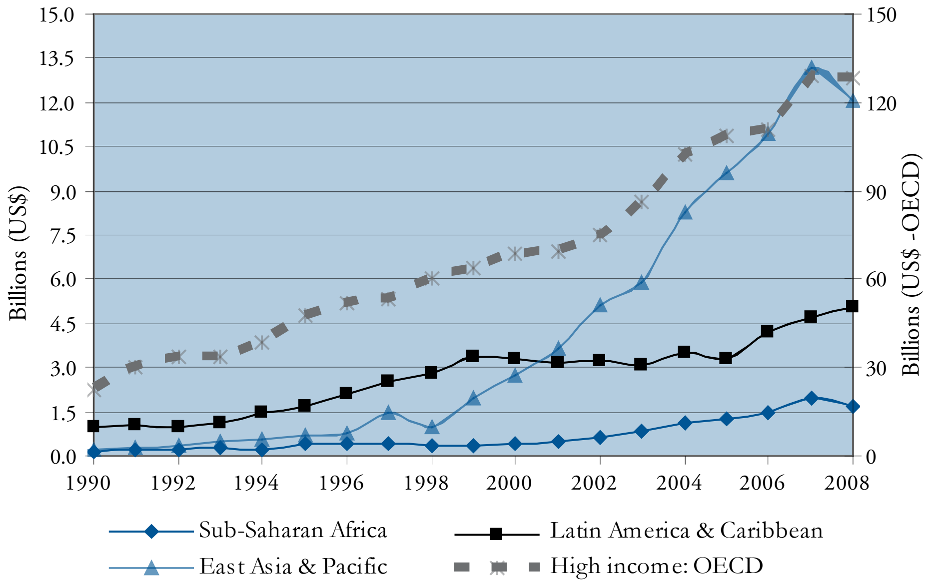
This chapter looks at the trends in global flows of technology at regional level, largely comparing Africa to other developing regions using the proxies explained earlier. It then provides a similar comparison, where data is available, among African countries and national examples where data is absent. The sections largely cover the period 1990 to 2008. This time period is deliberately selected bearing in mind that most economies started to liberalize and privatize in the 1990s. It was also in the 1990s that World Trade Agreement and its TRIPS Agreement were adopted. Therefore, it presents an interesting period to capture the effect of many of these changes in the structure of economies and governance of technology.

1 Trends in royalty and licensing fees payment and receipts.

There has been a significant and steady increase in the trade in knowledge assets over the last few decades. Royalty and licensing fee receipts were estimated to have increased from $24.2 billion in 1990 to $158 billion in 2008 while royalty and licensing fees payments were estimated to have increased from $27.3 billion to about $161 billion over the same period. In general, royalty and licensing fees payments and receipts have increased nearly 6-fold between 1990 and 2008 globally. As show in Figures 2 and 3, the 30 member countries of the Organization of Economic Cooperation and Development (OECD) accounted for about $128 billion (or 81%) of the global royalty and licensing fee payments and $158 billion (i.e. 98%) of the global receipts.

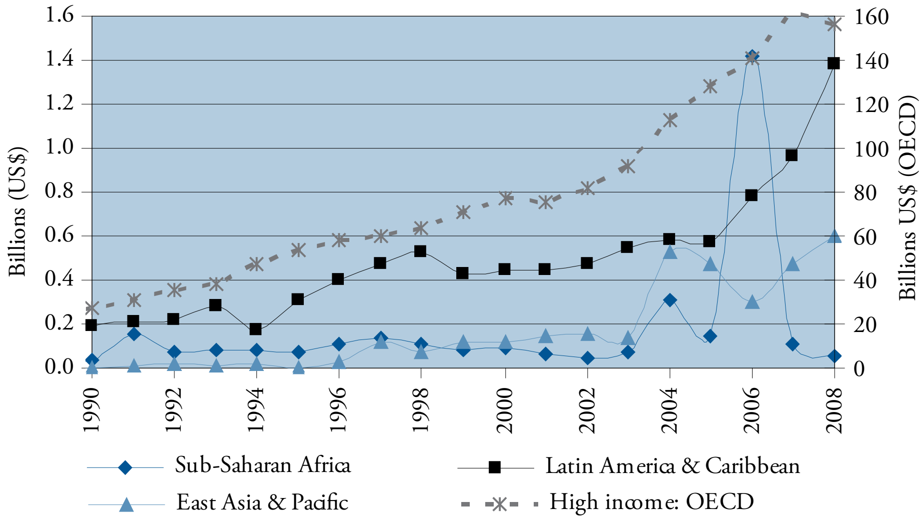
Africa recorded a faster growth in royalty and licensing fee payments well above the world average. It was observed that royalty and licensing fee payments increased 57 times for East Asia and the Pacific, 10 times for SSA, 6 times for the OECD and 5 times for LAC between 1990 and 2008. In terms of royalty receipts, East Asia and the Pacific registered the fastest growth followed by LAC, OECD and SSA as shown in Figure 2. LAC has registered the fastest growth in the last four years (2005 to 2008) - with royalty and licensing fee receipts more than doubled. In terms of royalty and licensing fee payments, East Asia and the Pacific and SSA registered higher than the world average.

Figure 2. Payments: Royalties and licensing fees



Source: World development indicators, 2008

Figure 3. Receipts: Royalties and licensing fees



Source: World development indicators, 2009

At national level, trends in royalty and licensing fee payments and receipts differ widely among African countries. South Africa remains the main consumer of knowledge assets in Africa with its payments reaching $1.68 billion in 2008. Indeed, South Africa's payments dwarf those of other main African countries such as Egypt's $241 million and Nigeria's $174 million in 2007 (see Table 1 for details of royalty and licensing fee payments of selected African countries). Of these, the fastest growth in payments of royalties and licensing fees between 1990 and 2007 has been witnessed in Cameroon, Senegal, South Africa, Swaziland and Tunisia.

For example, payments of royalties and licensing fees have increased 13 times for Swaziland, 12 times for South Africa, 9 times for Tunisia and 2.3 times for Senegal between 1990 and 2007. In terms of real value, Tunisia's royalty and licensing fees payments have increased from $1.13 million to about $10 million between 1990 and 2007 while those of Swaziland have increased from $9.3 million to $121 million over the same period. Similarly, payments by South Africa increased from about $132 million in 1990 to about $1.6 billion in 2007 while Senegal's payments increased from about $330 thousand to about $780 thousand over the same period. As a proportion of the world, South Africa's payments have grown from about 0.3% in 2000 to about 1.1% in 2007 and the global share of Swaziland had grown from about 0.04% to 0.07% over the same time.

However, there are other African countries whose royalty and licensing fee payments have fallen between 1990 and 2007. Countries that have seen their payments fall include Cote d'Ivoire, Egypt, Kenya, Morocco and Namibia. For instance, Kenya's payments for knowledge assets have fallen sharply from about $102 million in 1993 to about $23 million in 2007. Similarly, Morocco's royalty and licensing fee payments grew up to $201 million in 1999 but has since fallen to an annual average of about $ 36 million since 2000. Similar fall is seen in the payments of Egypt - from over $400 million in 2000 to an annual average of about $170 million since 2003, and in the payment of Cote d'Ivoire - from about $25 million in 1998 to about $9 million in 2006.

On the other hand, royalty and licensing fee receipts by African countries paint a contrasting picture. In terms of magnitude or absolute value of receipts, Angola, on average, occupies the first place followed by Egypt, South Africa, Kenya and Tunisia as shown in Table 1. Angola recorded its highest level of receipts in 2006 - $1.3 billion – giving rise to an annual average of $275 million between 2000 and 2007. It also accounts for the peak in Sub-Saharan Africa's receipts for 2006 in Figure 3. On this basis, Angola's receipts went up 25 times, followed by Botswana whose receipts went up 22 times between 1990 and 2007. South Africa, Lesotho, Madagascar and Cameroon are among countries that have seen their royalty and licensing fee receipts fall while Egypt, Cote d'Ivoire and Kenya are among countries that have witnessed a general growth in their receipts. The countries whose royalty and licensing fee receipts have increased are not exactly exporters of knowledge-intensive products or generators of technologies but rather charge royalties and licensing fees related to other activities such as explorations, mineral and mining rights and others related to travel and tourism, etc.

Table 1. Average annual royalty and licensing fee payments and receipts for selected countries in Africa (in US$ million)

	Payments		Receipts	
	1990-99	2000-07	1990-99	2000-2007
South Africa	195.0	809.8	52.0	37.2
Egypt	288.5	223.5	49.8	95.0
Swaziland	20.5	76.4	0.2	0.1
Kenya	48.4	44.0	12.9	16.8
Morocco	111.9	36.4	4.3	13.8
Madagascar	6.8	13.4	1.2	1.0
Cote d'Ivoire	13.1	12.9	0.3	3.3
Botswana	6.6	9.6	0.1	1.5
Tunisia	2.0	7.3	3.7	15.6
Senegal	1.3	5.0	0.9	0.1
Cameroon	1.1	3.6	1.7	0.5
Namibia	3.2	2.9	2.8	1.8
Niger	0.7	0.5	NA	NA
Cape Verde	0.1	0.2	0.1	0.2
Angola	NA	NA	10.7	274.7
Lesotho	NA	NA	32.2	15.3

Source: World Development Indicator, 2009
NA= Not Available

2 Trends in capital goods imports

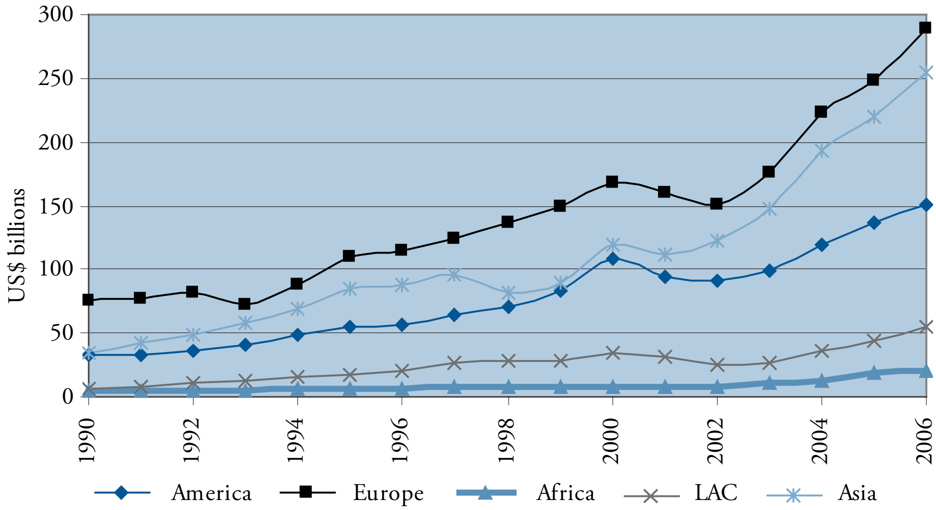
In general, the import of capital goods[7] has grown rapidly over the last two decades. Such imports have increased by 7.8-fold for LAC, 7.5-fold for Asia, 4.7-fold for North America, 3.9-fold for Europe and 3.7-fold for Africa between 1990 and 2006. However, Europe, North America and Asia are the largest importers of capital goods. Imports of capital goods by European countries increased from about $74 billion in 1990 to about $289 billion in 2006. As such Africa's imports of capital goods grew much slower than that of the other regions included in this paper (see Figure 4).

It was noted that Africa is the only region that spends more than 10 times on imports of capital goods than it earns in exports of similar goods. This perhaps indicates that Africa is not a major producer of capital goods as its exports of capital goods remained largely unchanged. On the other hand, Asia has joined Europe as a net exporter of

7 Capital goods refer to the sum of handling, electrical and non-electrical machinery, telecommunication equipment and metal work machinery or tools (SITC groups 723, 736, 744, 764, 771, 778 and 874).

capital goods and LAC's exports of capital goods have grown at the same speed as that of Asia (a 3-fold increase).

Figure 4. Imports of selected capital goods



Source: UNCTAD Handbook of Statistics, 2009

A closer look at Africa reveals that imports of capital goods have grown rapidly since 2001. Imports of such goods did not change much between 1995 and 2001 but has almost tripled in value between 2001 and 2006. Therefore, while Africa remains a small importer of capital goods, it has registered the fastest growth in the import of capital goods between 2001 and 2006 than any other regions.

To what extent is the upswing in the import of capital goods by Africa widespread among countries at different stages of development on the continent? Is this trend concentrated to the larger and more technologically advanced economies in the region? To shed light on these questions at national level, we look at trends in imports of capital goods by African countries. Data between 2000 and 2008 is used, and the trend is identified based on data that is available for at least 5 years and/or is sufficiently spread over this period to identify a trend. Given the UNCTAD database no longer provides such data on individual capital goods by country, we adopt the definition of capital goods as is used in the "Broad Economic Categories" (BEC) classification[8] 41

8 There are seven main BEC classifications: 1 - Food and beverages: 2 -Industrial supplies not elsewhere specified; 3 -Fuels and lubricants; 4 -Capital goods (except transport equipment), and parts and accessories thereof (41- Capital goods (except transport equipment) and 42 Parts and accessories); 5 Transport equipment and parts and accessories thereof 6 Consumer goods not elsewhere specified and; 7 Goods not elsewhere specified).

in Comtrade. This data is used only to identify trends among African countries. Since we have already demonstrated that Africa is not a major exporter of capital goods, we only focus on imports of capital goods.

In terms of rate of growth in imports of capital goods, Madagascar registered the fastest growth in imports of capital goods between 2000 and 2008 in Africa. Madagascar's imports of capital goods increased eight times within that period. Another four African countries – Zambia, Niger, Nigeria and Rwanda - saw their imports of capital goods increased more than seven times between 2000 and 2008 and those of Guinea and Uganda increased more than six times over the same period. In general, about 60% of the African countries (19 out of the 32) considered here saw their imports of capital goods more than tripled and another 16% of the countries saw their imports more than doubled over this period.

There are also a number of general observations. The best performing countries in terms of imports of capital goods are smaller economies – except Nigeria. Secondly, while the mining and petroleum producers and exporters performed well, the top importers include countries outside this category such as Ethiopia, Malawi, Rwanda, and Uganda. Some of the countries that have not witnessed a fast growth in the imports include Botswana, Mauritius and Swaziland.

In terms of value of imports of capital goods, South Africa is the leading importer. As shown in Table 2, South Africa's imports of capital goods stood at about $15 billion. South Africa, Nigeria, Egypt, Algeria and Morocco (in descending order) accounted for about 70% of the total imports of capital goods of the countries included in Table 2. About eight countries, for which data is available, had imports of capital good in excess of $1 billion in 2008. While this may sound insignificant, one has to remember that a number of African economies have GDPs of less than $20 billion.

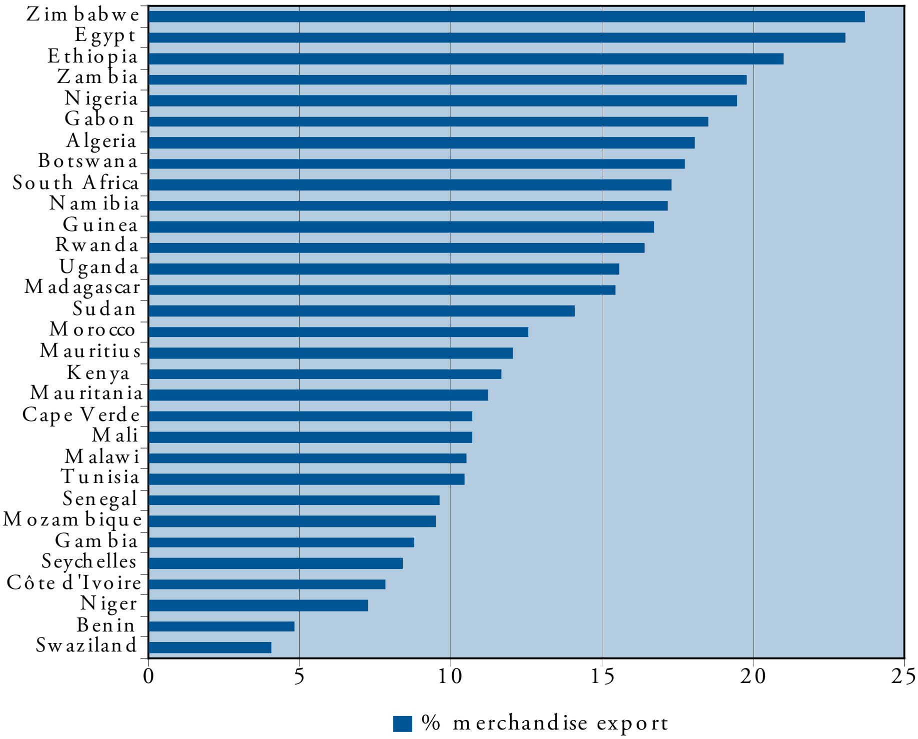
To determine the extent to which countries are investing in capital goods, we assess such imports as a proportion of total merchandise imports. As shown in Figure 5, about 10 out of the 32 countries spent more than 17% of their total merchandise import bill on capital goods. Zimbabwe, Egypt, Ethiopia, Zambia and Nigeria are the top five countries and they each spent almost a fifth or more of their total merchandise imports bill on capital goods in 2008. Only Benin and Swaziland out of the 31 countries whose data was available spent less than 5% of their total merchandise imports on capital goods in 2008.

Table 2. Imports of capital good (BEC 41) of selected African countries

	2000	2001	2002	2003	2004	2005	2006	2007	2008
South Africa	5089	4749	5010	6350	8500	10000	14088	14088	15322
Nigeria	851	1096	1815	2676	-	-	5235	5463	6280
Egypt	1771	1385	1166	896	1090	-	-	-	6201
Algeria	1432	1678	2144	2643	3489	3583	3540	4381	-
Morocco	1739	1401	1462	1841	2365	2668	2908	3793	-
Tunisia	1177	1293	1176	1315	1499	1494	1621	1976	2534
Kenya	414	439	336	364	580	580	777	1067	1473
Ethiopia	194	235	236	395	447	690	777	1097	1097
Sudan	225	257	334	384	640	1388	1687	1184	891
Uganda	122	139	128	174	237	347	357	533	737
Zambia	94	152	162	248	304	347	598	788	713
Madagascar	85	91	45	114	189	206	174	327	699
Senegal	168	168	88	201	260	391	391	424	629
Côte d'Ivoire	219	224	317	377	425	716	391	496	575
Botswana	347	249	432	575	370	341	318	489	571
Namibia	203	203	161	164	298	317	345	543	546
Zimbabwe	-	164	326	-	282	134	228	522	-
Mauritius	242	196	243	277	331	574	593	468	465
Mozambique		80	135	198	247	282	317	281	391
Malawi	75	61	62	89	99	124	115	124	357
Mali	78	129	79	110	100	119	163	216	337
Gabon	181	162	150	123	136	217	289		
Rwanda		31	31	29	23	57	71	97	230
Guinea	29	35	35		90	56	94	173	183
Niger	17	17	40	56	63	57	100	97	124
Swaziland	109	81	92	199	130	126	123	95	
Mauritania	34	43	23	26	819	670	66	134	87
Cape Verde	26	26	32	27	32	41	60	79	83
Seychelles		33	43			39	52		64
Benin	34	49	40	57	66	46	48		
Gambia	10	6	7	10	21	21	23	26	18

Source: Comtrade database, 2009

Figure 5. Capital goods imports (BEC 41) as percentage of merchandise imports



Source: Comtrade database, 2009

3 Trends in trade of business, professional and technical services

Most of the data on trade in services is not sufficiently disaggregated to identify technology transfer-related service payments and receipts. Here we use the United States - the top exporter and importer of such business, professional and technical (BPT) services - as a proxy of trends in global trade in BPT services. Geographical proximity, trade relations, language barriers, diplomatic relations and historical ties are likely to influence access to and trade in BPS among countries in different regions. Despite this limitation, United States has the data disaggregated sufficiently to at least portray some general trends in trade of BPT services.

According to the United States Bureau of Economic Analysis (USBEA), the trade in BPT services between the United States and the rest of the world has grown, at varying speeds, as shown in Table 3a. In general, payments by the United States for business and professional services grew faster than receipts. Intra-firm payments increased much faster than inter-firm receipts. While this raises some doubt that firms may be overstating payments to cover external profits, it is perhaps important to note that inter-firm payments also grew faster than inter-firm receipts.

Africa posted a 5-fold increase in receipts by and 51-fold rise in payments to the United States between 1990 and 2005. As shown in Table 3b, it was observed that receipts by the United States from unaffiliated[9] firms for business and professional services between 1990 and 2005 increased by about 7.7-fold in Europe, 6.5-fold in Asia, 5.6–fold in Africa and 4.3- fold in LAC. However, growth in payments by United States firms to unaffiliated firms for BPT services grew fastest in Africa (51-fold) followed by Asia (14.2-fold), LAC (9.5-fold), and Europe (8.7-fold) over the same period. As a result, Africa's share of United State's imports of BPT services has more than doubled – form 0.5% in 1990 to about 1.2% 2005 (see Table 3c).

There is also a major difference in the nature of BPT services that are traded between affiliates and their parent firms, between unaffiliated firms, and between the United States and developing regions. As shown in Figure 6, more than 40% of intra-firm payments to the United States was for management, consulting and public relations type of services and about 25% was for research, development and testing services in 2008. However, these two groups of BPT services made up less than 9% of inter-firm payments in 2008. Similarly, installation, maintenance and repair of equipment and legal services made up about 26% of the payments by unaffiliated firms to the United States while the same group of services constituted only about 4 % of payments by affiliated firms.

Similar differences are also observed at the regional level. Inter-firm trade in BPTs accounts for over 60% of Asia's payments but less than 40% of that of Africa. Similarly, about 33% and 22% of Africa's payments for BPT services to the United States are for management, consulting and public relations services and construction, architectural and engineering services, respectively. These two categories of services collectively account for only about 22% of LAC's and about 30% of Asia and the Pacific's payments for BPT services to the United States. It seems intra-firm trade dominates Africa's payments for BPT services.

While the rest of Africa is collectively a net importer of BPT services from the United States, South Africa has been a net exporter of such services in 2006, 2007 and 2008. Other developing countries that are net exporters of BPT services in the period reviewed include Brazil, India, Israel, Malaysia, Philippines and Thailand. Of these, India was the largest net exporter of BPT services to the United States – rising from $3.5 billion in 2006 to $6.8 billion in 2008.

9 Until 2006, only data between unaffiliated firms was disaggregated by country and thus by region. Since 2006, both inter-firm and intra-firm trade in business and professional services is disaggregated by country or region. Thus the data for 2008 is total trade in business and professional services while that for 1986 and 1996 are only for unaffiliated firms (inter-firm). For this reason, the 2008 is only used to determine the main importers and exporters of these services from and to the United States but cannot be compared to that of 1986 or 1996 to highlight a trend.

Table 3a Trends in the United States' international trade in business, professional and technical services (in US$ millions)

	Receipts		Payments	
	2001	2008	2001	2008
Intra-firm	30,744	55,484	20,966	50,603
Inter-firm	28,169	58,041	9,452	25,681
Total	58,913	113,525	30,418	76,284

Table 3b The United States' international inter-firm trade in business and professional services by region (in US$ millions)

	Receipts			Payments		
	1990	2000	2005	1990	2000	2005
Europe	2,182	10,153	16,805	687	3,481	5,979
Africa	230	1008	1,289	11	155	562
Asia	979	3,382	6,365	147	963	2,087
LAC	1314	3,690	5,640	126	574	1,208

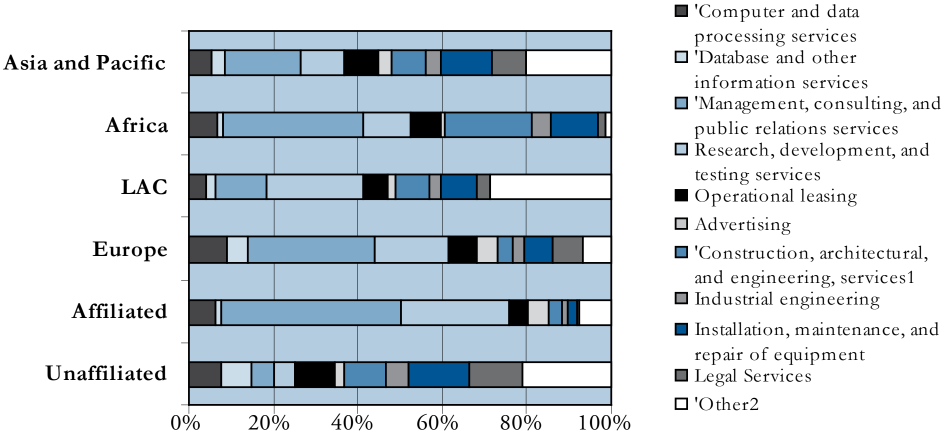
Table 3c As a percentage of the US receipts and payments

	Receipts			Payments		
	1990	2000	2005	1990	2000	2005
Europe	28	40	42	33	38	13
Africa	3.0	4.0	3.2	0.5	1.7	1.2
Asia	13	13	16	7	11	4
LAC	17	15	14	6	6	3

Source: US Bureau of Economic Analysis

NB: Data for trade in services between affiliated firms is available only from 2001 and receipts refer to exports of such services by the US and payments refer to imports (i.e. US firms paid for the services).

Figure 6. Difference in composition of import of BPS from the United States in 2008

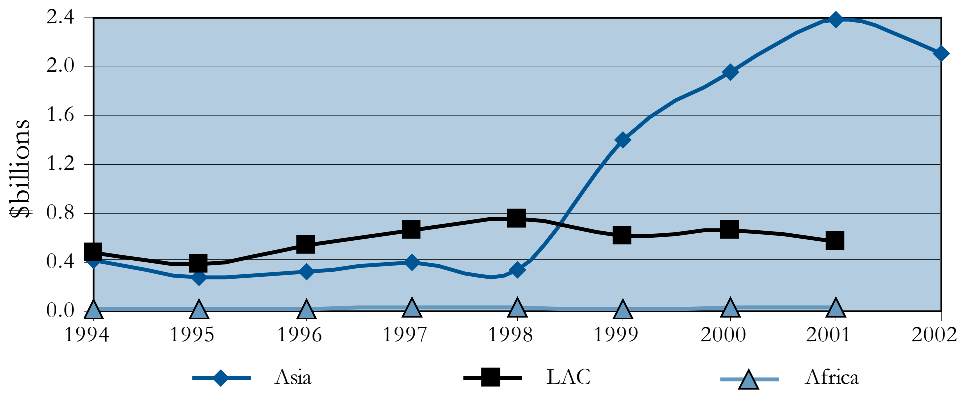


Source: US Bureau of Economic Analysis Table 7a, 2009

4 Internationalization of research and development.

Africa is not a favoured destination of R&D projects or outsourcing location of R&D and testing services. It was observed that affiliates of United States firms spent $29 million in Sub-Saharan Africa while spending $562 million in Latin America and the Caribbean (LAC) and $2.39 billion in Asia on R&D activities in 2001. Although expenditure on R&D by foreign affiliates abroad increased from about $29 billion to $67 billion globally between 1993 and 2002, Africa does not seem to be benefiting (UNCTAD, 2005a). As shown in Figure 7, R&D expenditure by foreign affiliates has increased rapidly in Asia between 1998 and 2002, while it has remained almost unchanged in Africa and LAC.

Figure 7. R&D expenditure by US TNCs abroad



Source: NSF, Science and engineering indicators, 2006

There has also been a noticeable increase in the number of technology-intensive firms establishing R&D units abroad. However, of the total of 596 R&D projects established abroad between September 2004 and October 2005, about 47% of them were established in three countries: India, China and Singapore and not a single African country was among the top 15 destination countries (OCO Consulting, 2005).

Although Africa does not feature highly among the top locations that attract R&D projects, a few countries such as Algeria, Egypt and South Africa seem to have benefited from this trend. For example, Boeing, the world's largest producer of aircrafts, invested $5 million in South Africa's Satellite Application Centre (SAC) for the Ka band Telemetry, Tracking and Command (TT&C) facility at SAC in 2003 to provide support for next-generation of satellite communication. It was the first of a few such centres globally (about 5) that Boeing was seeking to develop such centres through partnership arrangements. SAC has offered such services in the past to a number of renowned space agencies in tracking and command services.

Aspen, Africa's largest pharmaceutical producer, and Matrix, one of India's largest pharmaceutical firms, invested in a new plant to produce active pharmaceutical ingredients (API) for Aspen in India. This arrangement included the transfer of technology and intellectual property for the production of API to the new firm. Aspen had a similar arrangement with Eli–Lilly, one of the global leading pharmaceutical firms, involving the transfer of Lilly's drug manufacturing and packaging technology to enable Aspen to manufacture two essential anti-TB drugs for treatment of multiple-drug resistant tuberculosis. Under this arrangement, Lilly provides manufacturing know-how and access to technical experts. In 2010, Lilly paid $1 million to Aspen as part of the technology transfer agreement. Lilly is expanding the reach of its products while Aspen is acquiring vital technologies and expanding its export opportunities.[10]

Kenya is home to some of the world's top research and development institutions with a focus on regional health and agricultural challenges. The country hosts several international R&D institutions. Significant R&D investment and participation of international partners such as the Center for Disease Control (CDC) and Walter Reed Institute (United States), Wellcome Trust (United Kingdom) and Japan International Cooperation Agency (JICA) in the Kenyan Medical Research Institute (KEMRI) has made Kenya one of the top global producers of scientific publications in peer-reviewed scientific journals on malaria. Similar trends have been noted in Algeria, Egypt, Senegal, Mauritius and Morocco (Hassan, 2009). These countries have attracted a number of projects related to information technology.

If this trend continues, countries attracting facilities of TNCs that conduct R&D may acquire skills to generate new inventions at the frontiers of knowledge generation and help build a sound technology base or become owners of indigenously developed

10 Aspen receives $1 million in transfer of technology agreement, 03 February 2010 (source www.aspenpharma.com)

technologies. A quick glance reveals that, in the case of India and Singapore, an increasing number of foreign firms are seeking patent applications in the USPTO – an indication of the increasing performance of R&D activities in these countries by foreign affiliates (see Table 4).

Table 4. Total number of patents granted to top ten applicants in India and Singapore by USPTO between 2002 and 2006.

India		Singapore	
Council Of Scientific And Industrial Research	619	Chartered Semiconductor Manufacturing Ltd.	391
Texas Instruments, Incorporated	111	Seagate Technology, LLC	171
International Business Machines Corporation	106	Micron Technology, Inc.	128
General Electric Company	86	National University Of Singapore	103
~Individually Owned Patent	71	~Individually Owned Patent	93
Ranbaxy Laboratories Limited	45	St Assembly Test Services, Pte Ltd.	63
Stmicroelectronics Pvt. Ltd.	34	Hewlett-Packard Development Company, L.P.	57
Dr. Reddy's Laboratories Ltd.	22	Institute of Microelectronics	49
GE Medical Systems Global Technology Company, LLC	21	Agency for Science, Technology and Research	44
Cisco Technology, Inc.	20	Hewlett-Packard Company	37

Source: USPTO statistics, 2008 (NB: In italics and bold are foreign affiliates).

5 Trends in patenting activities.

It was observed that Africa is the only region where patent applications have actually fallen between 1990 and 2004. Based on national reports to WIPO, the number of patent[11] applications and granted patents worldwide grew rapidly between 1990 and 1996. Since then the number of patents granted per year has 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 8). However, the drop in Africa's data after 1995 is due to the missing data from Sudan and South Africa, who have not reported their resident patenting activities since these dates[12] (see Table 6).

It can be deduced from Table 6 that the proportion of non-resident patent applications ranges between 50% and 80% and has not changed much for LAC, while Africa and Asia registered steady increase since the early 1990s. The proportion of patents filed

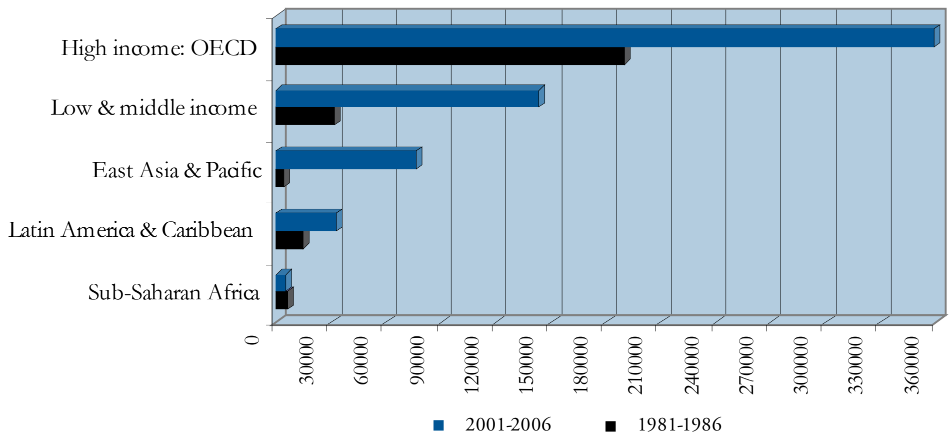
11 Unless explicitly stated, the term patent as used in this paper refers to utility patents (i.e. patents for inventions) and therefore may not include design and plant patents or utility models. In the United States, utility patent applications and granted patents represent over 90% of all patent applications.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

12 Although, WIPO has data up to 2004, a number of countries have not reported patent applications after 2000 and the major fluctuations in the graph are due to absence of national entries in some of the calendar years in WIPO data.

by non-residents is highest in LAC, averaging about 80% since 1992. Africa is the only region that registered a continuous decline in the late 1980s.

Trends in patent applications vary widely among African countries. In general, South Africa receives the highest number of patent applications followed by Egypt, Morocco, Tunisia, Algeria, Seychelles and Mauritius, according to WIPO database (see Table 7 for details). South Africa accounts for about 54% of all patent applications received by African national patent offices while Egypt accounts for about 23% during the period 2005-2007. On the extreme end, the national patent offices of Burkina Faso, Chad, Democratic Republic of Congo, Guinea, Mozambique, Niger, Somalia, Angola, Côte d'Ivoire, Gabon, Sudan, Botswana, Cameroon, Tanzania and Senegal received an average of fewer than one patent application annually between 1995 and 2007.

Figure 8. Average annual patent applications by non-resident



Source: WIPO, 2009

Table 5. Annual average patent applications by developing regions

		1990-94	1995-99	2000-04
Africa	Residents	6960	1661	397*
	Non-residents	7020	2385	686*
Asia	Residents	10109	15342	22521
	Non-residents	16602	31654	33419
LAC	Residents	3632	4068	4056
	Non-residents	13499	15548	8575

Source: WIPO
* =The drop in Africa is due to missing data.

In terms of growth, Africa shows a mixed picture as a number of countries such as Mauritius and Seychelles registered an increase in number of patent applications to their respective offices. The annual average of patent applications for Mauritius and Seychelles increased from about 3 and 1 per year in the period 1995 to 1999 to about 25 and 34 applications per year over the period 2005 and 2007, respectively. Other African countries that witnessed impressive growth in patent applications include Algeria, Kenya, Morocco and Uganda. Some of the countries with fewer than 6 patent applications per year recorded by their offices include Libya and Nigeria – some of Africa's largest economies.

Table 6. Annual average patenting activities of African countries

	1995 - 1999	2000-2004	2005-2007
South Africa	1710	648	900
Egypt	390	509	371
Morocco	56	46	120
Tunisia	45	45	31
Algeria	38	43	71
Seychelles	1	8	34
Madagascar	9	6	2
Mauritius	3	6	25
Kenya	18	5	23
Uganda	0	4	7
Zimbabwe	17	3	2
Swaziland	0	2	1
Central African Republic	1	2	0
Sierra Leone	0	2	1
Zambia	3	2	0
Mali	0	1	1
Nigeria	0	1	5
Burundi	0	1	1
Malawi	2	1	0
Ethiopia	1	1	1
Ghana	0	1	3
Libya	4	0	0
Namibia	0	0	1
Benin	0	0	1
Mauritania	0	0	1
Congo	0	0	1
Lesotho	2	0	0

Source: WIPO
NB: Burkina Faso, Chad, Congo D.R., Guinea Mozambique, Niger, Somalia, Angola, Côte d'Ivoire, Gabon Sudan, Botswana, Cameroon, Tanzania and Senegal reported much lower or no patenting activities.

In terms of foreign patent applications, the proportion varies widely in terms of number of countries of origin and number of patent applications. South Africa has received about 8,940 patent applications originating from over 90 countries between 1995 and 2007 - representing about 62% of the total received by the country. Other countries that received foreign patent applications originating from more than 14 countries (including foreign patent offices) during the period considered here include Egypt, Morocco, Mauritius, Seychelles and Tunisia. However, a number of African countries did not get a large number of patent applications from abroad. For example, about 96% of the patent applications received by Egypt were from its residents.

It was also observed that a number of patent applications received by some of the main African patenting national offices originated from Africa. For example, South Africa – the top patent office on the continent has received about 188 patent applications from 12 African countries. Although this seems to be a small number of patent applications over a 12 year period, it is substantial if one puts it in the right perspective. For instance, the number of patent applications originating from Zambia and Malawi received by South Africa over this time is higher than the total number of patent application received by their respective national patent offices. Nonetheless, about 11 countries report only applications originating from foreign countries. Based on the aforementioned information, one may conclude that the level of inventiveness is very low to utilize patents as sources of knowledge and few inventors and owners of knowledge consider Africa for foreign patent applications.

6 Trends in trademark use

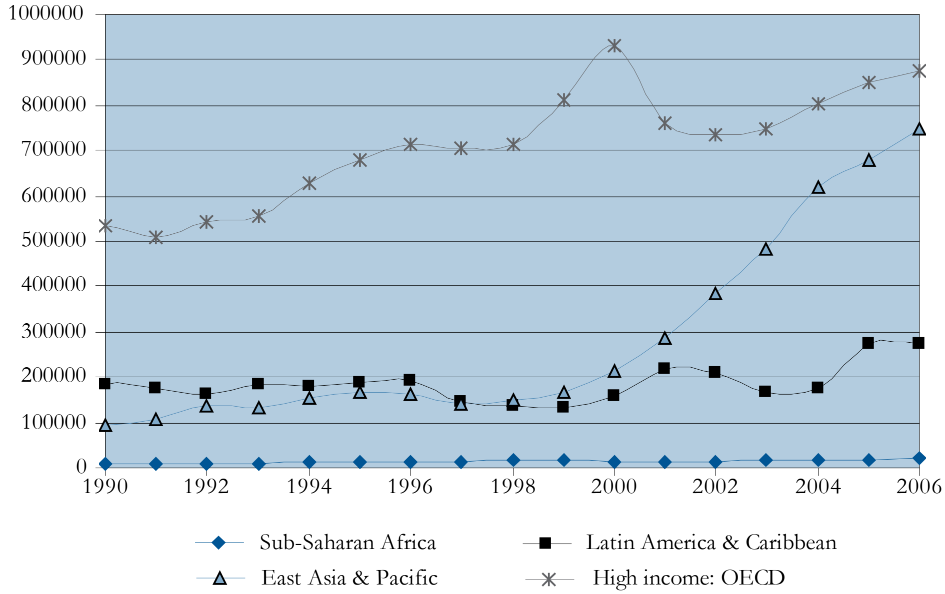
Africa registered a 2-fold increase in resident trademarks between 1990 and 2001. Only East Asia and the Pacific registered a higher growth in resident trademarks (8.1 times) than Africa (see Figure 9). The OECD countries recorded a growth of 1.6 times and LAC 1.5 times in the same period. In terms of non-resident trademarks, the OECD registered a decline while East Asia and the Pacific, LAC and Africa, in descending order, all registered an increase (see Figure 10). The highest number of trademarks is owned by the OECD countries and Asia. This is expected as most the trademarks are related to distinctive symbols associated with innovative products, services and designs.

The percentage of non-resident trademarks to total trademarks in SSA and LAC is higher than that of the other country groupings. For example, non-resident trademarks make up about 40% of SSA and 31% of LAC in 2005 while they only account for 14% for OECD and 12% for East Asia and Pacific. The proportion of non-resident trademarks has declined in all the regions.

In terms of technological learning (copying, imitating and improvements), non-resident trademarks may be more indicative of technology transfer while resident trademarks may be indicative of innovative and creative activities. For this reason, we only track trends in non-resident trademarks of some African countries whose data is available.

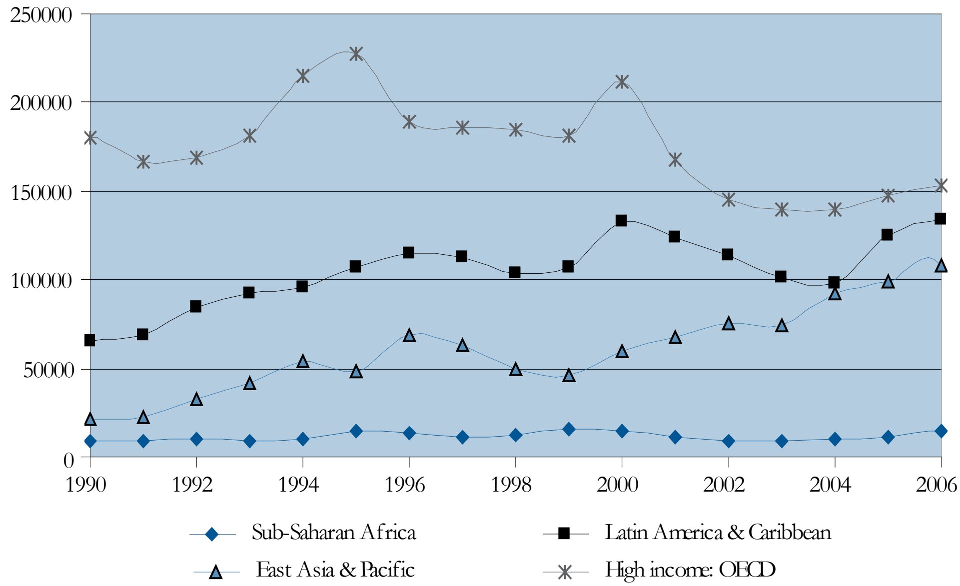
Of the countries which data is available, Kenya, Mozambique, South Africa and Zimbabwe are the countries reporting a relatively high number of non-resident trademarks (about 500 or more per year). The data of most of the SSA countries in the World Development Indicators database is simply indicative and not sufficient to draw any meaningful conclusions beyond the fact that non-resident trademarks outnumber resident trademarks in many SSA countries.

Figure 9. Resident trademarks registered



Source: World Development Indicators, 2009

Figure 10. Non-resident trademarks registered



Source: World Development Indicators, 2009

Chapter 3
Measures to accelerate technology transfer

There are several ways in which a country can promote and facilitate technology transfer. These include providing information on new and emerging technologies, supporting training and attachments, offering targeted tax incentives for technology acquisition, establishing R&D and technology sourcing units in advanced economies, developing international cooperation and partnerships, encouraging trade and foreign direct investment (FDI), among many others.

In this section, we place emphasis on a few viable ways that could be implemented relatively easily and quickly by African countries and likely to stimulate further learning, innovation and technology transfer. To achieve this goal, we first look at key national policies for facilitating technology transfer and several outstanding national examples. Some of the measures have been implemented successfully by some African countries that could provide valuable role models.

1 Domestic policies and technology transfer

Domestic policies are critical in setting the general direction of development, building the technological and industrial base, inspiring entrepreneurial individuals and researchers to acquire, adapt, use, upgrade and diffuse new and emerging technologies. Some countries provide direct support to promote technology transfer. For example, Malaysia grants a five-year tax holiday for approved research companies or institutions, and a double deduction of research expenditure may be claimed in some circumstances. Similarly, India allows a "super deduction" (of 125 per cent) of certain scientific research expenses and for R&D-related capital expenditures. Such privileges encourage technology transfer (UNCTAD, 2005b).

Some countries have used FDI to acquire advanced technologies and develop their industries. For instance, Thailand carefully screened FDI projects to identify their technological contribution, its investment promotion agency linked its SMEs to foreign invested firms and government provided direct support to enable its SMEs become competent partners, especially in the electronics industry. As a result, manufactured exports, as percentage of total exports, increased from 4.7% in 1970 to 65.5% in 1991 (Sribunruang, 1986) and the electronics industry accounted for about 40% of exports in 2002 and earned about $23.6 billion in revenues (McKinsey, 2002).

The development of Empresa Brasileira de Aeronáutica S.A. (Embraer), one of Brazil's most successful high-tech companies and a major manufacturer of aircrafts, has its origin in a government decision taken in 1968 to develop an aircraft manufacturing plant. Founded in 1969, the company became the fourth largest producer of aircrafts by 1990 and it acquired a large proportion of its technology through licensing. A number of its original products were produced under license. Since then, the company has acquired the necessary technological capability to design and produce its own aircrafts, some of which it has licensed to other manufacturers[13] (UNCTAD, 2002).

More recently, Rwanda has set into motion perhaps one of Africa's most ambitious plan on science, technology and innovation (STI), in particular IT, to develop its economy. Rwanda's Vision 2020, STI policy and ICT policy have placed great emphasis on integrated-ICT solutions for socio-economic development and transforming the country into a regional ICT hub. The direct involvement of the President, the integration of ICT within all line ministries and agencies, the requirement that agencies need to set aside 5-10% of their budgets to invest in ICTs, the proactive regulatory framework and the mobilization of the private sector and donors have all enabled Rwanda to acquire the necessary technologies to bring ICT services to even rural communities. Kigali, the capital city, is perhaps going to be Africa's first wireless hub. Most of the technology is being acquired from abroad through trade in goods and services.

The role that domestic policies play in technology transfer can also be achieved by comparing seemingly successful developing countries. Botswana, Korea, Mauritius and Tunisia are successful countries and had a GDP per capita of less than US$300 in 1970. By 2007, the GDP per capita of Korea had increased to $19,500 and that of Botswana, Mauritius and Tunisia had also increased to $5,200, $6000 and $3,300, respectively. However, in this pack of four countries, Korea obviously stands ahead like an economic giant when comparing with the three African countries today.

Korea is an accomplished exporter of sophisticated products and key technology developer with a high standard of living. Difference can also be observed in the rates of technology acquisition by the four countries. For instance, royalty and licensing fee payments made by Botswana and Korea in 1978 was about $121,000 and $2,000,000, respectively. By 1990, Korea's payments in terms of royalties and licensing fees were about 174 times higher than that of Botswana. As of 2007, Botswana paid $11 million while Korea paid about $5 billion (about 450 times) in royalties and licensing fees (see Figure 11). This widening gap in foreign technology exploitation is also reflected in research and development outputs, industrial development and trade.

Before making a simplistic conclusion that the three African countries did not pursue technology transfer vigorously, it is important to mention that Korea had a stock of scientists and science managers that served as a basis for launching a technological transformation of the country. For example, the first university in Botswana was established in 1978 while the first University in Korea was founded in 1885. By 1970, Korea had 12 patents registered by its residents in the USPTO while Botswana has

13 http://www.fundinguniverse.com

none even now. In other words, the difference in payments for technology reflects the difference in national endowments in skills and R&D resources.

Another difference is that Korea makes very clear technological and industrial plans: the number of people to train, public and private investment to be made, the number of firms and R&D centres to establish and the levels of exports, jobs and income to be generated, etc. For instance, in 1993 the government developed the Korea Biotech 2000 plan[14] of action with three main phases and a total investment budget of$15 billion by 2007. The first phase (1994-1997) aimed at acquiring and adapting bioprocessing technologies and improving performance of R&D investment. A total of $1.5 billion was earmarked for the first phase: $482 million from the government and $1billion from the private sector. The main goal of this phase was to establish the scientific foundation for the development of novel biotechnology products.

The second phase (1998-2002) focused on consolidation of the scientific foundation to develop platform technologies and improve industrial R&D capabilities. A total of $2.3 billion ($1.6 billion from the private sector and $720 million from public sector) was earmarked for this phase. The last phase (2003-2007) targeted development of commercialization capabilities to achieve increased global market share of Korean development biotechnology products. The target was to achieve a 5 per cent global market share for Korean novel biotechnology products. An investment of $10.5 billion (of which $ 4.3 billion was to come from the public sector) was envisioned as necessary to achieve the objectives of the third phase. It is now estimated that the biotechnology industry in Korea has an annual turnover of $4 billion a year and has been growing at approximately 10 per cent per year[15].

Similar to the example of Rwanda mentioned earlier, Korea often creates a platform for public research institutions and the private sector to interact. This is needed to secure commitment, monitor progress and further refine the development plan. It is important to note that the Korean biotechnology sector imported the enabling technologies such as fermentation, vaccine and drug screening and production capabilities from developed countries to enable it to develop and export drugs, vaccines and diagnostic kits.

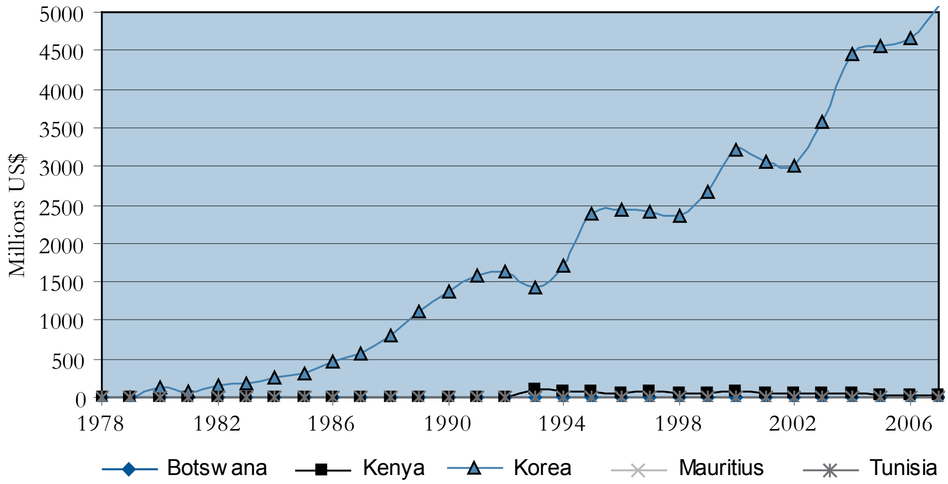
The aforementioned examples of Brazil, Korea, Rwanda and Thailand also indicate that government does not necessarily have to be a passive partner whose role is restricted to setting policies and rules. All the examples highlight the key and influential role of direct government involvement. This is not restricted to developing countries. Recently, the United States President has used every opportunity to promote technology development and diffusion in the areas of alternative and renewable energy and the

14 National Biotechnology Development Program - 'Biotech 2000'.Korea Initiative for Biotechnology Development 1994–2007, Ministry of Science and Technology, Seoul, Korea (1993).

15 Youngguk Cho, Korean Companies Ready to Take-Off", BioSpectrumAsia.com (Jan. 1., 2008).

government has committed resources to this goal. A similar effort by government is underway in Europe. Africa cannot afford to remain behind again.

Figure 11. Comparison of royalty payment



Source: World Development Indicators

2 Four easy and effective steps to promote technology transfer

A Promoting technology transfer through university-industry-government partnerships

One way of promoting the acquisition, adaptation, upgrading and diffusion of new and emerging technologies as well as birth and growth of firms is to improve the relationships between knowledge and skill producers (academia), knowledge users and product/service providers (industry) and regulators/policy makers (government), commonly referred to as the "Triple Helix" of University-Industry-Government (Leydesdorff and Etzkowitz, 2001). The three parties represent the key players of any national or regional innovation system. In brief, the triple helix model does not impose boundary restrictions in relations, interactions and location of innovations and entrepreneurship or the roles of the players. The triple helix is a "spiral model that captures multiple reciprocal relationships at different points of knowledge capitalisation" (Leydesdorff and Etzkowitz, 2001).

In order for academia to play this role, the universities have to expand their roles from being trainers and producers of skilled elites to owners of the knowledge and founders of firms. This gives rise to what has been termed the "entrepreneurial university" (Clark, 1998) whose key characteristics include:

- Independent, strong and efficient managerial system,
- Interdepartmental cooperation and increased collaboration with the outside,
- Broadened resource base,
- Transformation of faculty to accept entrepreneurial attitudes and,
- Shared entrepreneurial culture throughout the university.

These characteristics are seen as key in enabling universities to function as centres for knowledge diffusion and technology transfer, centres for development of firms and agents for economic and social development (creating jobs and wealth). The university, in this case, provides sufficient 'space' to enable research teams to operate as 'quasi-firms', [16] encourages enterprising individuals to work closely with their clients (industry and government) and supports or rewards entrepreneurship (Etzkowitz, 2003).

In practice, common goals and projects and the existence of specialized centres serve as a major vehicle for promoting such partnerships by linking academic and research units with industry and government. For example, it has been observed for a long time that academia-industry-government partnerships in Canada, the Republic of Korea and the United States are well established. 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 indicates the presence of university-industry-government relations in R&D projects[17]. Such investments are designed to enable universities to develop technologies of interest to industry and government.

Although these relations are not well characterised in developing countries, there is a growing volume of evidence that they play an important role. Several countries have already considered ways of encouraging such partnerships. For instance, South Africa's Innovation Hub (The Hub) is strategically located between two of the country's premier scientific and industrial research institutions: the University of Pretoria and the Council for Scientific and Industrial Research (CSIR). Its location promotes the flow of knowledge between The Hub's tenant (industry) and the centres of knowledge generation (academia). Similarly, Egypt's Mubarak City for Scientific Research and Technology Applications (MuCSAT) is located in an industrial area housing about 40% of the Egyptian industry. Established in 1993, MuCSAT comprises 12 research centres and occupies 250 acres. Its location is deliberately designed to encourage collaboration with industry.

16 Many research teams already exist as "semi-private enterprises" that identify opportunities and seek the resources needed to realize them. Often they have a credible research management team, invest in emerging fields of interest and compete for contracts and grants from private and public institution - just like private consultancy firms (see Etzkowitz, 2003).

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

The triple helix model could also be applied in low-technology fields and in least developed countries. In these countries, academia-industry-government relation may be even more important in adapting and diffusing technologies in areas such as agriculture, communication and health. For example, Zambia's second largest producer and exporter of flowers and horticultural products (York Farms Limited) and Zambia's main Internet Service Provider (Zamnet Communications Limited) were all developed by the University of Zambia in partnership with industry or donors and government (Konde, 2004). Similarly, Agro-Genetics Technology Limited (Uganda) and a number of cooperative nurseries in Kenya that supply tissue culture-based banana seedlings to farmers are based on tissue culture technology pioneered by Jomo Kenyatta University of Agricultural Technology (JKUAT) in Kenya in partnership with other public stakeholders.

Overall, academia-industry-government relations are playing an increasingly important role in promoting firm formation and technology transfer and diffusion. Therefore, policy makers should stimulate such relations, ensuring their contribution toward economic and social development.

B Technology transfer through government contracts

Governments are among the major consumers of products and services. They often source products and services in the domestic economy and internationally. Many African governments depend on foreign firms to acquire technologically sophisticated equipment. Governments can use such contracts to encourage local firms to source foreign technologies by floating technologically challenging contracts to local firms. Similarly, governments could ensure that international contractors work with local firms in implementing contracts to encourage technology transfer.

For instance, in 2003, the Chinese government and Microsoft signed a deal to use Windows as the preferred desktop operating system for government offices. In return, Microsoft was required to reveal its Windows source codes to allay the security fears of the Government and cooperate with state-owned China National Computer Software and Technology Service (CS&C), the country's largest software development and integration firm, to co-develop products based on Microsoft's software platforms and train 200 software developers and 120 architects within one year. Rather than simply allow Microsoft to wire up the government operations, the contract was clearly designed to promote technology diffusion.

Another example is the Airbus-Aeroflot deal involving the purchase of twenty-two A350 Airbus planes by the state-owned Russian airline in March 2007. This deal includes the participation of Russian firms in the production of the planes. A number of components for the production of Airbus planes are to be manufactured by Russian plants and the Engineering Centre Airbus in Russia (ECAR), one of Airbus' design and engineering centres. This deal follows the three partnership agreements proposed in 2006 by Airbus (engineering and manufacturing of parts, conversion of passenger planes to cargo planes and participation in design and manufacture of new-generation Airbus planes), with Russian firms and government, estimated to be worth about $25 billion.

Governments can also encourage technology acquisition and development through R&D contracts for the development of new technologies that meet their own aspirations. For example, the United States' National Institute of Health (NIH) spent about $4.9 billion in 2005 on contracts, of which about $2 billion involved R&D contracts. Some of these contracts focus on pushing the knowledge frontier. In 2006, NIH called for proposals from domestic and foreign private or public firms and institutes to develop technology for comprehensive determination of functional elements in genomes[18]. Such a push for development of technology is important in stimulating technology transfer.

In a nutshell, all these arrangements could be tailored to serve as conduits for the transfer of technology from one country to another. In Africa, Tunisia used the contract for global sourcing of motor vehicles to develop its automobile components industry. Firms that agreed to supply automobiles were encouraged to source some components from local firms. Despite its limited market size – a small population – the country managed to attract interest from car assemblers. Backed with incentives and technical support to local manufacturers of automobile parts, the country has developed an industry that supplies parts to car assemblers in Europe.

C Industrial technology alliances

Industrial technology alliances, as defined by the US National Science Foundation (NSF), are "industrial technology linkages with the aim of co-developing new products or capabilities through R&D collaboration" (NSF, 2006). There are at least four factors that promote the development of technology alliances:

- the multidisciplinary nature of R&D activities;
- the complexity of R&D;
- the uncertainty of commercial success of R&D products; and
- the high cost of R&D activities (Suarez-Villa, 2004).

Firms may seek alliances to spread the cost, risks and uncertainty, especially in knowledge intensive fields such as biotechnology where there are restrictive and lengthy regulatory regimes (Ernst & Young, 2005). Some of these partnerships may strategically position a firm to gain access to public and private resources of its partner(s), avoid regulatory and registration hurdles in foreign countries and access lucrative contracts and markets. In the life science industries, such as biotechnology and biopharmaceuticals, and the information and communication technology sector,

18 http://grants.nih.gov/grants/guide/rfa-files/RFA-HG-07-029.html

firms may engage in partnership to create a new firm. For instance, Dow Chemicals and Cargill had pooled their resources to establish NatureWorks LLC (formerly Cargill-Dow)[19] which develops biopolymers from renewable resources by exploiting their complementary technologies.

Industrial alliances are largely concentrated in developed countries. However, there is increasing evidence that firms from developing countries are seeking partners both in developing and developed countries for different reasons. For example, South Africa's Public-Private Partnership (PPP)([20]) initiative supported the establishment of the Biovac Institute – a joint venture involving British, Cuban, Thai and local interests (jointly called the Biovac Consortium) and the government of South Africa's former State Vaccine Institute. Similarly, government supported biotechnology funds have facilitated the acquisition of technology by local firms. BioPAD secured the transfer of recombinant expression technology (strains of micro-organisms and cell lines) from the Swiss based firm - Solidago AG – to Bioclones at a cost of $5.3 million investment. This facilitated the development of Ribotech Pty as a joint-venture between Bioclones (South Africa) and Solidago AG[21] BioPAD is a Biotechnology Regional Innovation Centre (BRIC) established by the Department of Science and Technology to promote the development of the biotechnology industry in South Africa in 2006.

These arrangements are crucial in enabling countries lagging behind to quickly gain access to knowledge, learn and run a business without needing to rediscover the "wheel". The risk of developing, producing, distributing and marketing new products is drastically reduced in industrial alliances such as joint ventures because even the least developed country may easily obtain exclusive access to its market especially where the government has a stake in the firm. Key to these arrangements is the fact that government plays a facilitating role in technology transfer through international industrial alliances and partnerships by completing science and technology agreements with other governments.

D International science and technology cooperation agreements

International science and technology cooperation agreements (ISTCAs) often contain clauses that promote technology transfer. Such promotion may take the form of cooperation in R&D through joint research projects in the field of common interest, strengthening the R&D capacity of the least developed party, exchange of scientists and researchers and fostering relations between research centres, among others.

The EC-Egypt Association Agreement seeks to promote technology transfer. Article 46 on "Investments and promotion of investments" states: "Co-operation shall aim

19 http://www.natureworksllc.com/

20 South Africa defines a PPP as a contract between a public sector institution/municipality and a private party, in which the private party assumes substantial financial, technical and operational risk in the design, financing, building and operation of a project.

21 http://www.dst.gov.za/media-room/speeches/speech.2007-05-22.8873281211

at increasing the flow of capital, expertise and technology to Egypt through, *inter alia*: appropriate means of identifying investment opportunities and information channels on investment regulations[..]. Co-operation may extend to the planning and implementation of projects demonstrating the effective acquisition and use of basic technologies". In addition, it also includes specific clauses on cooperation in science and technology (Article 43) and industrial cooperation in R&D (Article 45). In this case, the agreement seeks to promote R&D and facilitate FDI and technology transfer to the developing partner.

The treaty establishing the Common Market for Eastern and Southern Africa (COMESA) includes specific clauses that seek to promote industrial R&D, the transfer, adaptation and development of technology, and linkages through providing investment incentives to industries. In addition, COMESA's PTA Bank was created to facilitate investment in industrial projects such as the pharmaceutical manufacturing plant in Sudan, a sugar processing facility in Zambia and a flower farm in Ethiopia. COMESA realizes that financing plays an important role in facilitating investment and technology acquisition and use.

Countries enter into collaborative R&D activities to pool financial resources for large or expensive projects, tap expertise and natural resources located in other countries, participate in global projects and promote political, cultural, scientific and industrial relations. In addition, international collaboration could keep national policy makers informed about key international S&T policy decisions of other governments, promote international reputation, facilitate FDI and identify markets for technology products and services.

For these reasons, the Canadian government encourages its "departments and agencies, as an extension of their domestic mandates, [to] develop explicit plans to promote international S&T collaboration for the benefit of Canadian firms" (Canada, 2000). Similarly, Australia encourages international S&T collaboration to facilitate access to global S&T, increase international strategic alliances between researchers as well as industry, exploit emerging technologies, facilitate innovation in Australian businesses and commercialize R&D.

For instance, Brazil and China agreed (in 1989) to develop two remote sensing satellites through the China-Brazil Earth Resources Satellite (CBERS) Programme (Sausen, 2001). The Programme pools the human and financial resources of both countries to establish a remote sensing system that is competitive and compatible with international needs. To boost industrial development, a clause was included that obligated the Chinese to reinvest the equivalent of the money received from Brazil to purchase Brazilian products. The inclusion of such clauses stimulates industrial involvement and investment in R&D.

In the CBERS Programme, China bore 70 per cent of the cost while Brazil covered 30 per cent. Brazil is responsible for the development of the high-resolution cameras while China is responsible for the application platform. Recently, Brazil and China have agreed to swap fuel technologies and develop a joint venture for the construction of aircraft turbofan jets for low-cost and low-maintenance aircrafts. Such agreements benefit industries that develop, source and supply the technology such as aircraft manufacturers and suppliers of aircraft components.

Although most ISTCAs do not explicitly mention the involvement of private firms, enterprises are attracted by lucrative contracts associated with large collaborative projects. In cases where new centres are established between countries, they could have a demonstrative effect. For example, the ISTCA between the Republic of Korea and Russia in 1990 led to the establishment of joint research centres in Russia for collaboration in various areas such as aerospace, materials, energy, and optics, among others. Such joint centres may have facilitated Korean firms, such as Samsung, to enter into technology partnerships and establish R&D centres in Russia. Samsung has already utilized the advanced Russian materials technology to create an ultra slim notebook computer.

A similar push is also seen in the recent science and technology agreements between Brazil, India, Nigeria and South Africa. With rapidly developing economies and growing markets, countries may wish to use science and technology cooperation agreements to harmonize regulations, identify common areas of interest and leverage their national investment in science and technology.

Such collaboration also helps familiarize individuals in private and public institutions with the culture of partner countries and promote understanding. Such knowledge may be vital to foreign firms seeking to establish abroad or access technology and other resources located in other countries. In a knowledge economy, foreign investors are seeking to move to places where the cost of skills, knowledge and technology development are still low. African countries could utilize international R&D collaboration to leverage their R&D budgets, build domestic technological base, acquire international reputation and develop good policies. To achieve this goal, Africa has to sharpen its science and technology diplomacy to conclude S&T cooperation agreements with developed and developing countries in its areas of interest.

Conclusion

Technology transfer as used in this paper includes various processes associated with acquisition, learning or mastering of technology and further innovative activities. It is clear that countries that acquire technology to support these activities learn to innovate and, in the long run, become leading innovators. A number of countries highlighted in this paper have developed their industries, expanded and diversified their exports and improved the quality of life of their people through successful technology transfer.

Another key observation is that technology transfer is not only vital for developing countries but also developed countries. Indeed, most of the technology transfer related transactions and deals occur between developed countries. A number of developed countries such as Japan – the second major exporter of technology- remained net importers of technology until quite recently and another innovative and emerging technology exporter – Korea- remains a net importer of technology. As such technology transfer is not and should not be seen as a one-off activity but rather a continuous process. The development of new and improved products, processes and organizational arrangements (i.e. the process of innovation) is likely to depend on access to knowledge generated by others.

Perhaps one of the most surprising conclusions is that Africa is performing relatively well in a number of areas in terms of technology transfer, in contrast to what has been found in a previous study (UNCTAD, 2003). This may signal a technological resurgence at least at the industrial level. In general, Africa performed relatively well in the import of foreign technologies embodied in machines and some services. Africa's 10-fold increase (about 900%) in royalty and licensing fee payments between 1990 and 2008 is above the world average and the second highest among the regions compared in this paper. More importantly, a number of African countries recorded higher growth in this area than the African average: Cameroon (2,100%), Niger (4,300%) Senegal (2,300%), South Africa (1,100%), Swaziland (1,200%) over the same period.

We also note that Africa recorded the fastest growth in imports of capital goods between 2001 and 2006. A number of African countries including Guinea, Madagascar, Niger, Nigeria, Rwanda, Uganda and Zambia recorded an increase of more than twice the African average. Similarly, Africa's imports of business, professional and technical services from the United States rose at a slower rate than that of Europe and Asia while Africa's exports of the same services to the United States increased faster (51-fold) than any other region.

However, Africa performs very poorly in those proxies related to new and emerging knowledge. The continent registered limited increase in R&D expenditure by foreign affiliates, attracted very few R&D projects, and recorded the lowest growth in foreign patent applications and trademarks granted. This perhaps indicates the continent has a limited number of knowledge hubs and centres and research firms capable of undertaking R&D activities in Africa. This is also supported by studies that have also noted that the number of scientific and technical papers published in peer-reviewed journals has fallen in Africa but grown in all the other regions compared here (Hill, 2004).

At a global level, we can make three general observations. First, cross-border payments for technology are growing fast but are still concentrated among developed countries and involve only a handful of developing countries. This is not entirely surprising as technology transfer is needed to generate and improve productivity and efficiency (Nelson and Phelps, 1966). Second, countries that have benefited from increased global flows of technology have also registered remarkable development, such as Asia. This is expected as effective technology transfer is fundamental to the processes of learning and catching-up (Perez and Soete, 1988). Third, all developing regions import more what may be termed mature technologies (e.g. machines) than knowledge (e.g. services and patents). It has been observed that a number of African countries had more patents issued to their residents by the US Patent Offices before 1968 than between 1968 and 2004 (Konde, 2006).

Significant attention has focused on the ability of a country to acquire, absorb, master and exploit foreign technologies to become innovators (Trivigno, 2006; Eriksson 2005). While these trends may signal an increase in industrial upgrading, African countries may wish to invest in generating the scientific and technological base necessary to identify, acquire, operate, maintain and modify appropriate foreign technologies to meet their unique development ambitions (Nelson and Phelps, 1966).

Based on this understanding, we recommend a few simple measures that countries could implement to promote technology transfer and innovation:

1. Governments may wish to promote industry-academia-government (triple helix) partnerships to identify, acquire, adapt, upgrade and diffuse new and emerging technologies as well as incubate and nurture start-ups. Each of these players brings unique advantages that could reduce costs and risks associated with technology transfer.

2. Government contracts should be used to facilitate technology transfer through requirements that encourage joint ventures and projects between domestic and foreign firms, and between domestic industries and R&D centres.

3. Industrial alliances between domestic and foreign firms, especially those in which the government participates, invests or acts as guarantor could serve as a driver for technology transfer, learning and innovation.

4. International science and technology cooperation agreements (ISTCAs) between African countries and leading or emerging technology exporters could

be developed with a focus on joint research projects, exchange of expertise and knowledge, pooling of resources and exchange of good practices.

All these measures are not mutually exclusive and thus can be mixed, recombined and refined to come up with innovative organizational arrangements to fit national realities. Further, incentives for technology development, transfer and diffusion could also be built in these models. Other measures such as incubators, science parks, and industrial districts could be tailored to promote these models and vice-versa. The main objectives behind each of these recommendations are to encourage private sector involvement in innovation, leverage limited human, financial and institutional resources through partnerships and cooperation, and encourage learning through exchange of best practices and wider diffusion of technology.

To achieve these goals, countries need to mobilize their STI and non-STI development agents and agencies (e.g. those responsible for promoting investment, small and medium-sized firms, trade and industry and diplomacy) to take on board the need to facilitate technology transfer. This is important as many of the areas addressed do not fall within the mandate of the ministries or agencies of science and technology only. The cooperation of other key ministries will be crucial to the success of any program as highlighted by the case of Rwanda.

Further research is required to understand the drivers and conditions for promoting technology transfer to account for national differences among African countries. It will be interesting, for instance, to unmask why some of Africa's relatively larger economies such as Egypt, Kenya, Libya, Nigeria, Morocco and Zimbabwe seem to have underperformed according to the proxies used in this study. Such research may also wish to uncover the preferred modes of technology transfer and the motives in order to make informed policy decisions and ways of encouraging such transfers, especially in designing incentives for foreign and domestic investment, R&D performance and imports of expertise, services and capital goods or technologies.

While recognizing the efforts underway to assess and collect information on science, technology and innovation indicators, it may be important to include or develop reliable mechanisms to continuously collect and maintain data related to knowledge acquisition and generation. As demonstrated in this paper, data is missing even in relatively more advanced African countries. Organizations such as UNECA and AU and its NEPAD Agency should commit resources to collect such information to support informed policy making.

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UNECA Science, Technology and Innovation Programme

UNECA helps Member States to promote the use of science, technology and innovation (STI) to achieve sustainable socio-economic development. The STI Programme offers policy advice on new and emerging trends and technical assistance in designing policies, measures and projects to promote, nurture and harness Africa's creative minds and entrepreneurial talents.

The programme benefits from the expertise and inputs of the members of the Science and Technology Advisory Group (STAG), the Committee on Development Information Science and Technology (CODIST) and the biannual Science with Africa (SwA) Conference, among others.

The programme is implemented by the Science and Technology Section with the support of other units of the ICTs, Science and Technology Division (ISTD), under the overall guidance of the Director of ISTD.

I. Policy research and analysis

STI Policy Advice and Implementation

ECA provides policy advice to governments, upon request, to meet their specific development needs and aspirations. Policy advice ranges from STI policy reviews, institutional assessments and advice on draft national STI policies and laws, including support to parliaments in Africa. It also offers support in implementation of legal and regulatory frameworks as well as in development of sectoral and national innovation strategies.

Technology transfer for competitiveness of African countries

This area of work consists of a series of studies, publications and dialogues on "Technology Transfer for Africa's Development". The series is designed to draw attention to the importance of technology transfer in economic development of Africa; emerging global, regional and national trends in technology transfer; and the mechanisms, conditions, capabilities and costs associated with different channels and modes of technology transfer.

African STI Knowledge Hub

UNECA is adapting tools to assess the innovation environment, compile national STI policies and create platforms and databases on key issues. Surveys are undertaken to assess the level of awareness, understanding and perception of the key innovation stakeholders on a number of areas such as advocacy, regulation, education and business environment, among others. The Hub also collects information of existing and emerging STI related policies in Africa and important multi-lateral agreements.

II. Outreach and advocacy

Science with Africa Centre

The centre develops frameworks, indicators, model laws and other tools that could help guide policy makers to assess there own policies and activities against best practices. To achieve this goal, the centre conducts training workshops, policy dialogues and conferences to build capacity of partners, and achieve consensus among key stakeholders on emerging trends and technical issues. One of its major activities is the biannual Science with Africa Conference and its Quarterly Newsletter.

Science with Africa Conference is a vital channel for ECA, the African Union and other UN agencies operating in Africa to harvest new ideas, showcase the work of the United Nations, advocate for STI integration in development programmes and exchange experiences. The Conference brings together practitioners and policy makers in a constructive environment to brainstorm and identify emerging opportunities and alternative ways of harnessing STI to meet regional development goals.

ECA STI Support to AU/NEPAD

This is an ongoing activity in support of the AU/NEPAD S&T Consolidated Plan of Action. ECA provides a Science and Technology Forum that engages and brings together African scientists, policy-makers, the private sector and the development community. This active forum (www.dgroups.org/groups/sti4d-Africa) is used to advocate for the integration of STI in the economic and social development plans of African countries. Furthermore, ECA is the vice-convener of the UN Cluster on S&T of the Regional Coordinating Mechanisms (RCM) in support of AU and its NEPAD programme and the vice-chair of the African Cluster on Science and Technology.

Afro Guide

In collaboration with the AU Commission and the Good Clinical Practice Alliance – Europe, ECA helps in the development of guidelines for health research in Africa (Afro Guide). The collaboration is a follow-up activity to the Science with Africa conference. It seeks to establish commonly accepted African and international standards for the promotion of ethics and good clinical practice.

Access to Scientific Knowledge in Africa (ASKIA)

ASKIA is an initiative to support and promote access to scientific knowledge by African scientists, decision makers, students and researchers. The initiative enables African scientific institutions to tap into global scientific knowledge to promote the production of indigenously owned knowledge that supports economic and industrial growth.

III Business development support services

ECA AFRICA INNOVATION CENTRE

Several activities that fall within the African Innovation Centre are currently being developed by ECA, following the recommendation of "**Science with Africa**" initiative. In response to the call to create this specialized centre, ECA is launching the following sub-programmes and initiatives:

1. **African Science to Business Challenge (ASBC):** Every two years, a call for proposals is made in selected fields of technology. ASBC supports the winning candidate(s) to spend a year in the United States learning how to transform their ideas into a business. The initiative is currently supported by the Research Triangle International (RTI). ASBC is also expected to benefit small and medium-size enterprises (SMEs) and entrepreneurs operating in the informal sector.

2. **African Science and Technology Innovation Endowment Fund (ASTIEF)** seeks to invest in bankable R&D outputs that are likely to make a commercial and social return on investment. This novel initiative is being developed through a unique public-private partnership that brings together the entrepreneurial culture and creativity of the private sector, on one hand, and the ability of the public sector to improve the business climate.

3. **African Technology Development and Transfer Network** supports training programmes, sharing of experiences and expertise, and mentoring/coaching of emerging inventors and start-ups. It also offers matching services for investors, technology producers, inventors and SMEs. These measures are designed to promote technology development, diffusion and commercialization and policy making as well as attachments and secondment of staff from partner centres.

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