CRITICAL REVIEW OF TECHNOLOGY TRANSFER AND DIFFUSION FOR ECONOMIC DEVELOPMENT IN SUB-SAHARAN AFRICA

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Abstract
The study examines technology transfer as a policy tool for economic development in sub-Saharan Africa. The study believes that closing the technological capability gap that separates advanced economies from developing countries, and particularly the sub-Saharan economies, is a necessary condition to put the latter on a path of sustainable development and poverty reduction. The study used descriptive method of analysing secondary information and data through content analysis of existing records. The study explained that sub-Saharan countries are the poorest and the least developed nation states of the world, and that rapid transfer and diffusion of technology from developed countries could speed up the pace of economic development in these countries. To achieve technology transfer and diffusion, the study recommends that sub-Saharan governments should leverage on FDI. The need to establish an effective national innovation system (NIS) which provides an interface for technology-related Transnational Corporation (TNC) activity, supports the development of the absorptive capacities of domestic enterprises and their linkages with TNCs, and provides a regulatory framework, including a balanced framework for intellectual property that enables the development of a knowledge base and technological capacities has become important, among other recommendations.

Keywords: *Technology Transfer, Diffusion, FDI, Economic Development, Sub-Saharan Africa*

Introduction

Countries of the world have become more development conscious than ever and a lot of emerging countries as well as developing and transition economies are giving serious consideration to technology transfer as a viable path to development. However, success only happens to those countries that are able to make good of such technological transfers. It implies that developing countries need to acquire a wide range of technologies in order to realise their development ambitions.

Technological progress is critical to economic growth and development of any country. Given fast technological change in the more advanced economies, closing the technological capability gap that separates them from developing countries, and particularly the sub-Saharan economies, is a necessary condition to put the latter on a path of sustainable development and poverty reduction.

Several studies have investigated technology transfer as a development option for developing countries. These studies have concluded that foreign direct investment is the main channel for the transfer of technology. For example, Saggi (2002) examines channels of technology transfer and concluded that there are several important caveats to the expectation of positive contribution of foreign direct investment on host countries. He concludes that a positive correlation exists between the extent of foreign direct investment and economic growth in cross country basis, and that countries that are expected to grow faster attract foreign direct investment (FDI)

because it yields higher returns.

Similar view was echoed by Oyeranti (2003) who observes that foreign direct investment (FDI) cannot, and ought not to discriminate against both economic theory and recent empirical evidence, suggesting that FDI has likely potential positive impact in developing host countries. Nunnenkamp and Spatz (2003) however, criticize the view that developing countries should draw on foreign direct investment (FDI) to create economic development. According to them, developing local and new technologies through massive investment in research and development would transform these countries.

The arguments advanced in the literatures above have shown the importance or otherwise of technology transfer to poor countries, but have not given a comparative analysis between developed economies and developing countries of sub-Saharan origin. The study would cover this gap. Again, studies like this on sub-Saharan Africa are scanty and the paper would contribute to knowledge in this area.

The paper is therefore divided into nine parts. The foregoing part introduces the subject of study. The second part dwells on the research problem. Third part identifies the objective and significance of the paper. The fourth part explains the methodology and sources of data. The fifth part examines the conceptual and theoretical frameworks of the study. The sixth part discusses the existence of technological gap between developed and developing countries and the role of transnational corporations (TNCs) in technology transfer and diffusion as well as FDI as channel of technology transfer. The seventh part of the paper gives the effects of technology on economic development in Africa and sub-Saharan region in particular (including the positive and negative effects of technology). While the eighth part makes analysis and discusses the findings of the paper, the seventh part (last section) concludes the study with recommendations.

Statement of Research Problem

Governments of sub-Saharan countries have over the years failed to serve the development interest of their countries. Sub-Saharan Africa is the least developed region of the world. Poverty, underdevelopment and technological backwardness in this region have always generated issues of concern from different research perspectives (World Bank 1993; UNCTAD 2005a; Supachai 2005; and Gushibet 2011). According to UNCTAD (2011) and United States National Science Board (2010), technology transfer and diffusion could speed up the rate of technological catch up in these backward economies.

However, whether these countries could really use this as a policy option to enhance development has become a problem. The development and exploitation of the acquired technology into new products, processes, applications, materials or services has remained a challenge to sub-Saharan countries. This hinges on capacity, capability and utilisation since issues ranging from bad governance, illiteracy, insecurity to corruption are prevalent in these countries. Nevertheless, the search for solution has become the concern of this study. This involves broadening the intellectual scope of sub-Saharan African governments on how best to use technology transfer as a policy tool for attaining economic development and bridging the technological gap between developed and least developed countries. Thus, the study would provide answers to the following questions:

i) Can technology transfer serve as a policy tool that would accelerate the rate of economic growth and development in sub-Saharan Africa?

ii) Why have countries of sub-Saharan Africa unable to leverage on technology transfer to enhance their

growth and development prospects?

iii) What policy options can governments and policymakers take to overcome these limitations in sub-Saharan Africa?

Objective of the Study

Arising from the research questions, the broad objective of the paper is to critically investigate technology transfer and diffusion as a tool for economic development in sub-Saharan Africa. The specific objectives of the paper are; to examine technology transfer in relation to economic development in sub-Saharan countries, to identify policy options that could be taken by governments and policymakers to enhance technology transfer and diffusion for economic development in sub-Saharan economies.

Significance of the Study

The study would contribute to existing literature on the linkage between technology transfer and economic development in sub-Saharan countries. The study would provoke further debate both within and outside Africa concerning the method used and conclusions drawn. The work would be a valuable asset to researchers and policymakers who are interested in development policy.

Methodology and Data Sources

Descriptive method of analysing secondary data via content analysis was adopted in the study. Tables, figures and percentages were used for the descriptive analysis. It implies that the study is a qualitative research. Information and data were obtained from various editions of United Nations Conference on Trade and Development, UNCTAD reports, journals, official government publications, unpublished materials and internet sources. The study mainly used existing literatures and records relevant to the research topic. Using descriptive and deductive approaches, and having critically reviewed salient issues in existing literatures and records, conclusion and recommendations were made.

Conceptual and Theoretical Frameworks

Conceptualising Technology Transfer and Economic Development

Technology Transfer also called **Transfer of Technology (TOT)** and **Technology Commercialisation**, is the process of transferring skills, knowledge, technologies, methods of manufacturing, samples of manufacturing and facilities among governments or universities and other institutions to ensure that scientific and technological developments are accessible to a wider range of users who can then further develop and exploit the technology into new products, processes, applications, materials or services. It is closely related to (and may be considered a subset of) knowledge transfer (Wikipedia, Encyclopaedia). This is in consonance with the view expressed by UNCTAD (2011) which states that technology transfer and diffusion involves the cross border flows of both physical goods and knowledge, and acquiring new skills and managerial expertise.

The recipients of new and advanced technologies can benefit from higher productivity, new products and lower costs in the short term. While in the longer term the benefits of technology transfer depend on how much the recipients are able to deepen and develop their own capabilities (UNCTAD, 2011). Technology transfer helps in developing and promoting new improved technologies to increase productivity, efficiency, competitiveness and economic development. There is a practical value in technology transfer across cultural boundaries, but only if the transferred technology is applied in the recipient countries by overcoming resistance to change

(Mockler and Dologite, 1995).

On the other hand, economic development refers to elimination or reduction of inequality, unemployment, poverty, slavery, ignorance, and other associated social vices (Bozimo, 1999). It also means an inter-sectoral cooperation involving macroeconomic stability, liberalised trade and privatisation (Waeyenberge, 2006). Economic development was viewed by Rodney (1972) as an increase in skills and capacity, greater freedom, creativity, self-discipline, responsibility, and material well being at the individual level. At the level of society, it implies increased capacity to regulate both internal and external relationships in politics, production, trade and economics.

According to Todaro and Smith (2003), economic development is the increase in levels of living, including higher incomes, provision of more jobs, better education, enhanced material well-being, availability of infrastructures, modernisation and technical transformation, self-esteem, the elimination of ignorance and freedom from human misery. Development relates to the capacity and creative capacity of a people to effectively transform the natural resources of their environment through the imaginative application of their creative talents and labour power for the uplifting of their standard of living (Ake, 1996).

In this paper, economic development is viewed as a holistic process for the eradication of poverty, corruption and illiteracy, as well as the introduction and application of new technologies that could drive advanced transformation for better and sustainable standards of living in an economy. This underscores the imperative of technology transfer and diffusion into sub-Saharan economies.

Theoretical Framework

The success of technology development and transfer is dependent to a large extent on the capacity and leadership appropriate for different change management situations in the recipient country. Individuals can be apprehensive when confronted with technological change (Fiedler 1967; Rowe 1992). According to them, change and new technology can be threatening. The introduction of new and advanced technology is often not an improvement at first, and may not work and create resistance to change. Behavioural sciences theory provides considerable support and guidance to overcoming resistance to change through communication skills and training, as well as building step by step continuing small success stories. Streamlining the internal business processes in relation to both strategic and operational needs have become important in technology diffusion (Mockler and Dologite, 1995).

Technology transfer could speed up the rate of economic growth in backward economies (UNCTAD, 2011). It implies recognition of the widening technological gap between developed economies and developing countries. The transfer of technology from developed economies to developing countries (including sub-Saharan Africa) has become inevitable for the development of the latter and the benefit of the former. This is in consonance with the view expressed by Ogbimi (1997) who opines that technological development is achieved by learning and acquiring new knowledge, skills, and capabilities.

The relevance of behavioural sciences theory to this paper is enormous. It suggests that sub-Saharan countries should develop their capacity in science and technology innovation to build on every success recorded at every stage of development. It means that without resilience in capacity building and skills acquisition developing countries would continue to resist change necessary for development. Resistance to technological change is not the path of honour but the road to sustainable

underdevelopment in poor countries. The theory therefore opines that by exploiting and developing the transferred technology into new products, processes and applications, poor countries could take advantage of advanced technologies from industrialised countries in order to accelerate the pace of development in these peripheral locations (least developed nations).

Since governments of sub-Saharan countries have failed to rescue their economies from poverty, illiteracy, bad governance, corruption, underdevelopment and technological backwardness, behavioural sciences theory sees alternative strategy in innovation, technology transfer and diffusion as capable of speeding up the rate of technological catch up in these backward economies. However, whether these countries could really use this as a window for development has become the concern of the paper.

Technological Gap, Transnational Corporations and Inflow Of Fdi

Does Technological Gap Exist Between Developed and Developing Countries?

Some developing countries have made significant technological progress in the past two decades or so, even outpacing that in developed countries (World Bank, 2008). However, the technology gap between rich and poor countries remains wide, with developing countries employing only a quarter of the level of technology in developed countries, measured by the extent to which specific technologies have permeated economic activities (World Bank, 2008). The differences in R&D spending between the two groups of countries remain huge. For example, Table 1 below gives the list of top 40 Transnational Corporations -TNCs based on R & D expenditure. In addition, technological achievement varies widely among developing countries and within a country.

The technological gap between developed and developing countries is more pronounced for new and advanced technologies. Nevertheless, many developing countries are acquiring new technologies, including information and communication technology (ICT) equipment such as mobile phones and computers, at a more rapid pace than older technologies (UNCTAD, 2010a). More recently, the diffusion of new technologies in such areas as renewable energies and organic agriculture holds promise for a substantial, widespread advance in technological achievement in the developing world. In agriculture, for example, organic production offers a wide range of technological, economic, environmental and social benefits (UNCTAD, 2010b). A study of 114 cases in Africa shows that a conversion of farms to organic or near-organic production methods increased agricultural productivity by 116 per cent (UNCTAD and UNEP, 2008).

In many developing and transition economies, enterprises generally perform little R&D; the bulk of it is done in universities and government research institutes and is often de-linked from the productive sector. In the Russian Federation, this sector accounts for 63 per cent of total R&D, lower than most of developed countries. Enterprises are expected to be a core component of a national innovation system (NIS). In developing countries, particularly in least developed countries (LDCs), the limited role of the private sector in their NIS weakens the economic impact of R&D on efficiency, growth and competitiveness. Given the fact that business enterprises account for the bulk of R&D expenditures in the major innovation countries (table 1 below), attracting FDI can be a useful means for developing countries to promote technological progress. Indeed, globalization of R&D is marked by increased funding of industrial R&D activities by TNCs outside the borders of their home countries; and there has been a considerable shift in high-technology manufacturing and exports to the developing world (UNCTAD, 2005;

Table 1: Top 40 TNCs based on R & D expenditures, 2009

	Industry	($Million)		($Million)		(Number)			
1.	Toyota Motor	Japan	Automobiles& Parts	9 403		213 515			320 808
2.	Roche		Switzerland	Pharmaceuticals	8 893		45 943		81 507
3.	Microsoft		United States	Software		8 437		60 497	89 000
4.	Volkswagen	Germany	Automobiles & Parts	8 043		142 250		338 499	
5.	Pfizer		United States	Pharmaceuticals		7 507		48 418	116 500
6.	Norvatis		Switzerland	Pharmaceuticals	7 163		42 857	99 834	
7.	Nokia		Finland	Telecoms equipment		6 942		56 935	123 171
8.	Johnson&Johnson		United States	Pharmaceuticals		6 764		59 928	115 500
9.	Sanofi-Aventis	France	Pharmaceuticals	6 347			41 377		104 867
10.	Samsung Electro		Rep. of Korea	Electric Equipment		6 265		115 569	NA
11.	Siemens		Germany	Electrical Components	5 949		106 504		413 650
12.	General Motors	United States	Automobiles & Parts	5 875			111 292		217 000
13.	Honda Motor	Japan	Automobiles & Parts	5 857			104 120		181 876
14.	Daimler		Germany	Automobiles & Parts	5 785		109 641		258 628
15.	GlaxoSmithKline		UK	Pharmaceuticals		5 674		44 354	98 854
16.	Merck		United States	Pharmaceuticals		5 659		26 556	100 000
17.	Intel		United States	Semiconductors			5 473	34 010	79 800
18.	Panasonic		Japan	Leisure goods			5 386	80 764	292 250
19.	Sony		United States	Leisure goods			5 172	79 390	171 300
20.	Cisco Systems	United States	Telecoms equipment	5 042			34 968	65 550	
21.	Robert Bosch	Germany	Automobiles & Parts	4 971		53 031		274 530	
22.	IBM		United States	Computer Services		4 787		92 712	399 409
23.	Ford Motor	United States	Automobiles & Parts	4 744			114 545	198 000	
24.	Nissan Motor	Japan	Automobiles & Parts	4 737			87 747		175 766
25.	Takeda Pharm.	Japan	Pharmaceuticals	4 712			15 999		19 362
26.	Hitachi		Japan	Computer Hardware		4 332		104 007	400 129
27.	Astra Zeneca	UK	Pharmaceuticals	4 293			31 761	63 900	
28.	Eli Lilly		United States	Pharmaceuticals		4 189		21 141	40 360
29.	Bayer		Germany	Chemicals	4 118		43 298	108 595	
30.	EADS		Netherlands	Aerospace & Defence	3 998		58 488	119 506	
31.	Toshiba		Japan	General Industrials		3 934		69 209	199 000
32.	Alcatel-Lucent	France	Telecoms equipment	3770			21 056		78 373
33.	NEC		Japan	Computer Hardware		3604		43 844	143 327
34.	Bristol-Myers Squibb	USA	Pharmaceuticals	3531			20 946		28 000
35.	BMW		Germany	Automobiles & Parts	3401		66 406		96 207
36.	Boeing		United States	Aerospace & Defence		3360		66 109	157 100
37.	Ericsson		Sweden	Telecoms equipment		3336		27 999	86 360
38.	General Electric		United States	General Industrials		3218		150 003	304 000
39.	Peugeot (PSA)	France	Automobiles & Parts	3215			67 260		186 220
40.	Canon		Japan	Electric office equipmt	3168			33 377	168 879

SOURCE: United Nations Conference on Trade and Development, UNCTAD, 2011

Transnational Corporations as Major Players in Technology Formation and Diffusion

The generation of new and advanced technologies is concentrated in the developed world, and takes place mainly in large corporations (UNCTAD, 2005; United States National Science Board, 2010). Transnational corporations (TNCs) play a major role in global innovation. In most developed countries, a key role is played in the implementation of new technologies in production. TNCs account for about half of the world's total R&D expenditure and more than two thirds of the world's business R&D (UNCTAD, 2005). The world's largest R&D spenders are concentrated in a few industries, notably IT hardware, the automotive industry, pharmaceuticals and biotechnology. Currently, the R&D spending of some large TNCs is higher than that of many developing countries. Forty TNCs – with Toyota, Roche, Microsoft, Volkswagen and Pfizer being the top five – spent more than $5 billion on R&D in 2009 (see table 1 above). In comparison, among developing economies, total R&D spending exceeded $5 billion only in Brazil, China, the Republic of Korea and Taiwan

Province of China. There were five companies from developing countries listed on the largest 100 R&D spenders: three Republic of Korea TNCs and two Chinese ones – Samsung Electronics (the 10th largest), LG (66th), Hyundai Motor (69th), Huawei Technologies (79th) and the 80th position was Petro-China (UNCTAD, 2011).

The interaction between TNCs and domestic firms in developing countries can result in higher rates of knowledge and technology diffusion, thanks to a number of mechanisms, such as imitation, increased competition, backwards and forwards linkages, training and human resources mobility. The knowledge and technology involved takes many forms, including a wide range of hard and soft elements – e.g. technologies embodied in capital goods – and production, organizational, managerial and other skills. However, the extent to which such mechanisms can be operative in reality depends on a complex set of conditions, including the sectors in which the TNCs operate, the way they are integrated into the national economy, the absorptive capacities of local firms and the extent to which the set of actors, institutions, relationships and enabling environment (including explicit and implicit policies) that constitute the NIS of the host country are supportive of such knowledge flows.

Because of such complexity, it is difficult to assume that TNC presence will necessarily result in technological learning in the host country. To this, it should be added that firms that possess knowledge often face incentives to create barriers to easy dissemination. Technology transfer and diffusion involves the cross-border flows of both physical goods and knowledge, be it tacit or formal. The latter is becoming more important and involves acquiring new skills and managerial expertise. In the short term, the immediate recipients of new and advanced technologies can benefit from higher productivity, new products and/or lower costs. While in the longer term, the benefits depend on how much the recipients are able to deepen and develop their own capabilities. For an economy as a whole, the benefits also include many externalities, e.g. the diffusion of the technology and its spillovers to other entities. In technology transfer proxied by receipts and payments of royalties and license fees, developed economies continue to be the main home and host countries. This is captured in Tables 2, 3 and 4 below.

Foreign affiliates can diffuse technology and skills to domestic suppliers, customers and entities with which they have direct and indirect dealings. In particular, backward linkages between foreign affiliates and domestic firms are important for enhancing technology dissemination (UNCTAD, 2011). To ensure that local inputs meet their stringent technical requirements, foreign affiliates often provide the local suppliers not just with specifications but sometimes also with assistance in raising their technological capabilities. Such assistance tends to be more prominent in developing countries, and the knowledge transfer has had a positive impact on the suppliers' competitiveness (UNCTAD, 2001). This has provided a leeway for sub-Saharan countries to take advantage and leverage on.

In sub-Saharan African countries, direct technology transfer by TNCs has been constrained by the limited size of FDI inflows and their bias towards activities focusing on natural resources. Indeed, a common feature of the extractive industries, especially when TNCs are involved in a low-income country, is the relatively limited incidence of linkages with domestic suppliers, particularly as compared with manufacturing and services sectors (UNCTAD, 2007a). More importantly, lack of local capabilities and deficiencies in technological learning in these countries hinder the market dynamism necessary for continuous technological upgrading and prevent the indirect effects through linkages and spillovers from happening.

Foreign Direct Investment (FDI): Channel of Technology Transfer

The bulk of technology dissemination is undertaken through internalized channels within the networks of TNCs. Today, FDI has become an important source of new technology to the developing world, as illustrated by the amount of royalties and licensee fee receipts by developed-country TNCs from their foreign affiliates in developing countries (UNCTAD, 2011). However, the extent to which new, valuable technologies are transferred to host economies varies significantly between regions and countries. Some developing countries (e.g. China) have established certain technological capabilities with the help of FDI which countries of sub-Saharan Africa have failed to take advantage of the opportunity.

Nonetheless, there is little evidence of a significant contribution by FDI to technological capability accumulation in LDCs particularly countries of sub-Saharan Africa (UNCTAD, 2007b). Japan provides an interesting example on the level of technology transferred and used by their affiliates abroad, compared with that of their parent firms. In host developing regions, the level of technology at affiliates is lower or at par with that at parent firms. However, when it comes to affiliates in newly industrializing economies in Asia, the technology level used there is not much different from that used in affiliates located in developed countries and four fifths of affiliates use the same level of technology at their parent firms in Japan (refer to table 2 below).

Table 2: Technological levels of Japanese manufacturing affiliates abroad: comparison with those of parent firms, 2008 (distribution share)

Host region/country	Level of technology		
	Higher than in Japan	At par with Japan	Lower than in Japan
World	1.4	73.6	25.1
Developed countries			
European Union	3.9	86.7	9.4
United States	3.9	83.9	12.3
Developing countries			
Africa	-	33.3	66.7
Latin America and the Caribbean	1.9	68.5	29.6
West Asia	-	100.0	-
South, East and South-East Asia	0.7	71.1	28.2
China	0.9	69.7	29.4
Hong Kong, China	-	80.0	20.0
Memorandum:			
ASEAN4	0.5	70.6	28.8
NIEs3	-	79.5	20.5

Source: Japan, Ministry of Economy, Trade and Industry, 2010.

Acquisition of technology from parent firms is largely limited to some developing countries only. A few emerging economies (China, Mexico, Brazil, Republic of Korea, India and South Africa, in that order) were main technology recipients from United States TNCs, judging by data on payments of royalties and license fees (UNCTAD, 2011) as presented in Table 3 below:

Table 3: Royalties and licensee fee receipts by TNCs based in selected developed countries from their foreign affiliates, various years (millions of dollars)

Host region	Germany (2006)	Japan (2007)	United States (2009)
Total world	1 281	9 001	55 430
Developed countries	1 244	5 037	42 656
European Union	437	1 091	34 753
United States	652	3 400	-
Japan	70	-	3 276
Developing economies	30	3 965	12 774
Africa	3	15	522
Latin America and the Caribbean	6	148	5 011
West Asia	..	0	387
South, East and South-East Asia	9	3 354	6 854
South-East Europe and CIS	..	..	..

Source: UNCTAD, FDI/TNC database (www.unctad.org/fdistatistics).

In technology transfer proxied by receipts and payments of royalties and license fees, developed economies continue to be the main home and host countries (see table 4 below). However, the importance of developing and transition economies is rising in both host and home countries: their share in the world total of payments doubled between 1990 and 2009 to 26 per cent, while on the receipts side it quadrupled during the same period. Asia accounted for the bulk, though. This is amply illustrated in Table 4 below.

Region	1990	2000	2009	1990	2000	2009
	Receipt			Payment		
World	27 323	79 383	179 688	24 267	83 242	184 674
Developed countries	27 037	77 482	172 055	21 360	66 254	136 987
European Union	10 039	20 686	55 779	17 172	32 734	85 231
United States	16 640	43 233	89 791	3 140	16 468	25 230
Japan	2 866	10 227	21 698	6 051	11 007	16 835
Developing countries	278	1 733	6 879	2 859	16 164	42 346
Africa	38	193	106	230	840	2 279
Latin America and the Caribbean	195	457	1 627	984	3 371	5 305
Asia	41	1 080	5 146	1 646	11 953	34 761
West Asia	0	0	0	0	173	649
South, East and South-East Asia	41	1 080	5 146	1 646	11 780	34 112
Oceania	3	3	0	0	1	1
Transition economies	8	168	754	48	824	5 341
Memorandum: Share of developing and transition economies in the world total	1.0	2.4	4.2	12.0	20.4	25.8

Source: UNCTAD, based on IMF Balance of payments database

Approximating technology transfer through royalties and license fees overlooks the vast majority of technological upgrading of developing host country productive systems through the introduction of superior technology, processes and managements skills which are not necessarily subject to patents or licenses and are not the latest technology available. Indeed, developing Asia has hosted a large number of R&D centres or facilities established through Greenfield investment. In particular, China and India alone accounted for nearly half of all R&D centres and facilities established in developing and transition economies by TNCs in 2009 (see Table 5).

However, large parts of the developing world remain de-linked from TNC R&D systems (UNCTAD, 2005). For example, among LDCs, during the past five years (2005–2009) only three countries – Angola, Bangladesh and Nepal – hosted only one each of Greenfield R&D project out of a total of 649 such projects established in developing and transition economies (see Table 5). All of these three R&D centres in LDCs were established by developing country TNCs. In fact, not only in LDCs, but also in other developing countries, TNCs from developing and transition economies are beginning to establish R&D projects. They are emerging R&D players, accounting for one tenth of the total of 649 projects. South TNCs are set to play an important role in the South–South cooperation in R&D. Nevertheless, sub-Saharan countries are left behind without any meaningful R & D projects as shown in Table 5 below.

Table 5: Greenfield FDI projects in research and development, by host region/economy, 2005–2009 (in terms of number of projects)

Host region/economy	2005	2006	2007	2008	2009
World	330	369	188	224	198
Developed countries	149	187	97	125	102
Developing economies	171	179	87	97	91
Africa	5	2	2	7	3
Latin America and the Caribbean	3	10	3	9	13
Brazil	2	4	2	3	6
Mexico	1	2	1	4	1
West Asia	3	8	8	7	5
South, East and South-East Asia	160	159	74	74	70
China	72	63	25	23	21
India	57	56	24	20	23
Korea, Republic of	7	10	1	2	4
Singapore	10	17	15	15	14
Transition economies	10	3	4	2	5
Russian Federation	9	1	3	2	2
Memorandum					
Share of developing and transition economies in the total	55	49	48	44	48

Source: UNCTAD, based on information from the Financial Times Ltd, fDi Markets (www.fDimarkets.com)

Effects of Technology on Economic Development in Africa

Given that technology is that aspect of knowledge which deals with scientific and industrial methods in production of goods and services, it has to start with scientific discovery to invention, innovation and continuous improvement in that sequence in the production process. For these to work, there has to be increased knowledge, heavy capital investment, skilled labour force and technical know-how as well as the availability of entrepreneurial skill and the ability to put into use the benefits of innovations and technology transfer. There are basically two categories of technology namely; labour-intensive technology and capital intensive technology. While in the former, output is increased by employing more of labour over capital, more capital is required to raise output in the latter. It should be noted that modern technology is highly capital intensive and labour saving.

Positive Effects of Technology in Africa including Sub-Saharan Countries

Agricultural development: prior to the emergence of modern technology in developing countries, especially sub-Saharan Africa, the technology applied in farming and crafts was largely a result of local experiences accumulated over several generations. Production then was mainly for subsistence with little or no surplus. As civilisation widened, scientific findings gave rise to inventions and innovations which paved the way for modern technology to meet up with the increasing demand for agricultural

products such as food and raw materials. Therefore, scientific and agro-technological transfers are redeeming agricultural development programmes and schemes in developing countries.

Manufacturing: though agriculture provides the impetus to industrialisation, manufacturing is said to be the life wire of any economy. Since manufacturing is more capital intensive in nature, technology is indispensable for its growth. Therefore, the higher the level of technology the faster would be the growth of manufacturing sector.

Education and manpower development: the creativity and skills in man which are of fundamental importance in the development of an economy have been greatly developed with the emergence of modern technology. The development of human resource through education has given rise to varieties of machines and equipment (including computers). Thus, investment in human beings is the most valuable of all capital investment in an economy.

Health: with new and modern technology, medical personnel have at their disposal sophisticated medical apparatus and the product of research in pharmaceuticals and electronics with which they fight against diseases. Technology has paved the way for better monitoring and treatments of ailments or sicknesses. The result is high life expectancy, healthier people whose commitment and efficiency lead to improvement in overall output and possibly greater level of economic development.

Others: the exploration and extraction of natural and mineral resources on commercial basis for export particularly in developing countries would have not been possible without modern technology. Again, sports development, modern transport system and communication network among other advantages would have been illusive, but for new technologies from advanced countries.

Negative Effects of Technology in Africa including Sub-Saharan Countries

Technological development implies job insecurity in certain sectors of sub-Saharan countries as mass unemployment could result from installation of new machines in factories. The fact that development in new technologies could lead to new products means that some basic products in these economies would become obsolete. The tendency is that industries involved in the production of old products are likely to be out of business and thus wind-up as demand is shifted to new and improved products.

Advancement in technology could have a negative effect on the environment. The pollution from the growing industrial sector caused by liquid wastes from industrial processing plants and sewage system as well as gaseous emissions from industries and automobiles could pose detrimental effects on man and the environment at large. Furthermore, improvement in technology means increased demand on natural resources. The continuous exploration and exploitation of natural resources in sub-Saharan countries could lead to steady depletion of these resources. This poses a threat to the survival of future generations especially when the proceeds of these natural resources are not invested in productive sectors and ventures. This has been a common feature of developing countries including sub-Saharan Africa.

Despite these negative consequences, the positive aspect of technology has over-shadowed the harmful effects. Developing countries should therefore, endeavour to industrialise. Industrialisation being the cornerstone for

economic development cannot be attained in the absence of modern technology. Technology transfer has become necessary. In so far as conscious efforts need to be made in developing indigenous technology, there is greater need to acquire the needed skills and other necessary inputs from the technologically advanced countries.

Analysis and Discussion of Major Findings

The major revelation arising deductively from the critical review of conceptual and theoretical issues advanced in the paper is that enterprises and corporations of sub-Saharan origin do not invest in research and development. This has been adduced as the main reason why the development of new technologies and new products has not been possible in these peripheral economies. These countries rather depend on natural resource exploitation without the consciousness to industrialise. Since technology involves the application of scientific and industrial methods in production of goods and services in any economy, the manufacturing sector tends to suffer most in sub-Saharan countries, and this largely accounts for their lack of competitiveness in the global economy.

The paper found that home based enterprises in sub-Saharan Africa do not link up with transnational corporations (TNCs) in their respective countries in order to leverage on the FDI inflows from these TNCs. This has made countries of sub-Saharan Africa unable to learn and apply the new technologies offered by the TNCs. When these TNCs decide to leave any of the sub-Saharan countries they go with their technologies, leaving these countries as they were before the arrival of the TNCs. The paper deduced that without significant investment in research and development by companies in sub-Saharan Africa, the quest for economic development will remain a mirage in the sub-region.

Conclusion and Recommendations

The paper has shown that many developing and transition economies including sub-Saharan countries perform little R & D compared with the developed economies. Even the bulk of this little R&D is done in Universities and government research institutes that are not linked with the productive sectors and the real economy. These researches are often mere academic exercise without application since enterprises in these countries do not make any substantial investment in R&D that will drive innovation. Therefore, to make progress in sub-Saharan Africa there should be a synergy between Universities and industries, and expenditures in R&D should be taken seriously by both government and enterprises, especially industrial or manufacturing companies.

To maximise technology dissemination, there is need to boost the absorptive and adaptive capacities of domestic enterprises. This implies that government should formulate and implement policies that would enhance the incorporative and adaptive capacities of local firms in order to make them more amenable to global best practices in terms of innovations, new technologies and competitiveness. Therefore, creating technological capabilities at the domestic firm and industry levels, from a policy point of view, has become crucial.

To effectively leverage FDI as a means to achieve technology transfer and diffusion, developing countries especially in sub-Saharan Africa, need to establish an effective national innovation system (NIS) which provides an interface for technology-related TNC activity, supports the development of the absorptive capacities of domestic enterprises and their linkages with TNCs, and provides a regulatory framework, including a balanced framework for intellectual property that enables the

development of a knowledge base and technological capacities. The coherence between FDI policy and other relevant policies (especially innovation and science and technology policy) is important in this regard; and home country policies and international support can also play a role. If this is done, then the search for more FDI inflows has become imperative for effective technology transfer and diffusion which would have direct bearing on economic growth and development in sub-Saharan Africa.

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