A resurgence in acquisition of industrial technology in Africa?

Analysis of global trends in technology transfer.

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Abstract

Economic Development in Africa has made significant strides over the past 20 years. Most African countries carried out economic reforms that eventually contributed to positive and impressive growth in real gross domestic product (GDP), attracted an increasing amount of investment and enabled them to benefit more from favourable trade terms. To what extent do the economic growth rates also reflect a better and more sustainable integration of the African continent into the global knowledge economy? We examine this question by looking at trends in the use, trade and transfer of technology between African countries and the rest of the world. In this context we use royalties and licensing fees, capital goods imports and trade in business, professional and technical (BPT) services as indicators reflect the quality and quantity of technology transfer and global economic integration.

We find that Africa is performing better than expected in the acquisition of industrial technology-related proxies. It is found that, between 1990 and 2008, Africa and Asia enjoyed high growth rates in royalties and licensing fees payments. However, the numbers also show that Africa still lags behind in exports of capital goods and imports of services. We recommend four easy steps that African countries can use to promote a type of technology transfer that would particularly benefit the local private sector.

Introduction

Technology transfer plays a critical role in innovation, industrial development and competitiveness in the global market place. It is for this reason that technology transfer has been a subject of significant interest and international debate.

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" (UNCTAD, 1985; Patel, *et al* 2001). This definition 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 computer or tractor, and as a transaction between the supplier and user of the technology.

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. The transfer of a production process for the manufacture of a product or delivery of 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. 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 have 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.

Irrespective of the mode, 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.

Technology transfer may range from a single purchase to complex negotiations that involve several commitments lasting for months or even years. 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 steps and components of technology transfer.

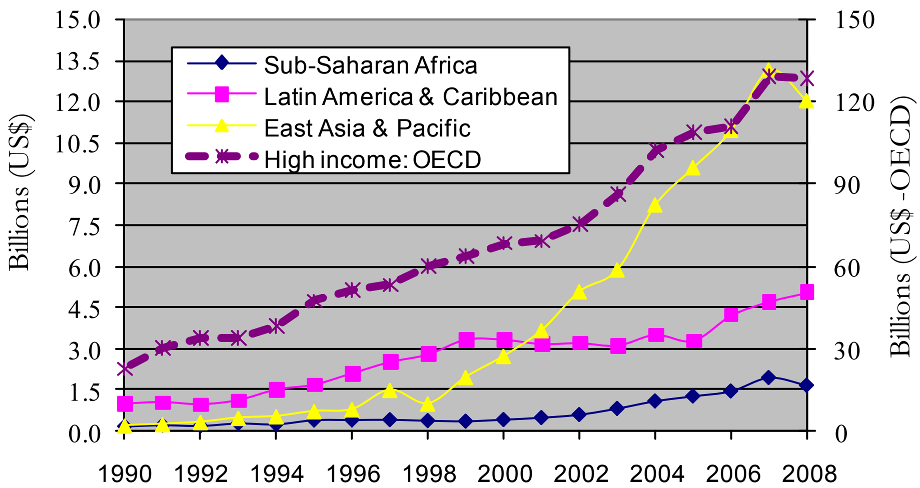
Indeed, technology transfer should not be seen as a one-time process but rather as a continuous process to acquire and absorb advanced technologies to remain competitive. For example, the development of the automotive industry in the Republic of Korea took several key stages. The country started with 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).

1. Tracking and 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. It is important to stress that the technological sophistication or knowledge content of capital goods or intellectual property asset may vary widely even within the same class of machines (e.g., in complexities, sophistication, performance and applications) and, as a result, their validity to serve as conduits for technology transfer (Navaretti *et al*., 2003).

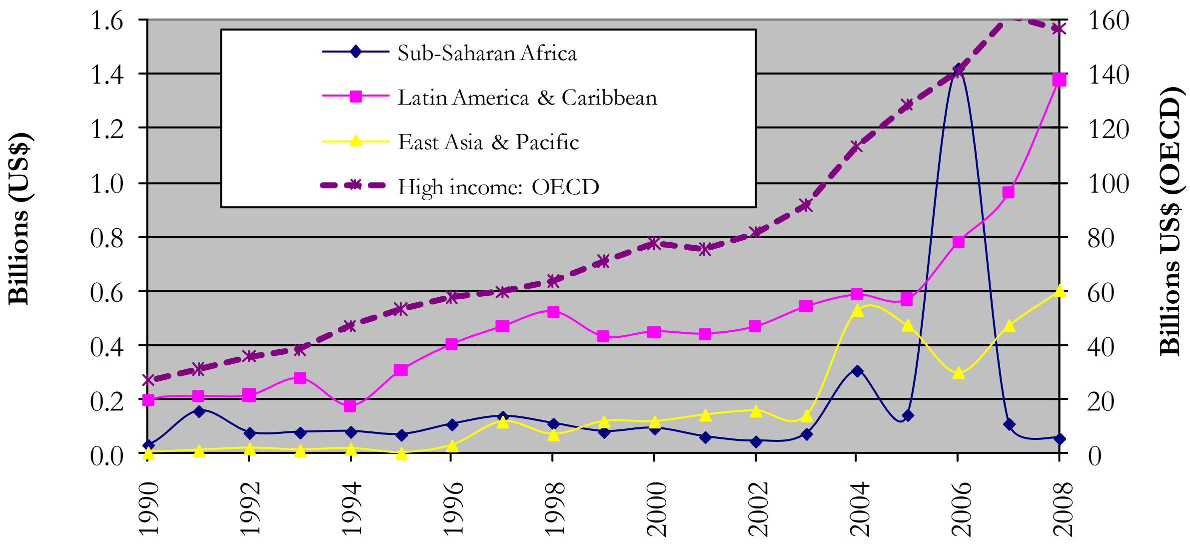
Services are another proxy for technology transfer. Services that play a key role in technology transfer include architecture, engineering, consulting, installation, research, management, operational leasing, financial and analytical testing services, among others. In particular, trade in R&D services is now seen as a key proxy of technology transfer. 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 effec-

Figure 1. Payments: Royalties and licensing fees



Source: World development indicators, 2008

Figure 2. Receipts: Royalties and licensing fees



Source: World Development Indicators, 2009

tively.

2. Trends in technology transfer in Africa

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 analysis largely covers 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 WTO Agreement and with it the 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.

2.1. 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. Globally, 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, royalties and licensing fees payments and receipts have increased nearly 6-fold between 1990 and 2008 globally. As show in Figures 1 and 2, 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.

In terms of royalty and licensing fee payments, East Asia and the Pacific and SSA registered higher than 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 1. LAC has registered the fastest growth in the last four years (2005 to 2008) - with royalty and licensing fee receipts more than doubled.

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

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

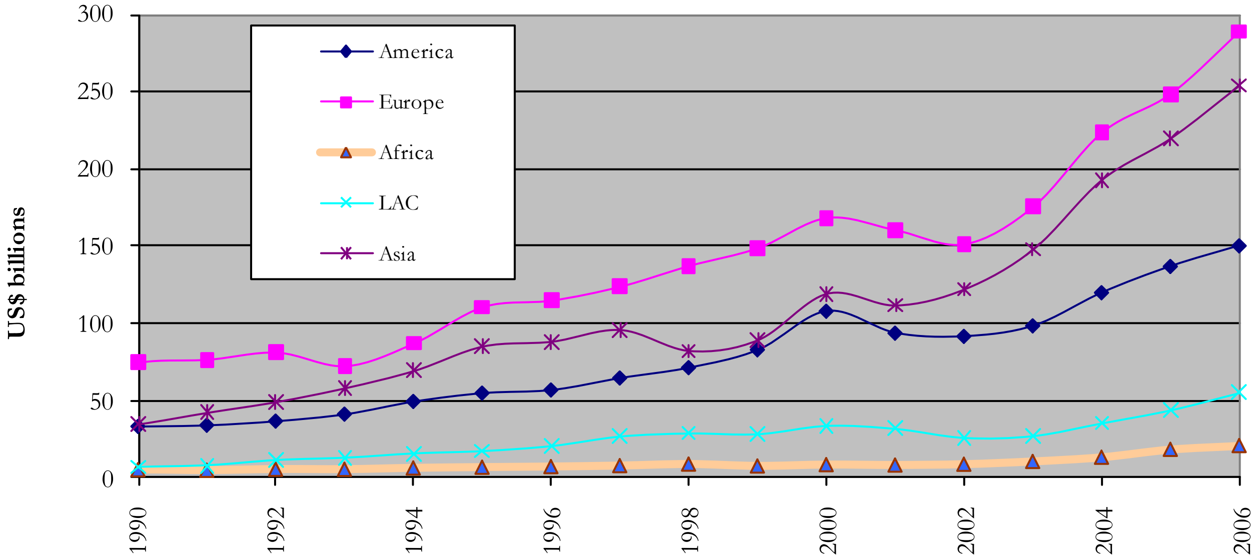
NA= Not Available

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 royalties 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.

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 of $1.3 billion in 2006, 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 2. On this basis, Angola's receipts went up 25 times, followed by Bot-

Figure 3. Imports of selected capital goods



Source: UNCTAD Handbook of Statistics, 2009

swana 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.

2.2 Trends in capital goods imports

In general, the import of capital goods 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 3) but accelerated much faster in the last five years.

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

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 in absolute value, it has registered the fastest growth in the import of capital goods between 2001 and 2006 than any other regions.

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. In general, about 60% of the African countries (19 out of the 32) considered here saw their imports of capital goods more than triple over this period (See Table 2).

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

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

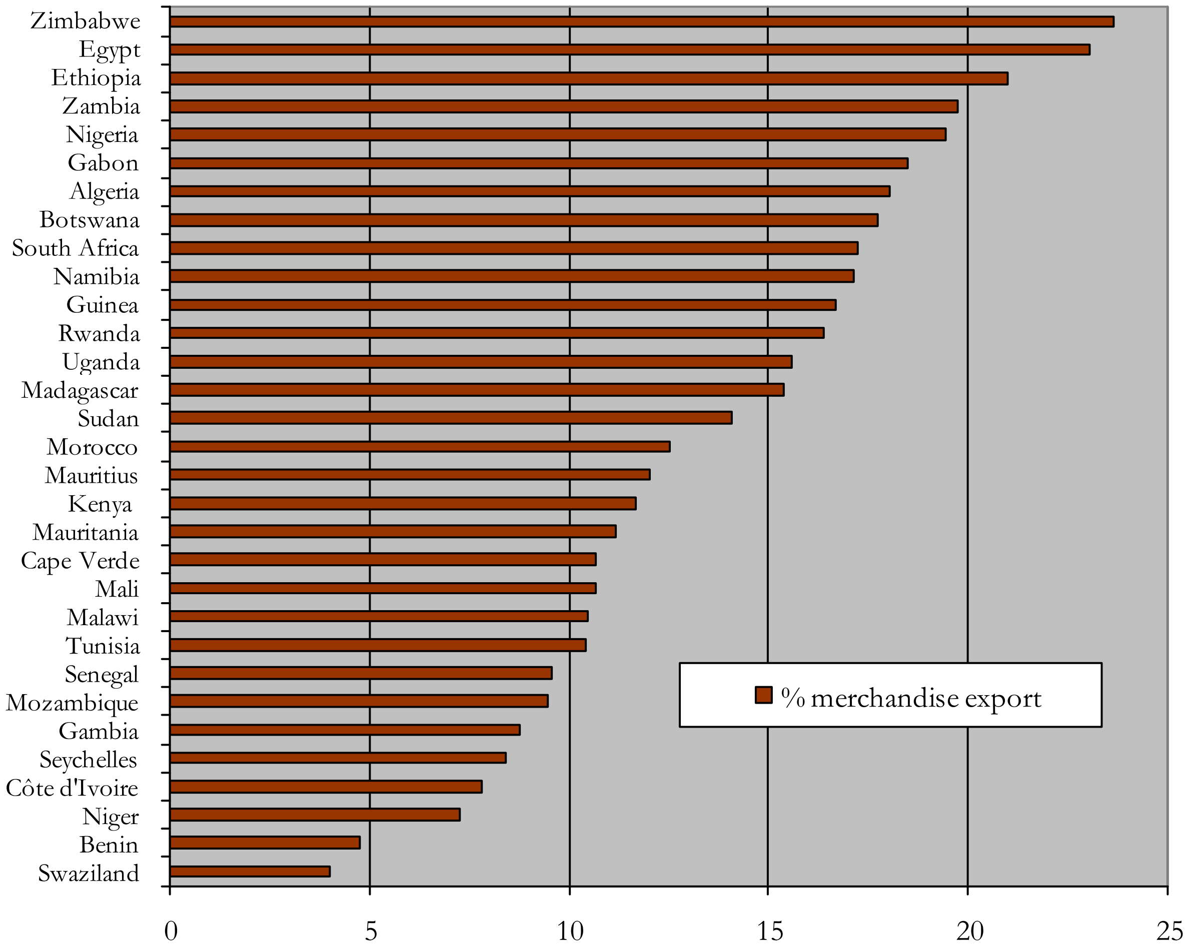
such as Ethiopia, Malawi, Rwanda, and Uganda. Some of the countries that have not witnessed a fast growth in the imports include Botswana, Mauritius and Swaziland.

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 4, 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.

2.3 Intra- and Interfirm Trends in trade of BPT services

Most of the data on trade in services is not suffi-

Figure 4. Capital goods imports (BEC 41) as percentage of merchandise imports



Source: Comtrade database, 2009

ciently 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 and 51-fold rise in payments to the United States between

Table 3a Trends in the US 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 US 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	1,008	1,289	11	155	562
Asia	979	3,382	6,365	147	963	2,087
LAC	1,314	3,690	5,640	126	574	1,208

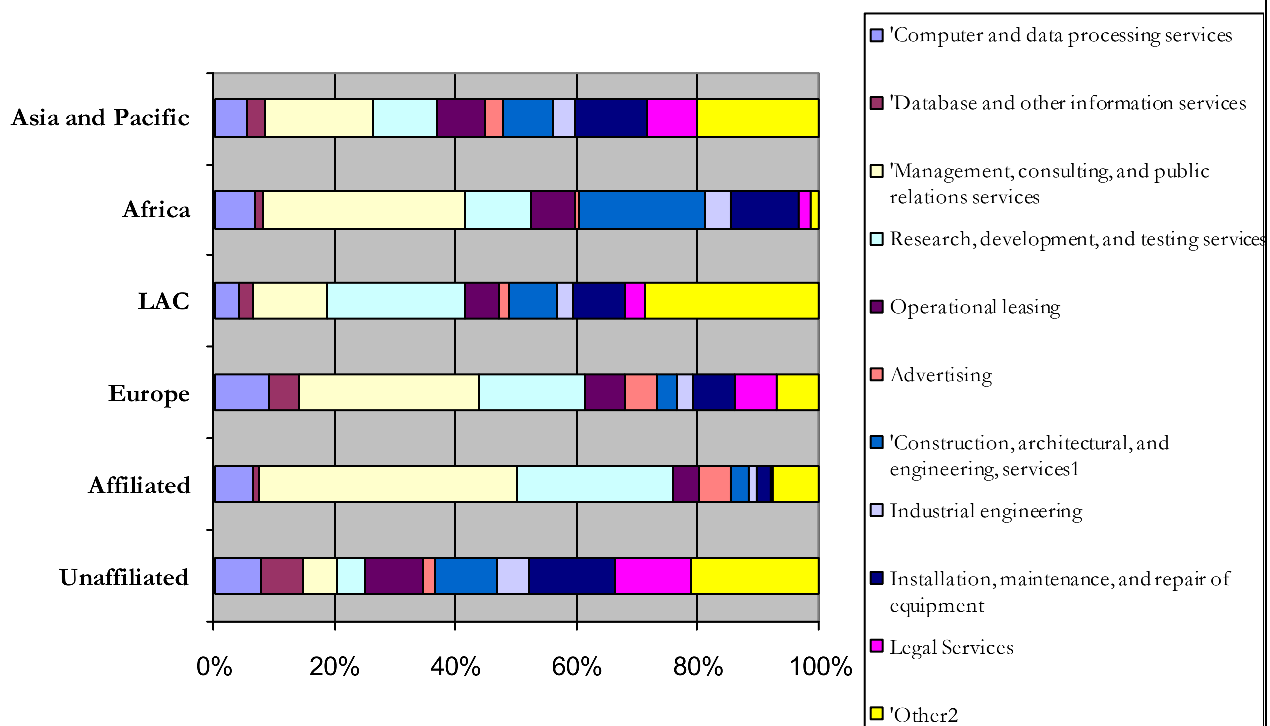
Table 3c As a percentage of the US receipts and payments

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



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

1990 and 2005. As shown in table 3b, it was observed that receipts by the United States from unaffiliated 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 5, more than 40% of intra-firms payment 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% of Asia's 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. The much higher share of intra-firm trade in Africa might be an indicator for little incentives for foreign investors to collaborate with the local private sector

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.

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

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 research, development and testing services.

Four easy and effective steps to promote technology transfer

There are several ways in which Africa 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 innovation and technology transfer.

Enhancing 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 entrepre-

neurial attitudes and, Shared entrepreneurial culture throughout the university.

These characteristics are seen as key in enabling universities to function as centres for knowledge creation, technology transfer, centres for development of firms and agents for economic and social development (creating jobs and wealth). The university, in this case, enables research teams to operate as 'quasi-firms'(Etzkowitz, 2003).

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 (http://www.theinnovationhub.com/) 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).

Similarly, Egypt's Mubarak City for Scientific Research and Technology Applications (http://www.mucsat.sci.eg/citypages/home.aspx) is located in an industrial area housing about 40% of the Egyptian industry. The locations are deliberately designed to encourage collaboration with industry.

3.2 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.

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.

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.

3.3 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, firms may engage in partnership to invest in a new firm.

These arrangements are crucial in enabling countries lagging behind to quickly gain access to knowledge, learn and run a business without needing to reinvent the "wheel". The risks 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 government playing a facilitating role in technology transfer through industrial alliances and partnerships by completing science and technology agreements.

3.4 International science and technology cooperation agreements

International science and technology cooperation agreements (ISTCAs) as well as multilateral environmental agreements (MEAs) often contain clauses that promote technology transfer. Whereas South-South ISTCAs have contributed significantly to genuine technology transfer, North-South MEAs have so far failed to do so. Promotion within ISTCAs 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.

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 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 percent of the cost while Brazil covered 30 percent. 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.

Some ISTCAs explicitly mention the involvement of private firms. For example, the ISTCA between the Republic of Korea and Russia of 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. Such collaboration also helps familiarize individuals in private and public institutions with the culture of partner countries and promote understanding.

Conclusion

The term technology transfer as used in this paper includes various processes associated with acquisition, learning or mastering of technology. 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. 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, unlike in a previous study (UNCTAD, 2003) where its performance was still considered to be poor. 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%) 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.

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, regions 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 related technology proxies (e.g. BPT services).

Significant attention has focused on the ability of a country to acquire, absorb, master and exploit foreign technologies to become innovators (Trivigno, 2006; Vinnova 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 and increase absorptive capacity:

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 bring unique advantages that could reduce costs and risks associated with technology transfer.
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.

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.
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. Furthermore, incentives for technology development, transfer and diffusion could also be built into 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, mobilize financial and institutional resources through partnerships and cooperation, and encourage learning through exchange of best practices.

To achieve these goals, countries need to engage 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. Cooperation of other key ministries will be crucial to the success of any program as highlighted by the case of Rwanda.

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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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.

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

Royalty and license fees are payments and receipts between residents and nonresidents for the authorized use of intangible, nonproduced, nonfinancial assets and proprietary rights (such as patents, copyrights, trademarks, industrial processes, and franchises) and for the use, through licensing agreements, of produced originals of prototypes (such as films and manuscripts)

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).
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.