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AFRICAN PRIVATE SECTOR SUPPORT AND INVESTMENTS FOR ICT RESEARCH AND DEVELOPMENT IN AFRICA

REPORT

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ICT, Science & Technology Division
United Nations Economic Commission for Africa
P.O. Box 3001
Addis Ababa, Ethiopia
Tel: +251 11 551 7200
Fax: + 251 11 551 05 12
www.uneca.org

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EXECUTIVE SUMMARY

There is abundant evidence that Africa is the only region yet to fully exploit the great potential of science and technology as an engine of growth and development despite the fact that up to 50,000 African scientists with post-graduate qualifications work outside their mother country. This is attributable to lack of scientific capacity due to the limited number of trained scientist and researchers in the continent, a situation further compounded by the brain drain. Sub-Saharan Africa has only one scientist and engineer per 10,000 people whereas developed countries have one for every 250 people and the continent spends barely 1% of Gross Domestic Product (GDP) on research and development and funding for higher education is quite low**.(UNECA, 2007).**

Against this background, and given the budgetary constraints of the public sector, it is essential to explore innovative ways of increasing investment in science and technology in Africa. On such way is to explore the possibility of African private sector support for investments in research and development. This is identified as a key issue by the Science with Africa Conference (3-7 March 2008).

It is against this background that the ICTs and Science and Technology Division of ECA which has a mandate to promote science and technology for development in Africa recruited this consultant to undertake a study on African private sector support for investment in ICT R& D in the continent. This will not only enable better understanding of the current situation but also help in determining a policy response and advocacy campaign in this regard. To this end, the report to be submitted by the consultant was designed to:

- Identify companies supporting ICT R & D in Africa
- Evaluate the contributions being made by such companies in this regard
- Clearly highlight trends and differences in different sectors
- Recommend a vision, goals and activities that ECA will use to harness such resources in the context of an ICT R&D strategy for Africa
- Table the findings at a meeting with private sector operators.

Due to the limitations of funds, and the constraints of data collection in the continent, the methodology had to be limited to desk research and the collection of secondary data through the internet. This in turn imposed limitations on the type of data that was to be collected path that was to be followed.

It was quite evident that it was going to be impossible to assemble and analyze primary data from private companies on their ICT R&D funding by simply sitting behind a computer. It would therefore have been impossible to achieve the research objectives by pursuing that approach.

The Researcher therefore decided that the study should focus on doing a survey of literature that catalogued and analyzed R&D generally and the participation of the private sector in ICT R&D in particular in places around the world, (OECD and Non-OECD countries) where this has proved successful and made a positive impact on development. The results of this extensive survey have been further analyzed to extract Best Practices from which useful lessons can be inferred.

The study however identified a few cases of ICTR&D in Africa as well as the limited private sector participation around them. These were examined to see if any useful lessons can be derived from them and extrapolated to other African countries.

Another useful approach in the study is the review of the efforts of ECA, either alone or in partnership with other institutions in harnessing information in the continent, a process that involves working with the private sector, Governments, the Academia, Regional bodies, International partners, other non-state actors, etc to coordinate these players for nurturing ICTs and ICTR&D in the continent.

These approaches proved especially relevant, in the light of the problems of data paucity or non-availability particularly for ICT R&D in the continent.

Section II, harnessing information for development is an attempt to summarize the efforts by various actors, globally as well as regionally, to nurture and mainstream ICTs into the African

development agenda at a pace that will make Africa more competitive on the world stage. Various activities of NEPAD, the ECA and other global players are reviewed. The main focus in this discussion is the NICI process initiated by ECA to help African countries formulate policies that will bring ICTs to bear on their development process. All African countries are now involved in the process at different stages; others have advanced to the point of undertaking sectoral projects, including the incorporation of Geo informatics in the NICI process. ECA efforts at nurturing ICTR&D through progammes like the ALN and the ARN are also discussed.

A lot of work has been done in the field of Research and Development and the literature is vast. In section III, a summarized literature survey is carried out, to give a comparative perspective of the global scope of R&D in terms of expenditure, sources of funding, sectoral performance, highlighting in the process the private sector contribution as against that of the public sector or Government within the OECD. The survey shows the United States, followed by Japan and Europe lead the world in R&D expenditure and that although the private sector especially Multinationals are the largest performers of ICT R&D, the public sector plays a significant role in the process .The section also examines international flows of R&D not only within the OECD and the 'new Europe' but also to the new emerging Markets of Asia and Latin America. The survey reveals that these international flows of R&D have led to a globalization of R&D with multinationals taking the larger share of the global market in terms of funding and performance. This has been possible because of several factors including, the urge to maintain the competitive edge, the level of preparedness of the recipient countries, the attractions of cheap professional expert labour and the availability of markets elsewhere.

R&D in Africa is discussed briefly to determine its historical trend and how Africa is positioned in all of these developments. The picture in Africa, except for South Africa is dismal. Although there are a few instances of investment by multinationals, Africa's infrastructure and human resource development even now, remain weak and unattractive to foreign investors for any kind of investment. Figures for expenditure and personnel for R&D in Africa are presented and compared with other regions of the world and in all cases and for all indicators, Africa occupies the least position. The few African countries that have shown some minimal investments are presented.

The US, Europe and Asia have invested heavily in R&D, which in turn is reflected in the growth of their industries and their economies. Section IV discusses the specific case of R&D in the ICT sector in these regions and the impact they have had on the growth of the sector and the economies. Looking at a comparative analysis of ICT R&D between Europe, Japan and the United States, the emerging picture shows that the United States maintains a slight edge over Japan and an even greater edge of Europe due to the greater investment by the private sector in the US over the others which in turn is due to the strong public sector leverage provided to the private sector by the government in the US. The impact of the differential between the US and the others is more pronounced in ICTs than in any other sector.

On the larger international scene, the trend is towards more internalization of ICT R&D directed particularly at the emerging economies of Asia (China, India, Singapore, and South Korea) and some Latin American countries. Off-shoring is a practice that has played a significant role in the expansion of ICT R&D in Asia and some parts of Europe.

Additionally, the study examines specific policy options in the OECD and the NON-OECD countries that have contributed to the growth of ICTR&D in these regions. The study takes specific note of best practices, (Public sector Leverage, the enabling environment, Tax incentives, Public/ Private Partnership, Investment in university R&D capacity building, etc.) that can have meaning for the nurturing of ICT R&D and the participation of the private sector in investment process in Africa.

The level of investment in R&D in Africa is very low compared to other regions of the world. This may be even more pronounced in the specific case of ICT R&D. This section (section V) presents an overview of ICT R&D in Africa in terms of the efforts by various actors in nurturing the process. In particular it examines in some detail, the leading role of ECA in helping African governments overcome their constraints they encounter and in formulating strategies that will mainstream ICTs and ICT R&D in the development process.

The section further examines the modest attempts in Africa to set up R&D institutions in ICTs in Africa and presents specific case study scenarios that mark the beginning of private sector support for ICT R&D in the continent. These Case-study scenarios are discussed within the context of successful strategies from other regions as well as the overall AISI strategy.

The level of investment in the continent or the lack of it, the enabling environment and associated constraints (policy, legislation, infrastructure and human capacity), bearing in mind the rapid diffusion of ICTs in Africa are also presented.

The section also summarizes important aspects of the international best practice discussed in the previous section in a bid to crystallize important lessons for private sector participation in ICT R&D in Africa.

The limitations in using the proposed methodological approach as outlined in the TOR to achieve the study objectives is discussed in some detail and the logic of instead reviewing best practice literature to reach the same conclusion is argued . So the overall objective in this section will be to draw inferences and important lessons from the best practices encountered in the huge body of literature examined and to argue the case for using it to improve private sector participation in ICT R&D as well as draw conclusions on the few case study scenarios in Africa that have been presented. These Case-study scenarios are also analyzed within the context of successful strategies from other regions as well as the overall AISI strategy.

The way forward focuses and highlights different strategies designed to encourage the Private Sector to contribute more effectively to ICT R&D and is discussed within the overall AISI strategy and the specific role of ECA. It concludes by recommending a Vision to ECA.

In articulating the strategies for private sector support the study recommends a role for the public sector based on the experiences of others; that of serving as a leverage for optimizing the chances for private sector participation and of creating the enabling environment in the form of policies, regulatory mechanisms and institutional frameworks for private sector investment in the field. The strategy recommended for private sector participation in ICT R&D is based primarily on the practices that have proved workable in those countries where there is progress in ICT R&D very little on the empirical evidence in Africa and the case for using that approach is also argued clearly with examples. The study concludes with a number of recommendations to ECA for governments, regional bodies, the ECA and the large number of private sector players currently in the various ICT categories in Africa. The recommendations give a central role to ECA and the Regional Economic Communities for engaging the private sector which in this case will range from small and medium enterprises to large corporations like Microsoft.

Specifically, the study takes note of the rapid expansion of ICT usage and diffusion in Africa and the role the private sector has played in that process, albeit from the point of view of the profit motive. The study also notes that the African private sector cannot be compared with the multinationals that have played such a key role in other parts of the world in promoting ICTR&D. Further, although it is the private sector that is in the lead in ICT R&D elsewhere, application of the public sector leverage and the creation of the enabling environment no doubt, carves out a unique role for governments in encouraging the private sector in supporting ICT R&D.

The study therefore concludes as follows:

- That in nearly all parts of the world where ICTR&D has been successful, it has been the private sector that has been in the driver's seat and that the globalization of ICT R&D investment has played a crucial part in the technology transfer to the indigenous private sector in those circumstances.
- That the public sector has to play the critical role of leveraging the private sector support and creating the enabling policy, regulatory and physical environment for enhanced private sector participation.
- That the ECA has been paying a crucial role in nurturing the process of ICT R&D

The study therefore recommends that Africa does not need to reinvent the proverbial 'wheel' and that it can benefit from important lessons learnt in the OECD countries and other emerging economies in Asia and Europe. It further recommends an increasing role for ECA, a more focused role for African governments and Regional Economic Communities in coordinating the efforts of existing private sector players in ICTs to be focused on R&D and providing them with the necessary incentives to expanded their investments into ICT R&D.

1 Background to the Consultancy

1.1 Terms of Reference

The United Nations Economic Commission for Africa (UNECA) in collaboration with the African Union Commission (AUC), other UN agencies and partners organized the conference on "Science with Africa" in Addis Ababa at the United Nations Conference Centre from 3-7 March 2008.., which I was privileged to attend. The main objectives of the conference were:

- To promote South-South and North-South cooperation in science, Technology and innovation through increased synergies between African based scientific organizations and those outside the continent;
- To explore ways of improving the interface between scientific research, policy development and business enterprise;
- To provide a framework for utilizing STI for attaining economic growth in Africa

The conference dealt with the following topics/issues pertaining to Africa's socio-economic development: (i) STI policy, (ii) STI – Idea Factory; (iii) Intellectual Property Rights (IPR), patents and technology transfer; (iv) international programmes to support STI; (v) energy, water, transport and infrastructure; (vi) **ICTs and innovation**; (vii) agriculture, health and life sciences; (viii) science with Africa marketplace; and (ix) developing guidelines for health research in Africa.

Cross –cutting issues such as, STI capacity building and climate change in Africa formed part of the discussions.

A number of very important recommendations on suggested actions and the assignment of responsibility to carry them out, on all the topics dealt with were presented, as part of the final report. However for the purpose of this study only a few of these recommendations will be highlighted as follows:

1) African governments should strengthen their will and commitment to prioritize the sustainable funding for STI activities in their respective countries. R&D funds should be mobilized by both the government and the private sector.
2) The AU, ECA and the UN family, in collaboration with other implementing partners should work with African based S&T entities to generate many factory ideas in order to boost R&D in Africa
3) African countries should develop ICT and innovation policy and strategies
4) African countries should establish the enabling environment for partnership for knowledge sharing and networking

It was in the light of these conference recommendations and as part of the wider mandate of the ECA to strength the continents capability for ICT innovation and related growth and productivity that a consultancy entitled ***"African Private Sector support and investments for ICT Research and Development "was*** awarded to me by the ICT, Science and Technology Division of the ECA with the following terms of Reference (TOR):

"CONSULTANCY FOR STUDY ON AFRICAN PRIVATE SECTOR SUPPORT AND INVESTMENTS FOR ICT RESEARCH AND DEVELOPMENT IN AFRICA

Background

There is abundant evidence that scientific enquiry has brought about great technological advances that influence all aspects of human endeavour and also transformed whole societies by lifting hundreds of millions of people out of poverty. Moreover, several of the Millennium Development Goals (MDGs) depend on science and technology in order to be met. For instance, the MDG targets relating to the reduction of hunger require increased agricultural productivity which as the success of the green revolution in Asia shows, is highly dependent on scientific advances. Similarly, the targets on reducing child mortality are partly dependent on access to vaccines.

1. ***There is, however, abundant evidence that Africa is the only region yet to fully exploit the great potential of science and technology as an engine of growth and development. This is partly attributable to lack of scientific capacity due to the limited number of***

trained scientist and researchers in the continent, a situation further compounded by the brain drain. Sub-Saharan Africa has only one scientist and engineer per 10,000 people whereas developed countries have one for every 250 people.

It is also estimated that up to 50,000 African scientists with post-graduate qualifications work outside their mother country.

An obvious solution is to increase investment in science and technology in African countries since inadequate funding is part of the reason for the low R & D capacity in the continent. For instance, the continent spends barely 1% of Gross Domestic Product (GDP) on research and development and funding for higher education is quite low. Against this background, and given the budgetary constraints of the public sector, it is essential to explore innovative ways of increasing investment in science and technology in Africa. On such way is to explore the possibility of African private sector support for investments in research and development. This is identified as a key issue by the Science with Africa Conference (3-7 March 2008).

ICTs are among the driving forces of globalization. African countries are facing new challenges to their socio-economic development as a result of this globalization process and the impact of the emerging new information age. While there has been global progress in improving access to ICTs and awareness of their potential, access to these technologies remains extremely uneven as evidenced by ICT-related growth and productivity, which are, to a large extent, confined to developed economies. The digital divide, characterized by highly unequal access to ICTs, manifests itself both at the international and domestic levels and therefore needs to be addressed by national policy-makers as well as by the international community. Emerging evidence indicates that ICTs are central to the creation of a global knowledge-based economy and can play an important role in accelerating growth, promoting sustainable development and eradicating poverty in developing countries and in countries with economies in transition. This in turn facilitates effective integration into the global economy.

Since the launch of AISI, ECA has been supporting member States to embark on the development of NICI policies, plans and strategies. This activity is considered as an important implementing mechanism. His Excellency, John Agyekum Kufuor, President of the Republic of Ghana also noted in his address delivered at the Opening Ceremony of the Second Preparatory Conference on the World Summit on the Information Society (WSIS) that:"It is important that we use the opportunities created through the African Information Society

Initiative of the ECA to link the implementation of the African strategies to the global Action Plan to achieve the Millennium Development Goals"11.The African Union Commission (AUC) has also taken a concrete measures towards harmonizing the national e-strategies and e-policies for the African member states and launched their initiative in 2007 to achieve this goal and the final proposal of the initiative will be presented to the forthcoming African Union CIT Ministerial Conference in May, 2008. In preparations for the second phase of the WSIS in Tunis, the AUC with the support of the ECA and Bamako Bureau developed the African Regional Action Plan on Knowledge Economy (ARAPKE) to be the steering working structure for the African member states to bridge the digital divide and harnessing the potential of ICTs to achieve the MDGs and the African Union vision. To this end, the Science with Africa conference demonstrated the potential of ICT for the support of African science based organizations.

It is against this background that the ICTs and Science and Technology Division of ECA which has a mandate to promote science and technology for development in Africa wishes to recruit a consultant to undertake a study on African private sector support for investment in ICT R& D in the continent. This will not only enable better understanding of the current situation but also help in determining a policy response and advocacy campaign in this regard. To this end, the report to be submitted by the consultant will need to:

- ***Identify companies supporting ICT R & D in Africa***
- ***Evaluate the contributions being made by such companies in this regard***
- ***Clearly highlight trends and differences in different sectors***
- ***Recommend a vision, goals and activities that ECA will use to harness such resources in the context of an ICT R&D strategy for Africa***
- ***Table the findings at a meeting with private sector operators.***

In the course of the assignment the consultant will be expected to liaise closely with the Director, ISTD and other staff of the Division as well as key stakeholders in the African science and technology community."

In order to kick-off the study the consultant was introduced to Thierry Ammossougbo, Regional Adviser, ISTD as the immediate contact in ECA, who in turn requested the submission of a work plan. Since the original TOR had a requirement for field visits, the work plan was initially

designed to reflect that aspect. The work plan was later redesigned when the TOR was modified to remove field visits from the data collection. Below is a format of the work plan as was finally agreed upon between the consultant and the Regional Adviser.

The main elements of the work plan clearly show a slight shift of focus from the collection of primary data to an examination of secondary data through desk research. This shift of focus may have been necessitated by the fact that data availability for ICT R&D is this context is still a challenge for many African countries and for many African researchers. The work plan therefore clearly shows that the study is essentially a desk research to determine as a first step, the extent of support and contribution ICT R&D is getting from the African from the private sector.

1.2 Limitations of the Report

As is evident from the TOR the objectives of the study are as follows:

- ***Identify companies supporting ICT R & D in Africa***
- ***Evaluate the contributions being made by such companies in this regard***
- ***Clearly highlight trends and differences in different sectors***
- ***Recommend a vision, goals and activities that ECA will use to harness such resources in the context of an ICT R&D strategy for Africa***
- ***Table the findings at a meeting with private sector operators.***
-

The first two objectives suggest the collection of primary data either through direct interviews, questionnaires or field visits. Due to the limitations of funds, and the constraints of data collection in the continent, the methodology had to be limited to desk research and the collection of secondary data through the internet. This in turn imposed limitations on the type of data that could be collected and the method that was to be adopted.

It was quite evident that it was going to be impossible to assemble and analyze primary data from private companies on their ICT R&D funding by simply sitting behind a computer. It would therefore have been impossible to achieve the research objectives by pursuing that approach.

The Researcher therefore decided that the study should focus on doing a survey of literature that catalogued and analyzed R&D generally and the participation of the private sector in ICT R&D

in particular in places around the world, (OECD and Non-OECD countries) where this has proved successful and made a positive impact on development. The results of this extensive survey have been further analyzed to extract Best Practices from which useful lessons can be inferred.

However data collected through secondary sources clearly has profound limitations when compared to primary source data. This is even more so in Africa were data availability through secondary sources has its attendant problems.

The following limitations to the study should therefore be noted:

The data presented in this Report should be regarded as illustrative rather than exhaustive. The TOR of the study required a continent wide survey and analysis of companies engaged in ICT R&D. It was impossible to pursue this path purely through the collection of secondary data sources without any means of physically reaching the actual sources of the data; i.e. the private companies or research institutions. Even if these sources of data were reached via the internet or by correspondence of some sort, it would have been impossible for them to volunteer confidential company information through the available means. Furthermore, there is a lot of evidence to suggest that data is hardly available in a majority of cases. The work plan was, subsequently, restricted to collection of secondary data.

Instead, under the circumstances, the consultant, with the approval of ECA, has modified the methodological framework and type of data that should be collected in order that the overall study objectives will be achieved within this limited scope of study. For example, instead of looking for African private companies supporting ICT R&D which invariably are almost impossible to find in many African countries, the study will focus on reviewing, in some detail, the literature available in the developed and developing for R&D generally and ICTR&D in particular. The reason for such an approach will be to determine as best as possible international best practice in the leading industrial countries as well as other developing countries which can be adapted to guide the process of developing the potential for ICT R&D.

As with all research, there are limitations to the interpretation of the results obtained in this study. Other issues need to be considered when trying to generalize these analyses to broader issues of interest. In addition, many of the African countries do not have efficient data collection,

dissemination and analysis mechanisms in the area of R&D in particular and Scientific research generally to support informed decision-making processes. Most references in the literature on ICTR&D are anecdotal. It is therefore difficult to draw inferences and conclusions that can stand scientific validation based on anecdotal evidence or very small collection of scientific data.

Other data may exist which would improve the completeness and reliability of the findings presented in this report.

ICT R&D is at a particularly dynamic stage in Africa, which means that there are new developments and announcements happening on a daily basis somewhere on the continent. Therefore, these reports need to be seen as "snapshots" that were current at the time they were taken; it is expected that certain facts and figures presented in the *Report may* become outdated very quickly.

It is anticipated that this report will serve as a base-line as well as a conceptual guide which can be used to develop a framework for collecting relevant primary data and the setting up of a database on Private Sector support for ICT R&D that will be updated collaboratively over time. It will also serve as a practical reference for the public and private sectors in the process of developing a strategy for supporting ICT R&D. The report will also contain a number of recommendations for the ECA that will supplement the extensive efforts that are already in place for supporting ICT R&D development in the continent.

1.2 Adaptations to the study Methodology

Data collection in this study is through secondary sources. It is essentially a desk research through the internet as well as consultations and discussions with ECA staff as well as the extensive network of AISI private sector and academic stakeholders. The study methodology has been refocused to review international best practices in business ICT R&D in the OECD as well as in non- OECD countries in the developing world in order to highlight policies and practices that may be of relevance to Africa and from which important inferences and recommendations can be put together for the future development of Private sector support to ICT R&D in the continent.

The literature surveyed is for investment in Research and Development generally and for the specific case of ICTs. The survey is done mostly for OECD countries in America, Europe and in the case of Asia, South Korea. A few non- OECD countries in Asia and Latin America are also surveyed to determine the paths they have pursued and to assess the progress they have made in achieving their objectives. Within these two categories, an attempt is made to examine policy options that have made a difference to Research and Development in specific cases in an attempt to extrapolate them and draw references for Africa.

Furthermore, there a few isolated cases for private sector contribution and support for ICT R&D in the continent present mostly within research institutions, universities and internationally sponsored projects and a few case scenarios that seem to represent ICT R&D within private companies. These few cases are highlighted to show case them, examine them for patterns and differences to determine how much has been done by them, whether there are any clues and whether their work represents any useful trend that may have meaning for the rest of Africa.
I believe that with this approach the overall objective of articulating a set of recommendations and a vision for private sector support for ICT R&D will be achieved.

2. Harnessing Information for Development in Africa

2.1 Background and Introduction

Advances in the field of Information and Communications Technologies (ICT), since the end of the 20th Century, have led to multiple convergences of content, computing, telecommunications and broadcasting. They have brought about changes in other areas, particularly in:

- **Knowledge management**
- **Human resources development**.

Increasing capacity of ICT has further been empowered by the growth of a global network of computer networks known as the Internet. It has impacted the way business is conducted, facilitated learning and knowledge sharing, generated information flows, empowered citizens and communities in ways that have redefined governance, and have created significant wealth and economic growth resulting in a global information society.

But our continent- Africa is lagging behind and needs to catch-up if we are to benefit from this technological advancement. Africa has failed to occupy any reasonable position in the New Information Order because it lacks capacity for ICT R&D among other things. Countries in Asia and Latin America have been able to scale up on ICT R&D and occupy important positions in the software and the chip industry. South Korea, Japan, India, are playing important roles in the evolution of Internet 2 while India, China and Mexico are contributing to the changing landscape of the business processing outsourcing (BPO) industry. These countries have moved from rendering low-end back office to high-end innovative service development and delivery. They no longer serve as outsourcing destinations. They are at the fore-front of advancing new knowledge in ICT.

Africa's place in the information society has always been hinged on its green market which is increasingly becoming a veritable ground for ICT solution providers. In the last six years, Africa has seen a fast uptake of mobile phones and a slow but steady spread of Internet presence. But local content and ICT R&D has become completely unexplored leaving the continent no better than a large market of consumers of imported ICT goods. **(Oruame, 2005).**

Most African countries, perhaps with exceptions of South Africa, Ethiopia, Tunisia and Egypt, have no clear-cut policy on funding ICT R&D and no country has made any substantial progress in this area. With India and China in the lead, Asia has earned considerable respect as a frontline player in the advancement of ICT knowledge. The two countries have in the last 10 years committed over $500 billion dollar in ICT R&D. The spin-off effects include the several software companies, thousands of startups engaged in BPO and a multitude of 'brain factories' in Shanghai and Bangalore producing exportable ICT solutions for the markets in Africa. **(Oruame, 2005).**

Africa's condition is somewhat paradoxical. Some of the great minds in ICT R&D are Africans. But virtually all live abroad. There are more than 20,000 Africans or people of African descendent living in the Diaspora contributing to the advancement of ICT to those countries outside the continent. A prominent figure is Nigerian born Phillip Emeagwali, the computer scientist associated with advancement in super computing. Emeagwali is only one of the thousands that have found the right environment to flourish outside the continent. **(ORUAME, 2005).**

Unlike Asia, the African environment has continued to stifle real prospect in ICT R&D. Evidence so far surveyed from the literature suggests that government funding is non-existent and the private sector support does not exist. While Asia has been able to muster sustainable support in terms of policy framework and funding for researchers in ICT R&D, Africa still gropes in the dark. The factors against ICT R&D are as legion as they are intimidating.

They include:

1. Inadequate public sector funding for research and development in general
2. Lack of human capacity in key institutions of learning, policy making and of research.
3. . The inadequacy or lack of appropriate policies required to create the ambiance for the attraction of manpower and resources for ICT R&D
4. The appalling state of universities and institutions of higher learning as well as lack of interaction between academic institutions in Africa.

The situation can best be summarized by the words of Gaston Zongo, ICT Policy Adviser for Panos Institute for West Africa in Senegal;

> **"We have always made the mistake of confusing ICT deployment for ICT R&D and acting on the assumption that with mobile phones and Internet gaining grounds, we have earned a place in the knowledge economy. How can we be part of a new world order when we are not among those in the forefront of the change process? We have no say, no role than to consume what Europe, America and Asia have created through research"?**

What then can be done to ensure that Africa does not miss the Information Revolution as it did in the case of the Industrial Revolution? What strategies do we put in place to improve upon funding for ICT R&D especially in respect of the participation of the private sector? How can Africa benefit from experiences in the developed and some developing countries in encouraging the private sector to take an active part in funding ICT R&D?

Many initiatives are underway at many levels, Global, Regional and sub-regional levels. This section reviews some of the more relevant contributions that are underway for harnessing information for Africa's development. It outlines in more detail the various efforts by ECA in this regard as well as its overall progamme for monitoring WISI global objectives.

2.2 Global, Continental and Regional Initiatives

As a contribution to the global effort, many initiatives have been carried out within the continent to help mobilize, focus and coordinate action by developing a strategic approach to harnessing the benefit of ICT for development.

At the global level the following initiatives have had specific significance for the continent:

- Digital Opportunity Task Force (DOT) which was created under the Okinawa Charter on the Global Information Society, by the G8 leaders ;
- the United Nations Task Force, a UN initiative for finding consensus on various perspectives;
- the Global Business Dialogue on e-Commerce a leading private sector voice on e-commerce policy and e-commerce related areas;

- the Global Information Infrastructure Commission non-governmental initiative aimed at fostering private sector leadership and enhanced private-public sector cooperation in the creation of an improved information infrastructure. **(Chetty, 2006).**

At the continental level, several initiatives for the harnessing ICTs for the development of the continent have been undertaken at the political and professional levels:

- The African Connection and the Ministerial Oversight Committee, developed the African Connectivity initiative, an African driven effort aimed at making Africa a full member of the Global information and knowledge society through accelerated development of infrastructure throughout the continent.
- The African Telecommunications Union, the de facto African regional telecommunications counterpart of the ITU, serves as the organ for the systematic pursuit of telecommunications development in Africa.
- The African Advisory Group on ICT (AAG-ICT) is an expert group that meets to provide confidential high-level advice to African Ministers of Information and Communication on strategic, policy and regulatory issues.
- The NEPAD e-Africa Commission is a special task team responsible for developing policies and strategies and projects as well as managing the structured development of ICTs at the continental level with the following mandate:
    1. To develop a broad NEPAD ICT strategy and a comprehensive action plan that will accelerate the development of Africa inter-country, intra-country and global connectivity and, promote conditions for Africa to be an equal participant in the Global Information Society.
    2. To serve as the primary advisory body to the Heads of State and Government Implementation Committee (HSGIC) of NEPAD, on the development and implementation of an effective NEPAD ICT programme in Africa.

The e-commission working through partnerships with Governments and civil society is prepared to undertake a number of activities geared towards fulfilling the objectives of NEPAD. The e-commission has developed a comprehensive strategy which takes cognizance of reviews and rationalizes existing projects and initiatives; collates information of best practices and experience in the key elements of the ICT programme for benchmarking and development of guidelines and so on**. (Chetty,2006).**

- The ADF III ICT Focus Group on Regional Integration is an effective forum for informed dialogue and consensus building on urgent development issues like the role of ICTs in regional integration

The role of ICTs for regional integration and cooperation has gained considerable attention. As a result Regional Economic Communities (RECs) are taking a leading role in regional consultations and studies such as harmonization of policies, regulatory frameworks infrastructure etc

- Economic Community for Central African States (CEMAC) has adopted the Yaoundé declaration which includes recommendation for the harmonization of the ICT sector and sharing of resources in the CEMAC countries.
- Economic Community for West African States (ECOWAS) has established an ECOWAS Consultative Regulatory Committee for Telecommunications to ensure the consistent and coordinated regulation of telecommunications within the community. A study on the harmonization of the West African regulations is underway.
- Southern African Development Community (SADC) has undertaken several studies on ICT. SADC has adopted a protocol on Transport, Communication and Meteorology and a Declaration on Information and Communications Technology and has created the Southern Africa Transport and Communications Commission.
- The UEMOA ICT initiatives include the harmonization of the regulatory frameworks, the creation of a forum of operators and service providers, the promotion of new ICTs, and liberalization of the national telecom markets.

2.3 UN-ECA and the African Information Society initiative (AISI)

As the result of the re-structuring of ECA in 2006, a new division called ICTs, Science and Technology Division (ISTD) was created. ECA's sub-programme component on Harnessing Information for Development (and/or ICTs, Science and Technology for Development) is geared towards supporting African countries to participate fully in the rapidly evolving people-centred,

inclusive, development-oriented Information Society to harness Science and Technology (S&T) to attain sustainable development.

The AISI was adopted by the conference of AU Ministers in 1996, to be supervised be the ECA as the first comprehensive effort by African governments to bring their countries into the information and knowledge era. The initiative has set a framework within which national stakeholders, as active and central players, set their own course of action and implement projects based on their priorities and development goals

The AISI proposes that Africa should build, by the year 2010, an information society in which every man, woman, child, village, public and private sector office has secure access to information and knowledge through the use of computers and the communication media.

The AISI foundation relies on the following inter-linked elements:

• An appropriate framework for the sustainable de**v**elopment of the Information Society in Africa, presented in a " a holistic set of decisions, directives, laws, rules and other mechanisms aimed at guiding and shaping ICT production, acquisition and utilization" - - a stable, predictable legislative and regulatory environment is a precondition for investment in the information and communications sector;

• The physical infrastructure, which caters for reliable network and telecommunication services

- AISI advocates for an improved interconnection in the region as well as the establishment of links with the international telecommunication networks;

• Institutions dealing with coordination and implementation - these include policy making organs, regulatory bodies and coordinating bodies;

• Human resources development, which is the cornerstone for the sustainability of the Information Society - AISI advocates for technological and managerial capacity building through education and training so that Africans will be well prepared to participate in the knowledge era and benefit from it; and the info structure, if suitable and relevant will promote access to the majority of the population, including the widely dispersed rural communities and the disenfranchised groups.

In pursuance of these critical development elements, the AISI provides a framework for the development and implementation of national information and communication infrastructure plans in all African countries and the pursuit of priority strategies, programmes and projects which can assist in the building of a sustainable Information Society.

To that end, ECA's work under this sub-programme focused on three broad interrelated areas as follows:

- ***ICT for Development*** aimed at policies, plans and applications integrated into the development strategies of countries, with a focus on the information and knowledge economy and ICTs in the socio-economic sectors. This also includes the establishment of virtual libraries and specialized information centres, providing access to knowledge for countries to meet the MDGs.

- ***Geo-information for Development***, which allows decisions and plans to be made based on various types of information about the location of resources/facilities required for decision-support in the areas of natural resources, environmental protection and management, food security, land reform, transport, health and education, etc.

- ***Science and Technology for Development***, the cluster will undertake research and policy analyses of Science, Technology and Innovation (STI) and development trends, so as to inform policy makers and planners, to develop and implement tools for the integration of STI parameters in development plans and strategies, and for the implementation, monitoring and evaluation of STI in development policies and activities.

A. Development-oriented policies for inclusive information society, including access, infrastructure and an enabling environment

Activities undertaken in the area hinge on the African Information Society Initiative (AISI) through which the formulation and development of national e-strategies on the continent, known as National Information and Communication Infrastructure (NICI) Plans are based.

The development of National Information and Communication Infrastructure (NICI) policies and plans is one of the most important programmes supported by AISI. The AISI provides the roadmap to guide African countries in addressing the challenges of the emerging globalization and the information age by developing and implementing NICI policies and plans within the wider national socio-economic development objectives, strategies and aspirations. NICI provides the framework within which ICTs are mainstreamed into the national planning process

in order to facilitate the achievement of national and sectoral development priorities and objectives. It is an on-going process through the planning, implementation and regular evaluation of programmes and projects developed according to the needs and priorities of each country.

The process is based on national needs and development priorities as determined by all the relevant stakeholders and with the Governments playing a central role in the creation of an enabling policy and legislative framework to promote an integrated national information and communication infrastructure. In addition, an enabling environment addresses the challenge of the massive investments required for ICT deployment in Africa. NICI therefore represents a long-term strategy to develop infrastructure, human capacity, content and applications as an integral part of overall national development.

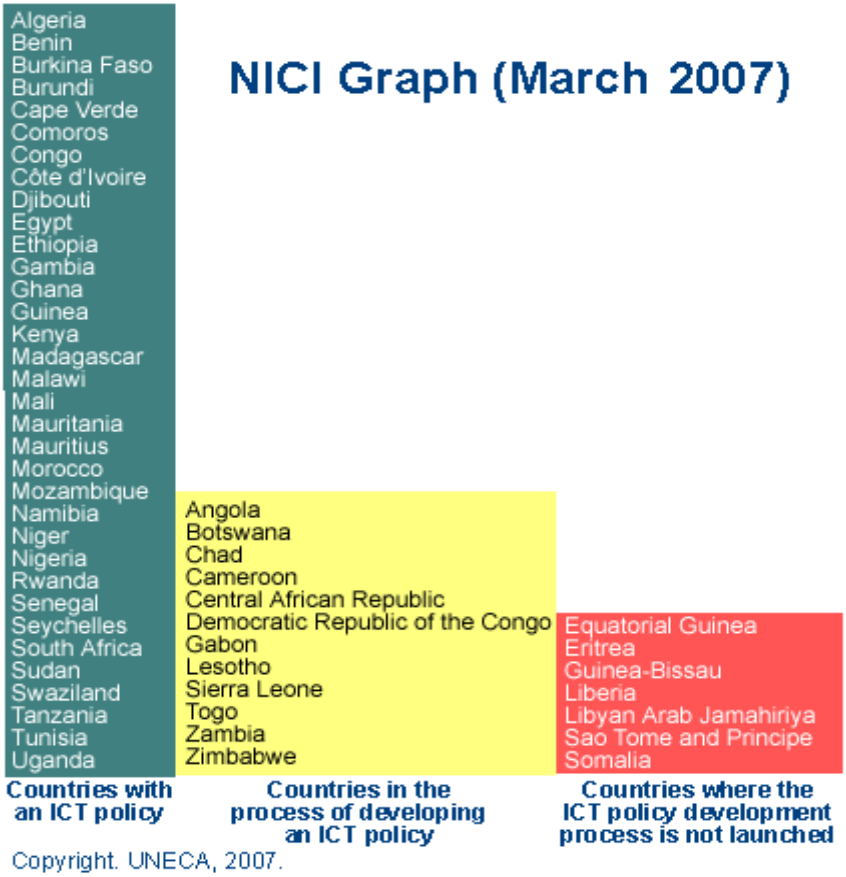
A number of African countries have successfully embarked on NICI processes that articulate long-term policy, infrastructure, content and application strategies as an integral part of their overall national development goals. In some cases, the development and implementation of corresponding action plans has been undertaken.

African countries engaged in the NICI process can be divided into three broad categories:

- Countries that are in the process of developing their national policies and plans;
- Countries that have partially completed their policy development processes and are in some cases implementing specific initiatives or sectoral projects;
- Countries that have completed their policy and plan development processes and have embarked on the implementation process.

Since the launch of AISI, the ECA has been supporting member States to embark on the development of NICI policies, plans and strategies. The current policy status in Africa is as follows: Countries with an ICT policy (33); Countries in the process of developing an ICT policy (13); Countries which have not initiated the ICT policy development process (7).

Figure 2.a NICI Graph (March 2007



In addition to the ongoing activities, requests on development/review of NICI policies or implementation plans have been received from the Comoros, Gabon, Guinea, Kenya, Sudan and Tanzania. Whilst most of these countries are in the first NICI cycle, some are in the policy phase with a few in the first NICI plan implementation phase. Rwanda is the only sub-Saharan Africa country currently under-going their 2nd NICI cycle.

Under the AISI framework the following sectoral initiatives have been undertaken:

- **E-health policy development process and implementation challenges in Uganda**
- ***The ICTs, Trade and Economic Growth (e-trade) Initiative:***
- **Knowledge Networks for Disadvantaged Communities**
- **African Health Info way**
- **e-Employment Project in Central Africa**
- **Telecommunications Sector Regulation:**
- **Policy-making support to African Regional Economic Communities (RECs)**

There have been major achievements and progress made in harmonizing the national ICT policies and plans as well as creating a sub-regional frameworks for regional economic integration:

- an e-government strategy was completed for the East African Community (EAC).
- Since September 2005, the Economic Community of West African States (ECOWAS) and ECA have been working together to create an ICT policy and harmonize legal frameworks for the sub-region, which would address the challenges of building the information society.
- In North Africa, a study is concluded in collaboration with the Arab Maghreb Union (AMU) on the status of e-commerce development in the sub-region to examine the feasibility of launching a sub regional e-commerce platform, which will facilitate business activities among member States.
- The draft ICT strategy for the Common Market for Eastern and Southern Africa (COMESA) is in the process of development. Also, ECA has also supported the Communauté Economique des Etats d'Afrique Centrale (CEEAC) and Central African Monetary and Economic Community (CEMAC) formulate the ICT Strategy for Central Africa.

In the analysis of the national ICT policies and draft policies of 28 African countries, it was found out that majority of the policies were developed in a participatory manner and the Economic Commission for Africa was involved in producing a good number of them.

(**Tarmokung, 2007).** All the countries looked at ICT as a means to solving many developmental problems and have thus generated visions and/or goals that implicate ICT in social and economic development.

Thus ICTs were to be involved in poverty eradication, health, better education and good governance for example. Other areas of application indicated in this study include agriculture, environment, science, tourism, culture and employment.
The policy analysis indicates that the major problems/difficulties facing ICTs in Africa and which the countries intend to resolve immediately include inadequate infrastructure, insufficient human resources and inadequate access. The plans to resolve these problems include working in partnership with local and foreign investors as well as international organizations.
One component of regional and international cooperation that stands out when one reviews the policies is international trade. All the countries have a plan of exporting ICT products and/or services.

B. Development of national geo-information policies

An important aspect of ECA's national policy formulation is the development of national geo-information policies, as well as their integration into national e-strategies.

Cartographic information used to be portrayed as maps, with limitations on the number of themes that can be incorporated into the decision and policy analysis process. In the information age, digital techniques are applied to cartography resulting in geographic information systems (GIS).

However, GIS services are currently provided by 'scattered' organizations that are difficult to access simultaneously to provide a coherent set of services. ECA has been providing advisory services to member States to develop spatial data infrastructures (SDI).

Progress is however slow due to the high cost in implementing the technical aspects of the SDI. The implementation in many countries has stalled with the setting up of the committees. Exceptions are South Africa, which developed and approved a National SDI Policy and strategy

and Nigeria, where the National Geo-information policy document was approved in 2003 and its governance structures are in place and functioning.

Geo-information content should be planned for at the start of the NICI process. ECA is therefore moving for the integration of NSDI into NICI policies in a number of African countries, namely Swaziland, Ghana, and Burkina Faso, etc.

With advances in ICT generally and GIS in particular, management of land-related information have been evolving the concept of the e-cadastre which African countries have still not started ECA is therefore preparing a publication on land management information systems in the knowledge economy.

C. Evaluation and monitoring of the ICT sector and its impact on Information Society

In an effort to provide African countries with a framework to identify ICT indicators and build their capacity to measure ICT4D, the Scan-ICT programme was launched in November 2000 with the goal of creating, a Pan African ICT network that would collect, analyse and disseminate all levels of ICT related knowledge in an open manner. It is a collaborative project between the Acacia programme of the International Development Research Centre (IDRC) and ECA, with support from the European Union (EU) and the Norwegian Agency for Development Co-operation (NORAD). The Scan-ICT programme seeks to build support for the phased development of a comprehensive African capacity to define, collect and manage key information needed to support the growing investment in ICTs as well as the transition of Africa to an Information Society. The first phase of the Scan-ICT programme, involved six countries (Ethiopia, Ghana, Morocco, Mozambique, Senegal, and Uganda).

As a follow up to the 1st phase of SCAN- ICT, ECA with the support of the Government of Finland is implementing the second phase of the programme with full involvement of National Statistical Offices (NSOs) in Cameroon, Gambia, Ghana, Mauritius and Rwanda.

D. Capacity Building activities

Capacity-building activities have also been central to ECA's mission of promoting awareness of the importance of harnessing and exploiting ICTs for socio-economic development. Through the activities of the Information Technology Center for Africa (ITCA), an ICT-focused exhibition

and learning center at ECA, a significant number of government agencies, national parliaments, academic and research institutions and NGOs in the region have benefited from training in the use and application of ICTs. The African Virtual Learning Academy (AVLAC) provides ITCA with additional means to address training needs and provide online capacity-building training to policy and decision makers, while the ECA-IDEP initiative which started in September 2005 is developing online training for policy makers on economic development and planning.

Others capacity-building efforts are continuously been implemented for various stakeholders including, central and local government officials, Members of Parliament, Women, Youth, Academia, Media, private actors on building the African inclusive Information Society.

E. Follow-up to the World Summit on the Information Society outcomes at the regional and international levels.

The Geneva and Tunis documents as well as ARAPKE entrusted ECA with follow up activities, especially through promotion and coordination of African efforts in the post summit process and provision of support to member States to implement the WSIS decisions.

In this context, ECA has organized and participated in several workshops, coordinated Africa's participation in several forums and spearheaded finalization of the ARAPKE document.

The rationale for this review is that the efforts by ECA at harnessing information for development have contributed in no small way to the rate of diffusion and the level of access to ICTs in many African countries. This review is also necessary to highlight the specific role ECA has been playing in helping African, State and non State actors take active part in developing their capacities for the utilization of ICTs to accelerate Africa's development. It serves as a means of helping these actors create the necessary enabling environment that will encourage the African private sector and the multinational companies engage fully with investment in ICTs and ICT R&D. Many of the activities reviewed above have been done with a number of stakeholders in the private sector, Governments, the Academia, Intergovernmental organizations and other UN agencies. Due to the limitations of time and the scope of this study, there are many other activities of the ECA which have not been reviewed.

3. A Brief Overview of International R and D

3.1 Introduction

Although it is no panacea, scientific and technological knowledge has proven valuable in addressing the challenges countries face in a variety of areas such as sustainable development, economic growth, healthcare, ICTs and agricultural production and increasingly, the international competitiveness of a modern economy is defined by its ability to generate, absorb, and commercialize knowledge.

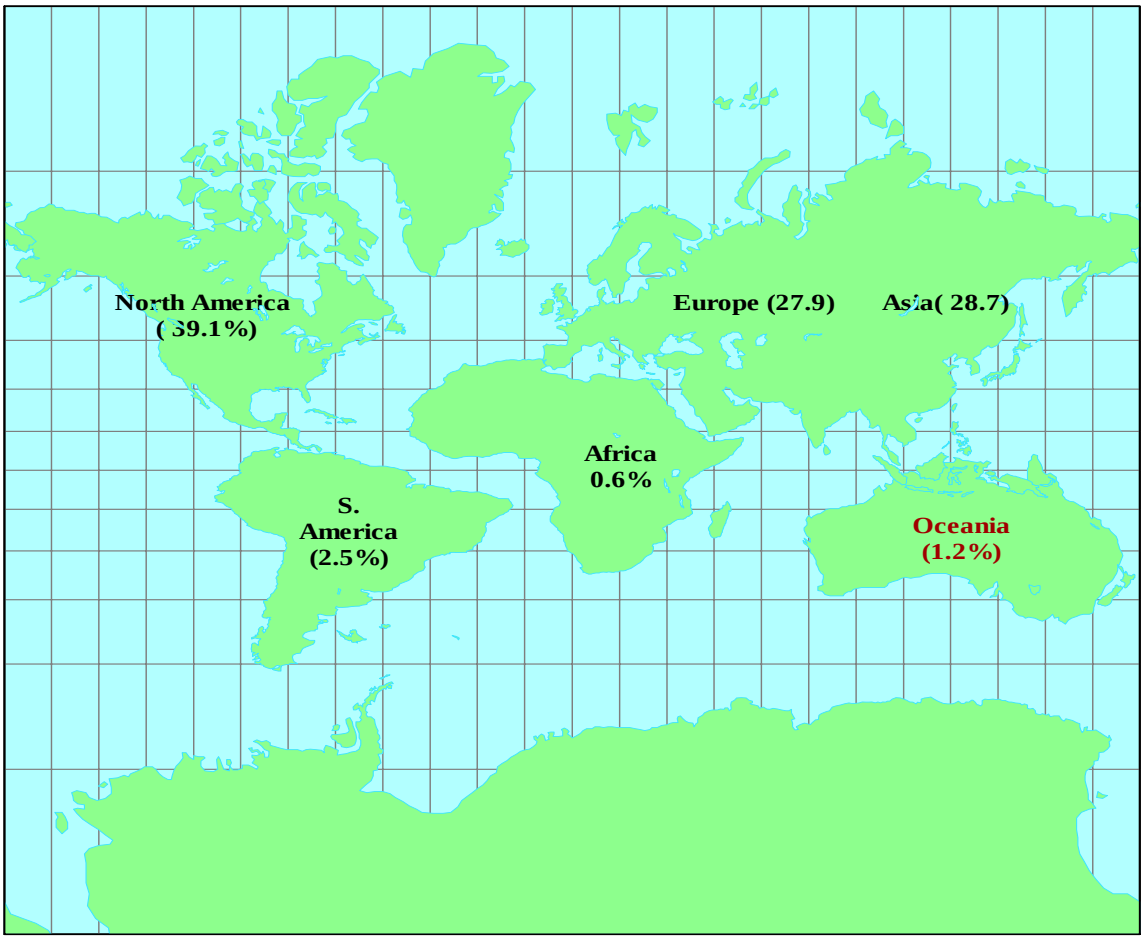
Nations benefit from R&D performed abroad, but domestic R&D performance is an important indicator of a nation's innovative capacity and its prospects for future growth, productivity, and S&T competitiveness. Such R&D performance, expressed in terms of expenditure and patents, varies across nations and the ability of nations to acquire such a capacity depends to some extent on the level of interaction between it and other nations (more or less advanced).

This section reviews literature that compares international R&D spending patterns and includes data on absolute expenditure trends, sources of funding, measures of R&D intensity, the structure and focus of R&D performance and funding across sectors, and corporate research-related spending patterns, priorities and policies. The objective of this review is to highlight the patterns of international R&D, how their movement across the world has resulted in the globalization of technological development and to determine how R&D expenditure has served as a catalyst for socio-economic.

Worldwide R&D performance is concentrated in a few developed nations. In 2000, global R&D expenditures totaled at least $729 billion, half of which was accounted for by the two largest countries in terms of R&D performance, the United States and Japan. The figure below illustrates that over 95% of global R&D is performed in North America, Asia, and Europe. Yet even within each of these regions, a small number of countries dominate R&D performance: the United States in North America; Japan and China in Asia; and Germany, France, and the United Kingdom in Europe. Wealthy, well-developed nations, generally represented by OECD member countries, perform most of the world's R&D. The 30 OECD countries represented 82% of global R&D. **(Sci. and Eng., 2006).**

The R&D performance of OECD countries grew from $602 billion in 2000 to $652 billion in 2002. The G-7 countries (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States) performed over 83% of OECD R&D in 2002. The United States accounts for 43% of OECD R&D, a slight drop in share from 2000 when it performed 44% of all OECD R&D. Outside of the G-7 countries, South Korea is the only country that accounted for a substantial share of the OECD total (3.5% in 2002, up from 3.1% in 2000).

Figure 3.a R&D Expenditures and Share of World Total by Region, 2000.



R&D Estimates from 80 countries in Billions of purchasing power parity dollars (ppp)

World Total= $729 million (ppp)

Source: OECD. Main Science and Technology Indicators 2004

3.2 Trends in Research and Development expenditure in Europe

The Lisbon strategy set the target that by the year 2010 the EU should achieve a research intensity of at least 3% of GDP. Furthermore, the business sector should be responsible for 2/3 of the total R&D expenditure.

According to the most recent statistics, **(Uotila, 2006)** R&D expenditure as a percentage of GDP ('Research intensity') in 2004 in the EU25 countries was 1.90% (the equivalent percentage being 1.92% in 2003).

Between 2001 and 2004 there was an average annual rise of 1.3% in R&D expenditure (EU25). In the US this percentage was -0.1%, and in Japan 1.8% between 2001 – 2003.

However, judging by the research intensity, it was higher in the US (2.59% of GDP in 2003) and Japan (3.15% of GDP in 2003). According to Israeli data4, the figure for Israel was as high as 4.8% in 2002.

In 2003, 54% of the total EU25 R&D expenditure was financed by the business sector, while in the US the business sector covered 63% and in Japan and Israel 75%.

As for the highest research intensity in the EU in 2004, Sweden (3.74% of GDP) and Finland (3.51%) occupied the top positions. The next most research intensive countries were Denmark (2.63%), Germany (2.49%), Austria (2.26%), and France (2.16%). The countries with the lowest research intensity were Malta (0.29%), Cyprus (0.37%), Latvia (0.42%), and Slovakia (0.53%).

The annual average R&D expenditure growth rates during the period 2001 to 2004 were highest in Estonia (16%), Cyprus (15%), Lithuania (12%), and Spain (10%, between 2001-2003), whereas R&D showed a declining trend in Portugal (-4%, between 2001 -2003), Belgium, Slovakia and Sweden (-2%).

In 2003, the largest shares of R&D expenditure, financed by the business sector, were found in Luxembourg (80%), Finland (70%), Germany (66%), Sweden (65%), Denmark (61%) and Belgium (60%).

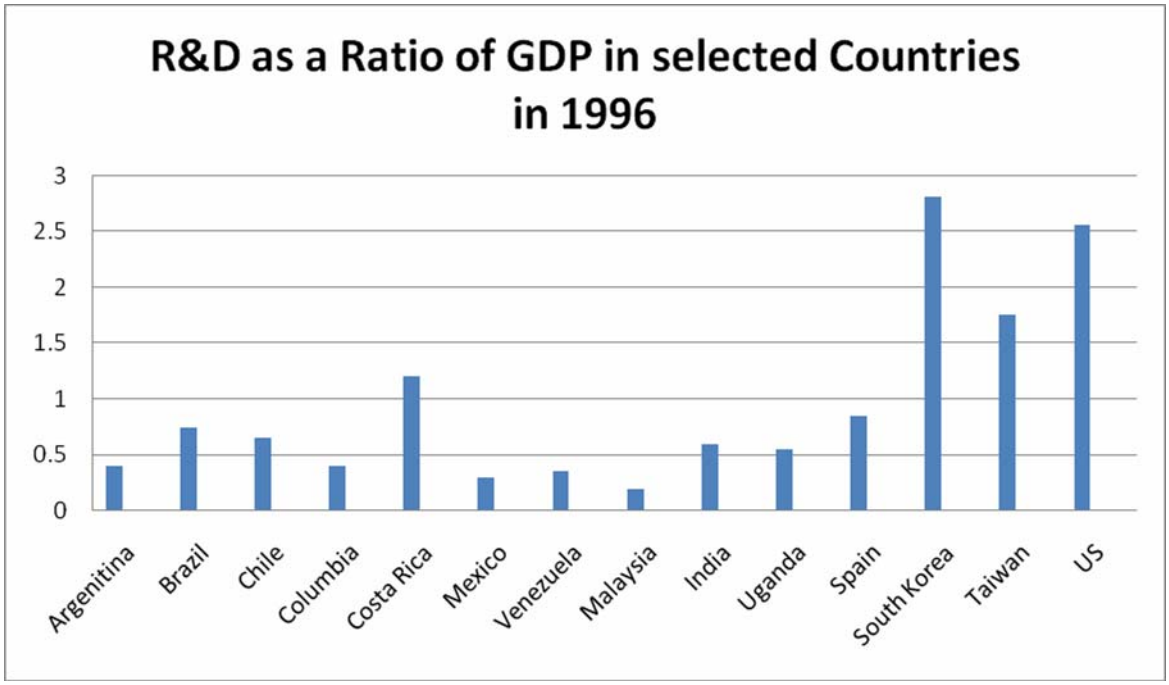
Several lesser-developed nations now report higher R&D expenditures than most OECD members. In 2000, Brazil performed an estimated $13.6 billion of R&D, roughly half the amount performed in the United Kingdom **(RICYT, 2004).** India performed an estimated $20.0 billion in 2000, making it the seventh largest country in terms of R&D in that year, ahead of South Korea **(UNESCO facts sheet/UIS, 2005).** China was the fourth largest country in 2000 in terms of

R&D performance, with $48.9 billion of R&D, only slightly less than the $50.9 billion of R&D performed in Germany **(OECD, 2004).** In 2002, an estimated $72.0 billion of R&D was performed in China, making it the third largest country in terms of R&D performance.

Despite efforts to increase investments in R&D, expenditure remains very low in developing countries. In 2000, developing countries spent 0.9% of their GDP on R&D, still falling short of the target of 1% mentioned in various S&T policy documents and international declarations for over 30 years.

Nevertheless, there is considerable variation across countries. The so called "New Industrialized Economies of South-East Asia" have long surpassed that benchmark, reflecting a solid recovery after the economic crisis of 1997. China reached the 1% R&D intensity goal in 2000 and now plays an important role in global R&D. These countries are responsible for pulling up the 'developing country average' close to the 1% benchmark. On the other hand, India - the other large Asian economy – has been struggling over the decade around the 0.7% mark.

Figure 3.b R&D as a ratio of GDP in selected countries in 1996



Source: RICYT

R&D investment in Latin America remained stable from 1990-2000, reaching 2.9% of the world total in 2000. In absolute terms, Latin American expenditure almost doubled during this period, but its GERD/GDP ratio improved only slightly from 0.5% to 0.6 %**.(UIS, APRIL 04)**

The ratio of R&D to GDP was less than 0.8 percent in 1996 in five of the six Latin American countries. Costa Rica was the only country in the entire Latin American region, where R&D exceeded 1 percent of GDP. While the share of R&D to GDP, particularly in Brazil and Costa Rica, was generally comparable to some developing countries, it was far below that of Asian tigers, such as Taiwan and South Korea (See figure above) or upper income countries, such as the United States.

3.2.1 Sector focus and Sources of Funding for International R&D

a.) Sector Focus

The is diversity of R&D investment by industry in the United States which is an indicator of how the nation's accumulated stock of knowledge and well developed S&T infrastructure have made it a popular location for R&D performance in a broad range of industries. Compared with the United States, many of the other countries display much higher industry and sector concentrations. In countries with less business R&D, high sector concentrations can result from the activities of one or two large companies. This pattern is notable in Finland, where the radio, television, and communications equipment industry, accounted for almost half of business R&D in 2002. This high concentration likely reflects the activities of one company, Nokia, the world's largest manufacturer of cellular phones.

By contrast, South Korea's high concentration (46% of business R&D in 2003) of R&D in this industry is not the result of any one or two companies, but reflects the structure of its export-oriented economy. South Korea is one of the world's top producers of electronic goods, and its top two export commodities are semiconductors and cellular phones.

Other industries also exhibit relatively high concentrations of R&D by country. Automotive manufacturers rank among the largest R&D-performing companies in the world. Because of this, the countries that are home to the world's major automakers also boast the highest concentration

of R&D in the motor vehicles industry. This industry accounts for 29% of Germany's business R&D, 27% of the Czech Republic's, and 19% of Sweden's, reflecting the operations of automakers such as DaimlerChrysler and Volkswagen in Germany, Skoda in the Czech Republic, and Volvo and Saab in Sweden. Japan, France, South Korea, and Italy are also home to large R&D-performing firms in this industry. (WIR, 2005)

The pharmaceuticals industry is less geographically concentrated than the automotive industry, but is still prominent in several countries. The pharmaceuticals industry accounts for over 20% of business R&D in the United Kingdom, Belgium, and Denmark. The United Kingdom is the largest performer of pharmaceutical R&D in Europe and is home to GlaxoSmithKline, the second largest pharmaceutical company in the world in terms of R&D expenses in 2002 and 2003.

The office, accounting, and computing machinery industry represents only a small share of business R&D in most countries, with the United States and Japan accounting for over 90% of this industry's R&D among OECD countries. Only the Netherlands, reports a high concentration of business R&D in this industry (27% in 2002), most likely representing the activities of Royal Philips Electronics, the largest electronics company in Europe.

One of the more significant trends in both U.S. and International industrial R&D activity has been the growth of R&D in the service sector. In the European Union (EU), service-sector R&D has grown from representing 8% of business R&D in 1992 to 15% in 2002 (R&D funds technology linkages, US). In 2002, the EU's service-sector R&D nearly equaled that of its motor vehicles industry and more than doubled that of its aerospace industry. According to national statistics for recent years, the service sector accounted for less than 10% of total industrial R&D performance in only three of the countries shown (Germany, South Korea, and Japan) (R&D funds technology linkages, US). Among the countries listed in the figure, the service sector accounted for as little as 7% of business R&D in Japan to as much as 42% in Australia, and it accounted for 27% of total business R&D in the United States. Information and communications technologies (ICT) services account for a substantial share of the service R&D totals.

b). Sources of Funding

In most OECD countries, government financing accounts for a small and declining share of total industrial R&D performance. In 1981, government provided 22% of the funds used by industry in conducting R&D within OECD countries. Government provided the largest share of Russia's R&D (60%), as it has in Italy in past years (more than 50% in 1999). In the remaining six G-8 member nations, government was the second largest source of R&D funding, ranging from 19% of total R&D funding in Japan to 37% in France. In nearly all OECD countries, the government's share of total R&D funding has declined over the past two decades, as the role of the private sector in R&D grew considerably. In 2002, 30% of all R&D funds were derived from government sources, down from 44% in 1981.The relative decline of government R&D funding is the result of budgetary constraints, economic pressures, and changing priorities in government funding (especially the relative reduction in defense R&D in several of the major R&D-performing countries, notably France, the United Kingdom, and the United States). This trend also reflects the absolute growth in industrial R&D funding, irrespective of government R&D spending patterns. (Sci. and Eng., 2006)

Most of the funding for industrial R&D in each of the G-8 countries is provided by the business sector. Government and industry together account for over three quarters of the R&D funding in each of the G-8 countries, although their respective contributions vary from country to country. Among these countries the industrial sector provided as much as 73% of R&D funding in Japan to as little as 31% in Russia.

In most Latin American countries, public spending accounts for over 70 percent of R&D funding, compared to approximately 25 percent in some of the newly industrialized countries of Asia and less than 50 percent in most industrialized countries.. The public sector was the dominant funder of R&D in the six countries(Brazil, Argentina, Mexico, Chile, Costa Rica, and Venezuela): · Governments and universities — the traditional sources of R&D financing in Latin America — provided the bulk of R&D funding during this period, (RYCIT).

Table 3.a Financing Sources of R&D in 1996 in percentage Share in Latin America

Country	Government	University	Industry	Non-Profit	Foreign	Total
Argentina	46.3	20.3	28.0	1.7	3.7	100
Brazil	57.2	2.8	40.1	NA	NA	100
Chile	69.5	7.5	16.6	NA	6.4	100
Costa-Rica	53.4	14.8	17.4	4.5	9.9	100
Mexico	66.2	8.4	17.6	1.1	6.7	100
Venezuela	32.0	23.4	44.6	NA	NA	100

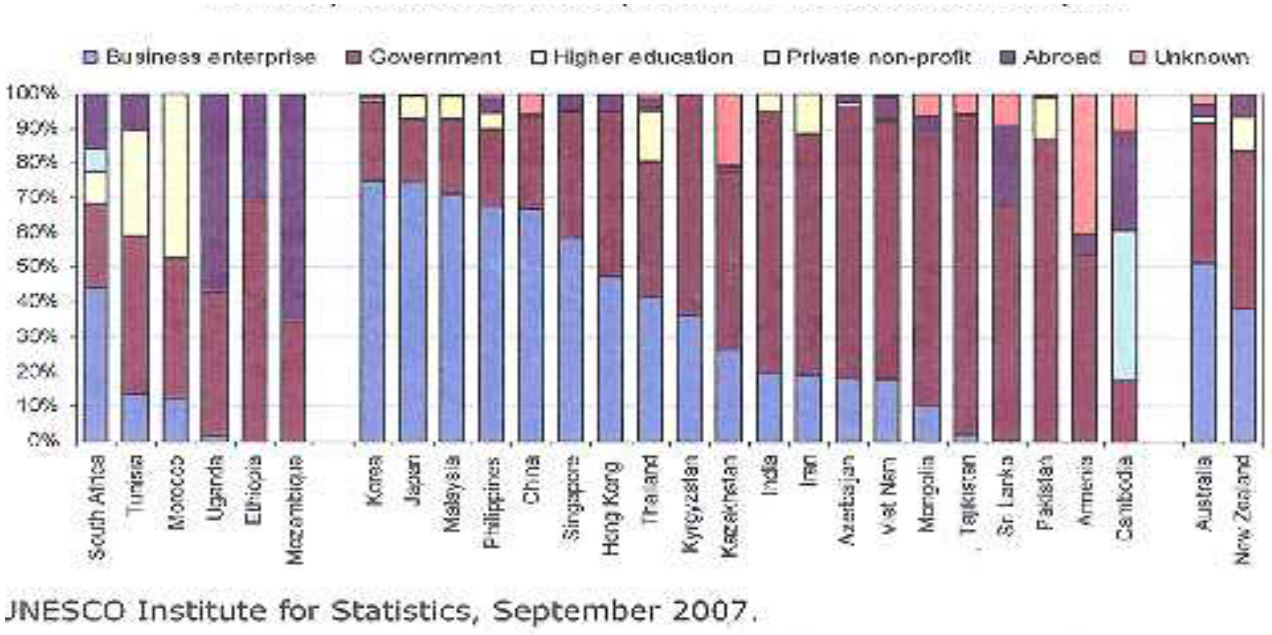
Source: www.unq.edu.ar/ricyt/.

The universities that finance R&D consist predominately of large public institutions, and are conduits of additional public funding of R&D. With the exception of Venezuela, the public sector, including the university sector, accounted for two thirds to three-quarters of R&D funding in 1996.The public sector's share may be understated because the industrial sector includes publicly owned firms. This appears to be the case in Brazil, where public firms provided one third of industrial funding in 1995.

The vulnerability of public spending to financial volatility and crisis may have also played a role in the low, and sometimes erratic, level of R&D spending in Latin America

Figure 3.c Funding in Africa, Asia, and The pacific.

Source of Funds, 2005 or latest available year.



JNESCO Institute for Statistics, September 2007.

3.1.2 Qualitative comparisons of International R&D

Data on R&D expenditures are often used to make international comparisons, in part because of the relative ease of comparing monetary data across countries. Although the cost of R&D in two countries can be compared, it is significantly more difficult to assess the quality of the R&D being performed in the two locations. As with other economic indicators, R&D expenditures are only proxy measures, and they do not contain all of the information policymakers and researchers need to answer their questions about science, technology, innovation, and competitiveness. In order to assess a country's R&D activities, a variety of factors could be considered in addition to quantitative data on R&D expenditures.(**Sci. and Eng., 2006**). Following are examples of factors that may relate to a country's R&D performance and innovation capabilities which in the case of African R&D capacity building may be very crucial:
Culture of cooperation between sectors; the number and quality of linkages between the various R&D performing sectors can be used as a measure of how well a country leverages its innovation infrastructure.

Human capital; the availability of a high-skilled workforce is essential for a competitive national R&D system. The ability of a country to retain its highly skilled scientists and engineers is as important as its ability to train scientists and engineers in its education system. Just as foreign companies can relocate R&D activities to lower-wage countries, mobile, skilled workers can relocate to countries with higher wages.

Intellectual property protection; Strong intellectual property laws help firms to capture benefits from R&D investments. Although foreign firms may invest in R&D in countries with weak intellectual property protection, such as China and, until recently, India, the R&D performed there may be less innovative than that performed in the firms' home countries.
Legal restrictions on research; Cultural pressure and government regulations can influence the nature of a country's research portfolio and be important considerations when comparing countries' R&D performance in specific fields of research.

Market for new technology; the presence of a sophisticated, demanding, and wealthy domestic market can be a strong motivator for firms to invest heavily in R&D. The growth of the U.S. market for pharmaceuticals compared to Europe's is a contributing factor to the increasing attractiveness of the United States as a locus for pharmaceutical R&D. Similarly, the pervasiveness of mobile communications technology in Finnish and Japanese societies has helped these countries remain world leaders in this market.

Quality of research institutions; the quality of research institutions (universities and government facilities) in a country, as defined by quantitative measures (such as publication output and number of prize-winning faculty) as well as qualitative measures (such as peer rankings), is an important factor when making international comparisons of R&D activity.

Research infrastructure; certain types of research require extremely specialized and expensive facilities and instrumentation. The availability of advanced research infrastructure and instrumentation, from radio telescopes to supercomputers, can influence the nature and quality of research performed in a country.

3.2 Globalization of international Research and Development (R&D)

Multi- National Corporations (MNCs) have been expanding R&D outside their home countries in recent decades. R&D investments by MNCs, within their affiliates or with external partners in joint ventures and alliances, support the development of new products, services, and technological capabilities. These investments also serve as channels of knowledge spillovers and technology transfer that can contribute to economic growth and enhance competitiveness. International R&D links are particularly strong between U.S. and European companies, especially in pharmaceutical, computer, and transportation equipment manufacturing. More recently, certain developing or newly industrialized economies are emerging as hosts of U.S.-owned R&D, including China, Israel, and Singapore.

Furthermore, the geographic distribution of these expenditures has evolved to reflect the extent of globalization. In 1994, major developed economies or regions (Canada, Europe, and Japan) accounted for 90% of overseas R&D expenditures by U.S. MNCs. By 2001, this combined share

was down to 80%. The change reflects modest expenditures growth in European locations, compared with larger increases in Asia (outside Japan) and in Israel.

Nevertheless, affiliates located in Europe accounted for at least 60% of these R&D expenditures in 2001 and in 2002, led by the United Kingdom and Germany. R&D expenditures by foreign affiliates in mainland China and Singapore accelerated in 1999, exceeding half a billion dollars annually since 2000. By 2002, they became, respectively, the second and third largest Asia-Pacific hosts of U.S. R&D after Japan and ahead of Australia.

Brazil and Mexico have represented around 80% or more of R&D expenditures by U.S. MNCs in Latin America since 1994. Again, six countries in Latin America (Brazil, Argentina, Mexico, Chile, Costa Rica, and Venezuela) accounted for 97 percent of R&D performed in 1996 by U.S. subsidiaries in the entire region. This substantial increase is consistent with the general trend of increased globalization of U.S. R&D and efforts by many Latin American countries to open up their economies to foreign trade and investment.

Finally, Israel and South Africa represent virtually all of the R&D expenditures by U.S. MNCs in their respective regions over the same period.

3.2.1 Patterns of Globalization of R&D

The evolution of the globalization of R&D can be analyzed in terms of waves (phases). Such a framework helps in a comprehensive understanding of globalization as a broader process. Each wave represents a set of distinctive characteristic features, yet reveals the continuation from one wave to the other **(Reddy 2000: pp52-56).** The division of time periods should be taken as approximate indications and not as precise cut-off dates.

a. *The beginnings of the internationalization of R&D – the first wave in the 1960s*

b. *The growth of international corporate R&D –the second wave in the 1970s*

c. *From internationalization to globalization of R&D –the third wave in the 1980s*

d. *The evolving patterns of globalization of R&D -the fourth wave in the 1990s*

A number of major changes have been taking place since the 1980s in the nature and scope of R&D undertaken abroad by Multi-National Corporations which need to be highlighted here. Increasingly higher-order R&D, such as regional technology units, global technology units and corporate technology units, had been located abroad in what can be regarded as the *third wave* of globalization of R&D. Such R&D abroad is carried out as part of long-term corporate strategy and is often carried out through inter-organizational collaboration. Hence, the change in the term from internationalization to globalization, reflecting the characteristic differences from the earlier waves. The main driving forces for this phenomenon had been:

- First, the increasingly globalized basis of competition, aided by the convergence of consumer preferences worldwide, creating a need for learning;
- Second, the increasing science-base of new technologies, necessitating multi-sourcing of technologies;
- Third, the rationalization of Trans National Corporations' operations, assigning specific global roles to their affiliates abroad.

These trends are visible mainly in microelectronics, pharmaceuticals, biotechnology and new materials. The improvement of information and communication technologies and the flexibility of new science-based technologies, that allow de-linking of R&D and manufacturing activities, vastly facilitated this globalization process.

In recent times, the key driving forces for globalization of R&D since the 1990s have been the increasing demand for skilled scientists and rising R&D costs. These forces are triggering the *fourth wave* of globalization of R&D, encompassing some developing economies and countries in transition. The mismatch between the outputs of universities and the needs of industry is giving rise to shortages of research personnel throughout the developed world, especially in engineering fields related to electronics, automation and computer-aided development/manufacturing **(OECD 1988),** compelling companies to widen their research networks in order to tap more geographically dispersed scientific talent. The existence of an

international market for investments in research, education and scientific and engineering personnel and the necessity of scientific knowledge for competitiveness are leading corporations to direct their investments to those geographical areas which can best meet their research needs, including developing countries.

Multi-National Corporations are also sensitive to variations in the cost of R&D inputs from country to country **(Mansfield et al. 1979).** The movement by Multi-National Corporations is facilitated by the availability of large pools of scientifically and technically trained manpower in these countries at substantially lower wages *vis-à-vis* the developed countries. The categories of industries involved are microelectronics, biotechnology, pharmaceuticals, chemicals and software.

The selection of locations for R&D by Multi-National Corporations depends on several criteria. These include:

1) Proximity to a manufacturing site;
2) The availability of local universities and professionals;
3) The ability to build up a critical mass of local researchers (critical for global technological research);
4) The attractiveness of sources of technical excellence, e.g. Universities, customers or suppliers etc. and,
5) The availability of excellent communication systems **(de Meyer and Mizushima, 1989).**

The choice of location of R&D also depends on the type of technology to be developed and the advantages of national scientific capacity. For instance, the United Kingdom has been attracting significant foreign R&D investments in the pharmaceutical industry, because of its high quality skills in the life sciences and in chemistry. Similarly, Germany has been a centre for foreign R&D activities in the electrical engineering and electronics industries, reflecting German excellence in these areas **(Wortmann, 1990).**

The globalization of corporate R&D has been mainly limited to location of R&D units between developed countries but, globalization of corporate R&D continues to evolve as a phenomenon. In recent years, the globalization processes have been encompassing more industries, as well as

more geographical areas. Hitherto uncommon locations are attracting R&D-related FDI by Trans National Corporations **(Reddy, 1993).**

Since the mid-1980s, as an offshoot of the globalization of corporate R&D, Multi-National Corporations have started performing some of their strategic R&D in some developing countries. Multi-National Corporations involved in this new trend seem to be mostly those dealing with new technologies. This strategic move by Multi-National Corporations is facilitated by the availability of large pools of trained manpower, at substantially lower wages compared to their counterparts in developed countries and, an adequate infrastructure.

The performance of strategic R&D, aimed at developing products for global/regional markets or mission-oriented basic research by Multi-National Corporations, has implications for the innovatory capabilities of developing host countries **(Reddy, 1993).**

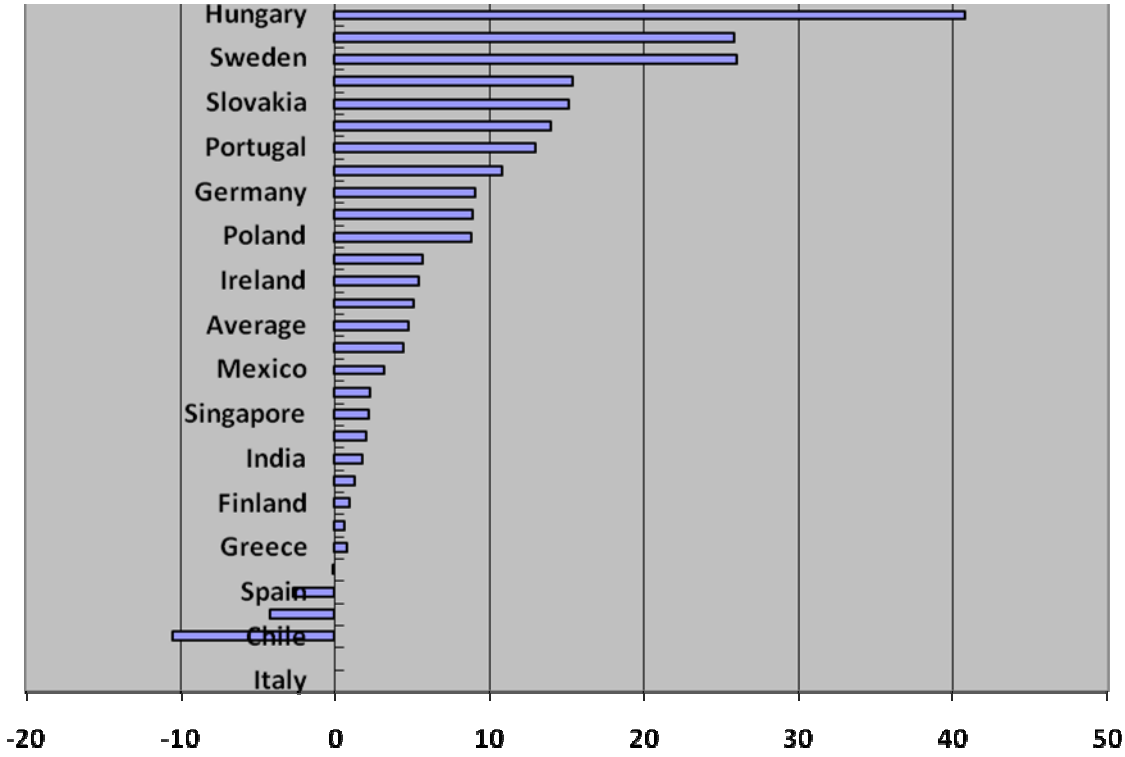
R&D expenditures by foreign affiliates in mainland China and Singapore accelerated in 1999, exceeding half a billion dollars annually since 2000. By 2002, they became, respectively, the second and third largest Asia-Pacific hosts of U.S. R&D after Japan and ahead of Australia. Brazil and Mexico have represented around 80% or more of R&D expenditures by U.S. TNCs in Latin America since 1994.

In the former transition economies that are now new EU member countries, foreign affiliates have become important R&D players since the mid-1990s.

This has happened partly through the early acquisition of flagship firms carrying out R&D such as Škoda Auto in the Czech Republic in 1991 and Tungsram in Hungary in 1990.
An UNCTAD survey of privatization through FDI carried out in 1999 found that in the two years following the privatization deals, R&D expenditure increased by 13.6% in the sample firms **(Kalotay and Hunya, 2000, p. 53)** In the new EU member countries, R&D by foreign affiliates has also expanded through Greenfield projects. Of the 108 R&D projects initiated in the new EU, South-East Europe and the CIS taken together in 2002-2004, 66 were registered in the new EU member countries, with the Czech Republic, Hungary and Poland taking the lead.

Various affiliates on the list have “innovative” R&D mandates for regional or global markets. In South-East Europe as well, foreign affiliates have gained a prominent role in R&D**. (WIR, 2005)**

Figure 3.d (**Trends in R&D spending by foreign affiliates, selected economies, 1995-2003**



Source: WIR, 2005

Finally, Israel and South Africa represent virtually all of the R&D expenditures by U.S. TNCs in their respective regions over the same period.

3.2.2 Developing-country MNCs R&D Expansion abroad

Another new trend whereby developing countries are connecting to global knowledge networks is the emergence and fast growth of foreign R&D activities by MNCs from developing

economies. As the phenomenon is very recent, the top R&D spenders of developing countries are still relatively small.

However, some almost all from Asia have moved up in ranking on the list of the largest R&D-spending firms since the late 1990s. Moreover, the expansion of their R&D appeared to be on a relatively large scale in 2002-2004

Some developing-country MNCs such as the IT Company, Ingenuity Solutions (Malaysia), have targeted the knowledge base of developed countries such as the United States, when investing in R&D abroad. Similarly, Bionova of Mexico acquired DNA Plant Technology of the United States in 1996 and, as a more recent example, the Singaporean firm Cordlife, acquired Cytomatrix (United States) in 2004. **(WIR, 2005)**

MNCs from the Republic of Korea started establishing R&D affiliates abroad only in the 1990s. In 2005, a survey carried out by the Korea Industrial Technology Association identified 60 foreign R&D centres owned by Korean firms.

The United States was the main target of such investment (17 R&D centres) followed by China (15), Japan (7), the Russian Federation (5) and Germany (5). The majority of R&D centres in China (12 of the 15) have been operating since 2000.

A recent study of large Chinese MNCs found that they operated 77 R&D units at the end of 2004, including a surprisingly high 37 units abroad (**von Zedtwitz 2005**). Of these foreign R&D units, 26 are located in developed countries, predominantly in the United States (11) and Europe (11), mostly serving as listening posts or in product design roles.53 The remaining 11 units, located in developing countries, are typically small in size . Two Chinese MNCs, Huawei and Haier, are illustrative of the trend of R&D units being located mainly in developed countries.

Indian MNCs are also globalizing their R&D, focusing mainly on serving their customers in specific regional markets. The leading software firms have all invested abroad, mostly in developed countries.

There are also examples of South-South FDI in R&D. A number of firms from Malaysia, the Republic of Korea, Singapore, and Thailand have set up R&D activities in India related specifically to software development. **(Reddy 2000, pp. 97-103).**

In 2003 Samsung Electronics (Republic of Korea) announced plans to open R&D centres in China, India and the Russian Federation; LG (Republic of Korea) has expanded its R&D activities into India; and Bogasari International (Indonesia, food processing) chose Singapore, in part due to the country's favourable R&D incentive schemes for foreign investors. Other Chinese companies from the electronics industry, such as ZTE and UTStarcom, have also established R&D centres in India and other developing countries, aimed essentially at offshore software development. **(WIR., pp 164- 165).**

Some Indian software R&D affiliates are located in other developing regions (e.g. Tata has invested in Uruguay) as well as in new EU member countries (Hungary). Indian firms in other industries such as pharmaceuticals and chemicals are also investing in R&D abroad.

The essence of such extensive discussions on foreign affiliates on MNCs is to show:

1. The extent of private sector involvement in R&D globalization in the developed and developing countries where such an involvement has contributed significantly to R&D capacity.

2. That there are certain factors which are crucial for attracting multinationals to locate in a specific country and the development of those factors needs carefully planned programmes and investment from the Governments of developing countries.

3. That preparing the enabling environment in African countries for FDI is one sure way of attracting investment not only for the African industrial development, but African R&D capacity building in the private sector.

4. That the African countries are more likely to benefit in their quest for developing National R&D capacities from MNCs through foreign direct investments and globalization of R&D.

3.3 Research and Development (R&D) in Africa

3.3.1 Background

In the world's globalised, hyper-competitive and knowledge-based economy, coupled with high level of obsolescence, research has assumed strategic dimensions in attempts to ensure a Nation’s continuous competitiveness and solvency. In the last section we reviewed how countries in the OECD and beyond have put a lot of emphasis on R&D as a means of attaining sustained economic growth. It is recognized that there is a strong correlation between the size of the investment that a nation makes in science and technology research and development (usually assessed as the fraction of the country’s GDP invested in R&D) and the standard of living and other measures of economic well-being that predominate in that nation. It is against this background and the numerous problems encountered within the African research environment that various efforts are being made to set up structures and initiate processes that will improve the climate for R&D.

In fact the most serious difficulties, the S&T community are encountering in Africa include a steady decline in R&D investment, the brain drain, obsolescence and dilapidated infrastructure. The list should also include insufficient levels of numeracy and literacy, and too few girls and women with S&T education, at all levels.

Available figures suggest that overall government support for R&D in Africa is one of the lowest in the world (about 0.2 per cent of GNP). Only South Africa and the Seychelles spend 1 per cent or more of GNP on R&D. Many experts agree that investment needs to be above 1 per cent of GNP to have any significant impact. S&T investment in the most developed countries is closer to 3 per cent of GNP.

Yet even 1 per cent may not be a realistic target for some African countries. The Director-General of UNESCO has suggested a minimum target of 0.4 per cent of GNP for the least developed African states. Meanwhile, representatives of African Member States themselves have called on the United Nations Development Programme (UNDP) to earmark 3 per cent of all its African national allocations for research and development.

It is against this background that various efforts are being made within the continent to improve upon its attractiveness as a research investment destination as well as build the structures that will improve upon the capacity of intuitions and human resources.

As one of its main areas of focus in its business plan, ECA promotes S&T and innovation for Africa's development through policy analysis, advocacy and capacity building of its Member States. ECA is also a bridge that brings emerging global UN issues on S&T to Africa, and takes Africa's S&T issues to the UN. It achieves its objectives through alliances and partnerships, most notably with the African Union, the African Development Bank and with the African S&T communities and networks of Centres of Excellence. The recent repositioning of ECA to better serve Africa's development needs has created a new, focused Division of ICT, Science and Technology (ISTD), thus aligning S&T more closely with its partners for enhanced collaboration.

The Constitutive Act establishing the African Union calls upon the development of the continent by promoting research in all fields particularly in science and technology. In this regard, the first Conference of African Minister's for Science and Technology, in November 2003, recommended the integration of Africa's science and technology programmes particularly AU Commission and NEPAD programmes into a consolidated and well-coordinated policy and programme framework for Africa in order to direct socio-economic development of the continent through science and technology.

At regional level the African Union Commission 2004-7 Plan of Action aims to 'promote human resource development, capacity building and science and technology as tools and youth as partners for socio-economic development'.

Emphasized in NEPAD's S&T Consolidated Plan of Action of 2005, 'to enable Africa to harness and apply science, technology and related innovations to achieve sustainable development, and to ensure that Africa contributes to the global pool of scientific knowledge and technological innovation', African countries first made a bold attempt to make progress in S&T by adopting in July 1979, the Monrovia Strategy and in April 1980, the Lagos Plan of Action (LPA) for the Economic Development of Africa 1980–2000 and the Final Act of Lagos.

UNECA supports the NEPAD S&T Consolidated Plan of Action, and promotes establishment of S&T parks and incubators in member States. It has also been undertaking research and development activities on selected emerging issues and topics of importance. As part of its work to promote the application of S&T for development, ECA provides support to selected centers of excellence in the various sub-regions and facilitate networking among them.

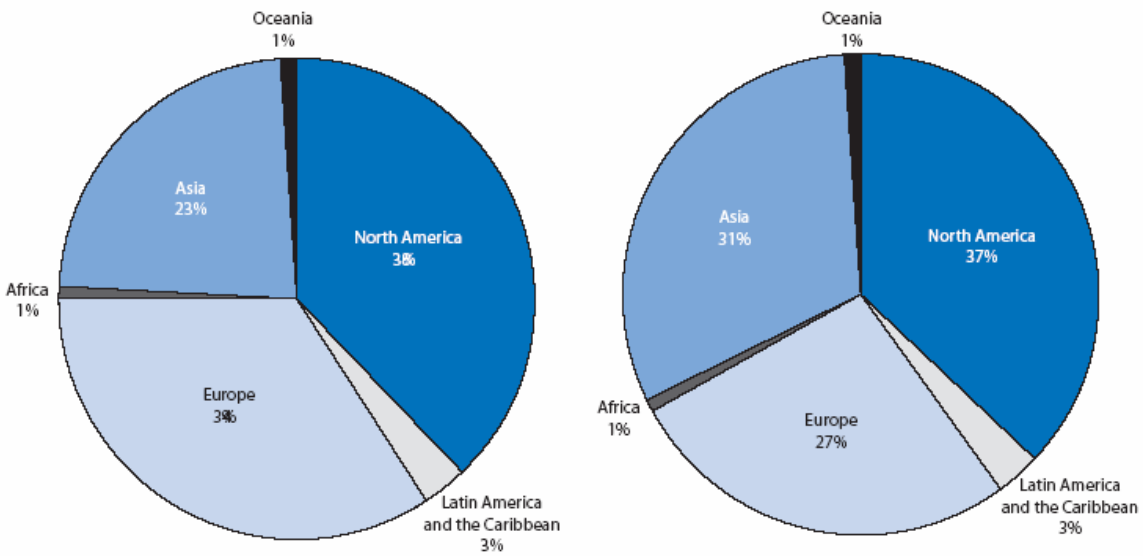
3.3.2 R & D Expenditure in Africa

The situation in Africa where not much financial resources have been committed or earmarked for the development of S& T is very dismal. Most countries are unable to commit the minimum of 1.0 percent of their GDP to S&T development. This target was set in the 1970s, as part of the Lagos Plan of Action for accelerated development in Africa **(NEPAD, 2003).**

In general Africa's investments in R&D activities remain very low in comparison to other regions and at the individual country level, although there has been encouraging signs of increasing investments, or some governments' interests to expand their spending on science, technology and innovation activities on the continent through various policy developments and project initiatives.

Research and Development (R&D) expenditure and intensity are two of the key indictors used to monitor resources devoted to Science and Technology world-wide. A more meaningful indicator is to express R&D expenditure as a percentage of the gross national product (GNP).

Figure 3.e Shares of the world R&D expenditure by regions (1990-2000)



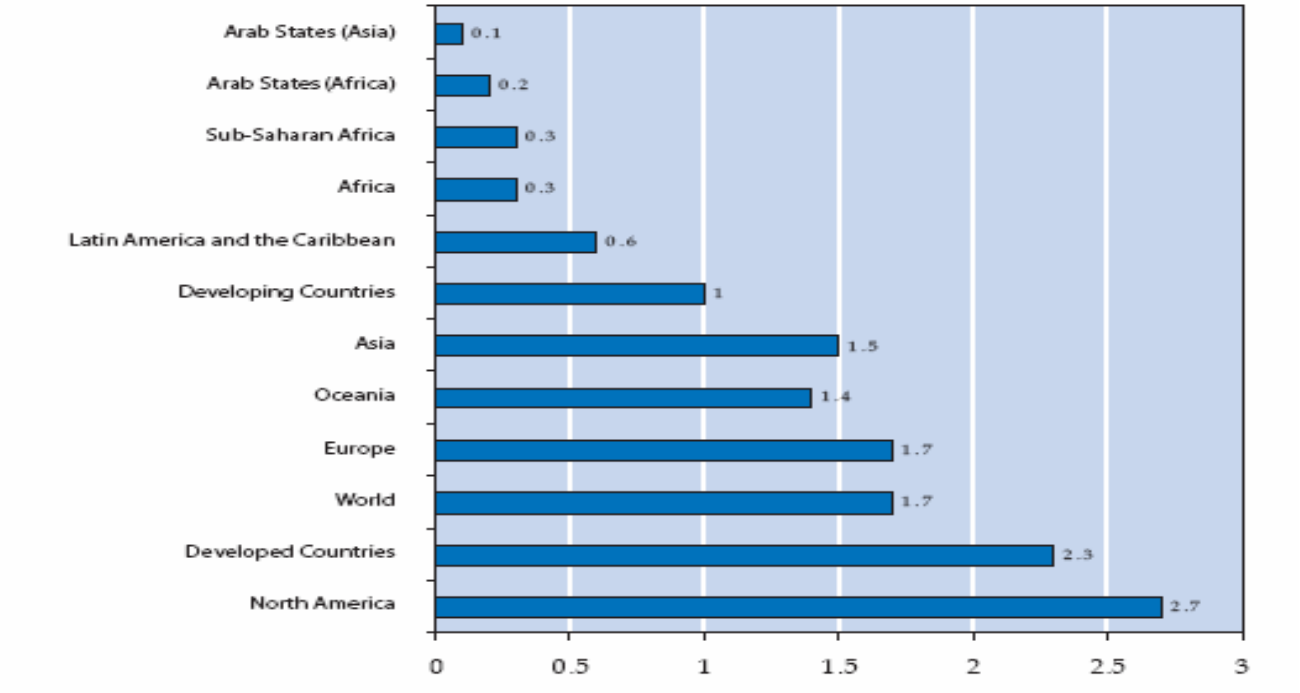
Source: ECA

The graph above shows that the only meaningful increases in R&D expenditure in the last decade were in Asia where the figure rose from 23% in 1990 to 31% in 2000 and in the United States where it rose from 35% to 37%. Europe share of R&D expenditure in the world decreased from 34% to 27% and the share in Africa remains the same.

The tables and graphs illustrate the percentage to gross domestic product (GDP) devoted to R&D activity. The data for the different regions of the world given in the following table show the pattern of R&D expenditure in the last decade. Africa's R&D expenditure showed a decline from 1.3% in 1990 to 0.8% in 2000.

According to this source Africa, Latin America and the Caribbean and Oceanic regions showed much lower levels of expenditure. R&D expenditure in Africa decreased in the first half of the last decade and recovered in the second half continuing with constantly to 2000. R&D intensity also fell from an initial 1.3% to 0.8% of GDP spent in R&D. South Africa accounted for 62% of the estimated total expenditure in Africa in 2000, spending 0.8% of its GDP on R&D and contributing significantly to fluctuations of regional figures over the decade.

Figure 3.f Gross domestic expenditure on R&D as a % of GDP 2002



Source: ECA

The above graph also indicates the low R&D intensity on the African continent Afigure of 0.3 according to this source is recorded for Africa one of the lowest in the world.

The target agreed by the 8th African Union Heads of State Summit, held in January 2007 is Addis Ababa that Made Science, technology and sustainable development the main topics of discussion, was to achieve spending one percent of GDP for R&D by 2010. So far this has only been achieved by Tunisia which has inverted 1.03% of its GDP in R&D.

There is however progress made in few countries such as Botswana, D R Congo, Mauritius, Morocco, Mozambique, Seychelles, South Africa and Tunisia that spent more than the average 0.3 percent on R&D. They all meet the target set by the Conference of Ministers for each African country to consecrate at least 0.4 – 0.5 percent with the exception of Botswana and Mauritius who spend a little below 0.4%.

R&D intensity in Sub-Saharan Africa, where 34 of the 49 least-developed countries in the world exist, is generally less than 0.3%, with the exception of Tunisia, followed by South Africa, Morocco, Mozambique, DRC, Seychelles, Botswana and Mauritius (0.87%, 0.75%, 0.52%, 0.40%, 0.39% and 0.38% respectively).

Looking at their GDP, we can see that some of the countries are more serious on R&D investment such as D R Congo investing 0.5% of the GDP (4.4 billion US$ in 2004 GDP) as compared to Mauritius 0.38% of her GDP (6.1 billion US$ in 2004 GDP) although the population of Mauritius (1.2 million in 2004) in smaller than that of DRC (with 58 million people in 2004).

Table 3.b GERD for selected countries in Africa.

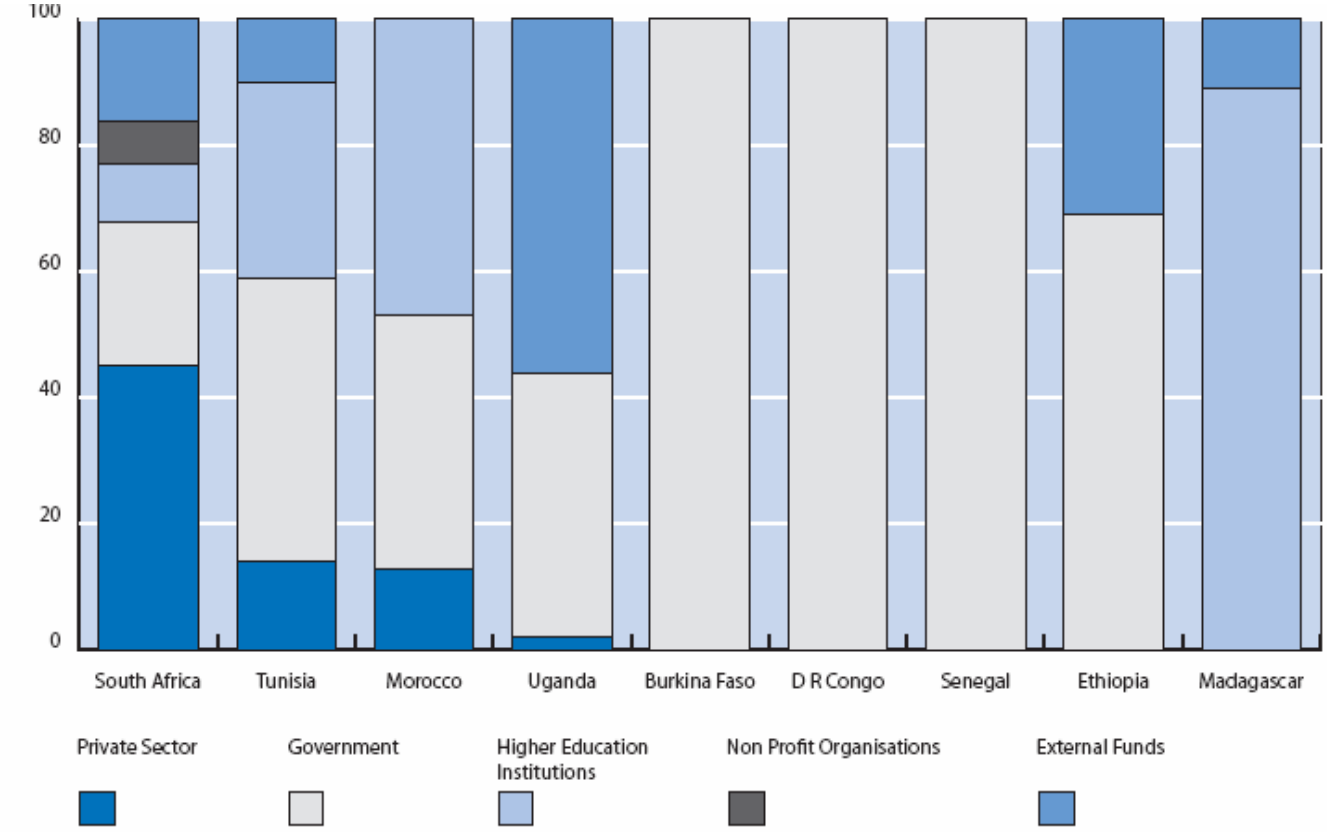
Country	Year	GERD ('000) in local currency	GERD in PPP $('000)	GERD as a % of GDP	GERD per capita
Algeria	2005*	4,994,000	154,644	0.07%	4.7
Botswana	2005	205,567	85,238	0.39%	48.3
Burkina Faso	2005*	4,914,954	28,918	0.18%	2.2
Democratic Republic of Congo	2005*	16,116,424	196,783	0.48%	3.4
Egypt	2000*	654,600	456,604	0.19%	6.8
Ethiopia	2005*	192,227	149,423	0.20%	1.9
Lesotho	2004*	5,400	3,510	0.06%	2.0
Madagascar	2005*	15,942,004	27,129	0.16%	1.5
Mauritius	2005*	690,030	59,926	0.38%	48.1
Morocco	2003	3,144,000	918,760	0.75%	30.1
Mozambique	2002	501,580,800	94,466	0.52%	5.1
Saint Helena (UK)	2000*	51,156	….	….	….
Senegal	2005*	4,090,000	19,662	0.09%	1.7
Seychelles	2005*	15,271	5,447	0.40%	65.7
South Africa	2004	12,009,981	4,176,398	0.87%	88.5
Sudan	2005	19,284,000	216,889	0.29%	6.0
Tunisia	2005	384,000	866,571	1.03%	85.8%
Uganda	2005	34,531,052	95,426	0.23%	3.3
Zambia	2005*	9,272,025	3,410	0.03%	0.3

Source : UIS, UNESCO 2007

*partial

The following figures provide country perspectives on the sources of R&D investment. The indicator reflects the percentage of total investment originating from the business sector, government, higher education institutions, and private non-profit organizations or from abroad.

Figure 3.h-GERD by sources of funds for selected countries, 2005



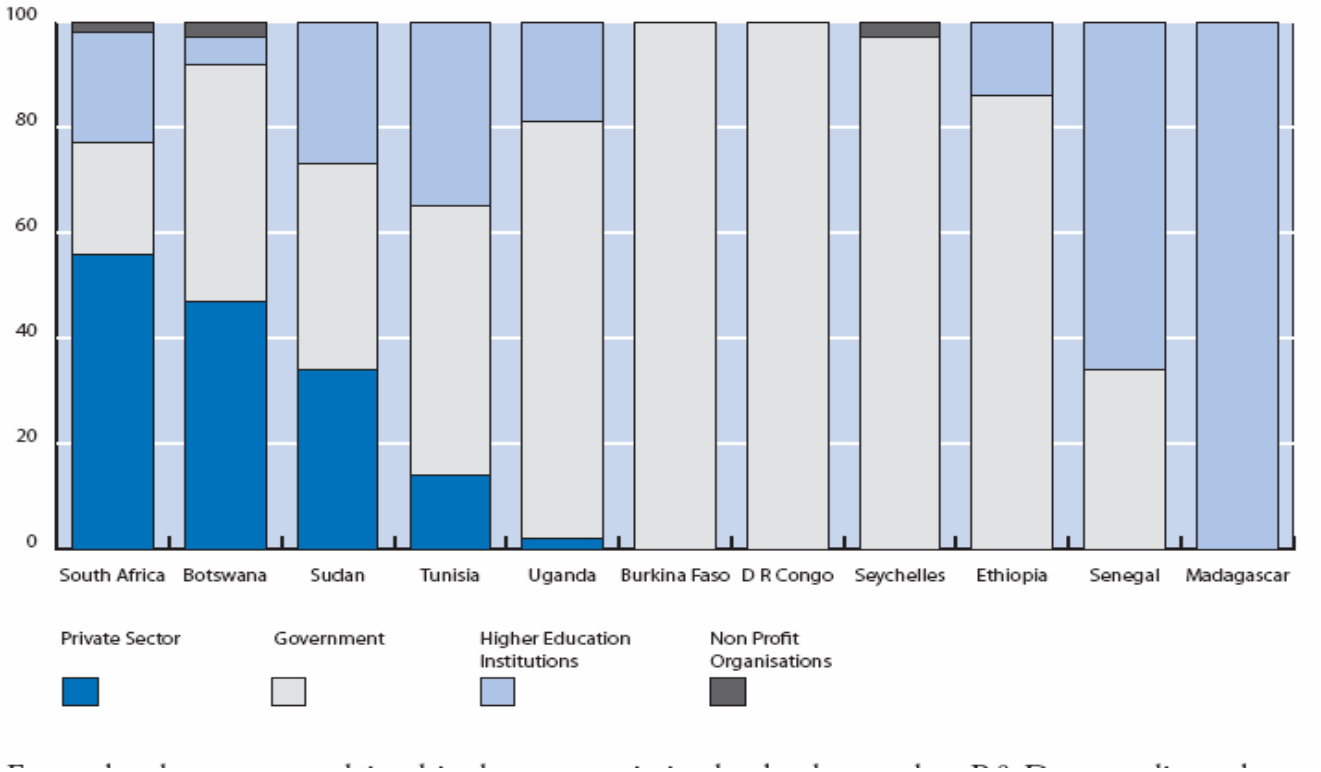
Source: ECA

The above and following graphs show how R&D investment is allocated and spent by key sectors: business, government, higher education institutions or private non-profit organizations. In some countries, such as Burkina Faso, D R Congo and Senegal, government purely finances R&D activities. In some other countries a wide range of sectors are involved in both financing and executing R&D activities such as in South Africa, Tunisia, Morocco and Uganda. Private businesses are active in South Africa, Tunisia and Morocco where relatively the R&D investment is a bit higher than the rest of the countries.

The fact that business accounted for nearly half of South African R&D spending show just how important its contribution is in boosting R&D.

The following table shows GERD by executing (implementing) sector in selected African countries:

Figure 3.i-GERD by executing sector in selected countries, 2005



Source: ECA

From the data presented in this document, it is clearly shown that R&D expenditure has grown worldwide between 1996 and 2005. Most African countries invest less than 1% of GDP in R&D, but there are some notable exceptions such as Tunisia, which have significantly increased its investment during the past 10 years. There is however a clear need to collect and analyse quality R&D statistics especially in Africa, to support evidence-based policy-making at the national and regional level.

As portrayed in the above graph, in many of the countries, government executes the majority of R&D programmes. Private sector significantly contributes to both the financing and executing of R&D activities in South Africa while the data for Madagascar shows that higher education institutions are the main sources of funding and the sole executing sector for R&D activities

. A few sub Saharan countries, Botswana, Sudan and Tunisa Have an active private sector in executing R&D Most African countries invest less than 1% of GDP in R&D, but there are some

notable exceptions such as Tunisia, which have significantly increased its investment during the past 10 years. There is however a clear need to collect and analyze quality R&D statistic especially in Africa, to support evidence-based policy-making the national and regional level.

Although it can't be determined empirically, research expenditure by private sector in Africa has been insignificant because of the predominance of primary production in the GDP of countries in the region, the low value added in manufacturing, the fact that imported plants tend to have a monopoly on innovations and because subsidiaries of multinational corporation in Africa carry out requisite research outside Africa. Hence the private sector involvement in R&D is of paramount importance towards a new shift for self-reliance that helps to cut the continent's dependence on overseas funding.

In addition African governments, on their part, need to consider R&D expenditure tax deduction incentives to encourage participation of the private sector in scientific research and development activities.

3.3.3 R & D Personnel in Africa

Available figures suggest that as many as 30,000 Africans holding Ph.D. degrees are living outside the continent. Students who are able to find employment in the countries leave, while some of those trained abroad do not return. Meanwhile, poor salaries and prospects in universities mean that trained scientists and engineers often move to civil service jobs or to business and commerce.

The foundation of a vigorous R&D programme is to invest in the educational system as well as in science and technology fields, hence contributing significantly to development and economic growth of a country. The following table portrays selected indices of the base of human resources for R&D in the world. As is shown in the figures, Africa lags behind in the evolution of an R&D –intensive economy hence its economic growth. As noted in the table below, Africa has the lowest R&D personnel with 1.1% of world researcher following Latin America and the Caribbean and Oceania with 2.5% and 1.4% respectively. South Africa alone contributes 0.2%

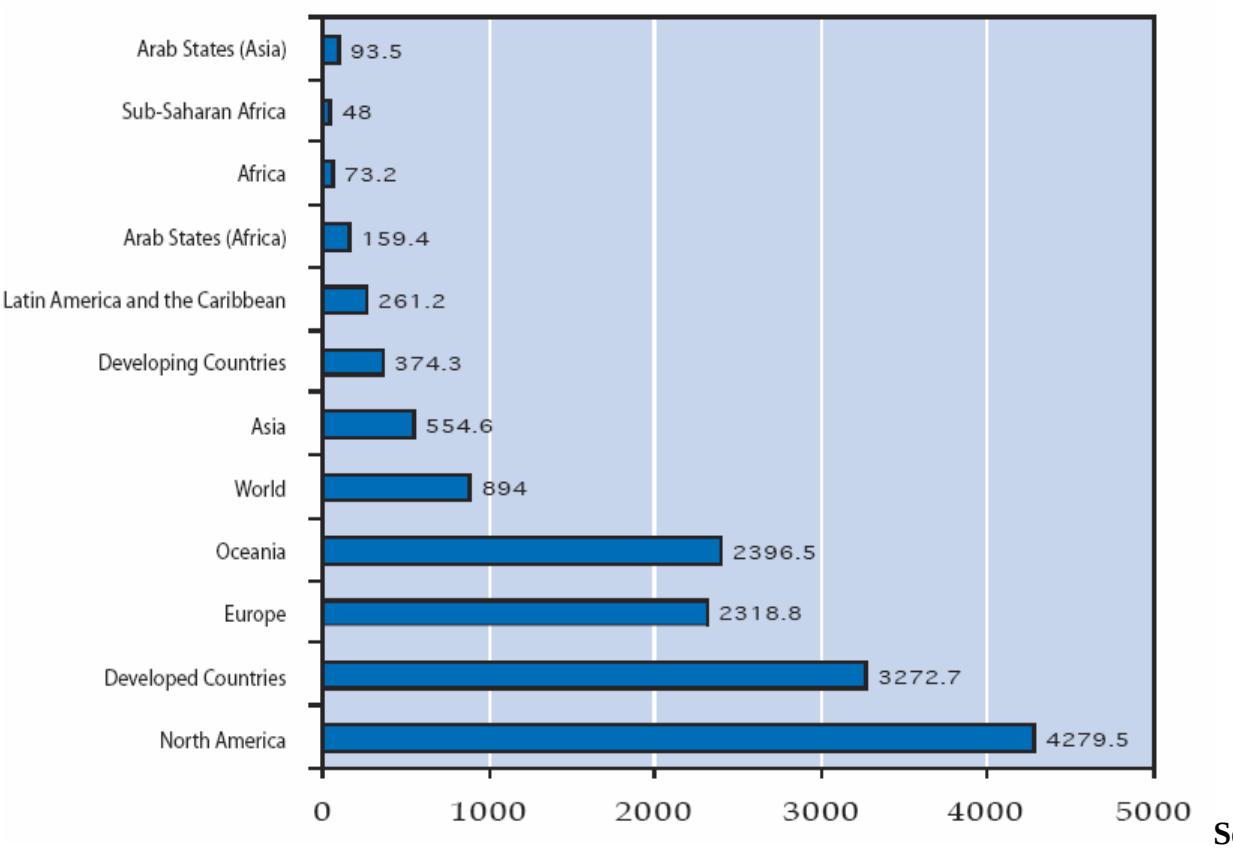
(one-third of Sub-Saharan Africa) of the World's researcher following combined figures of Sub-Saharan Africa with 0.6% and 0.5% respectively.

Table 3c: World Researchers , 2002

Region /category	Researchers (thousands)	% of World researchers	Researchers per million inhabitants	GERD per researcher (US$ thousands)
World	5521.4	100.0	894.0	150.3
Developed countries	3911.1	70.8	3272.7	165.1
Developing countries	1607.2	29.1	374.3	114.3
North America	1368.5	24.8	4279.5	224.5
Latin America and the Caribbean	138.4	2.5	261.2	156.5
Europe	1843.4	33.4	2318.8	122.7
Africa	60.9	1.1	73.2	76.2
Sub-Saharan Africa	30.9	0.6	48.0	113.9
Arab States Africa	30.9	0.5	159.4	40.9
Asia	2034.0	36.8	554.6	128.5
Oceania	76.2	1.4	2396.5	114.4
Selected African countries				
South Africa	8.7	0.2	192.0	357.6

Source: UNESCO Institute for Statistics estimations, December 2004

Table 3.j- Researchers per million inhabitants by principal region/sub-region 2002.

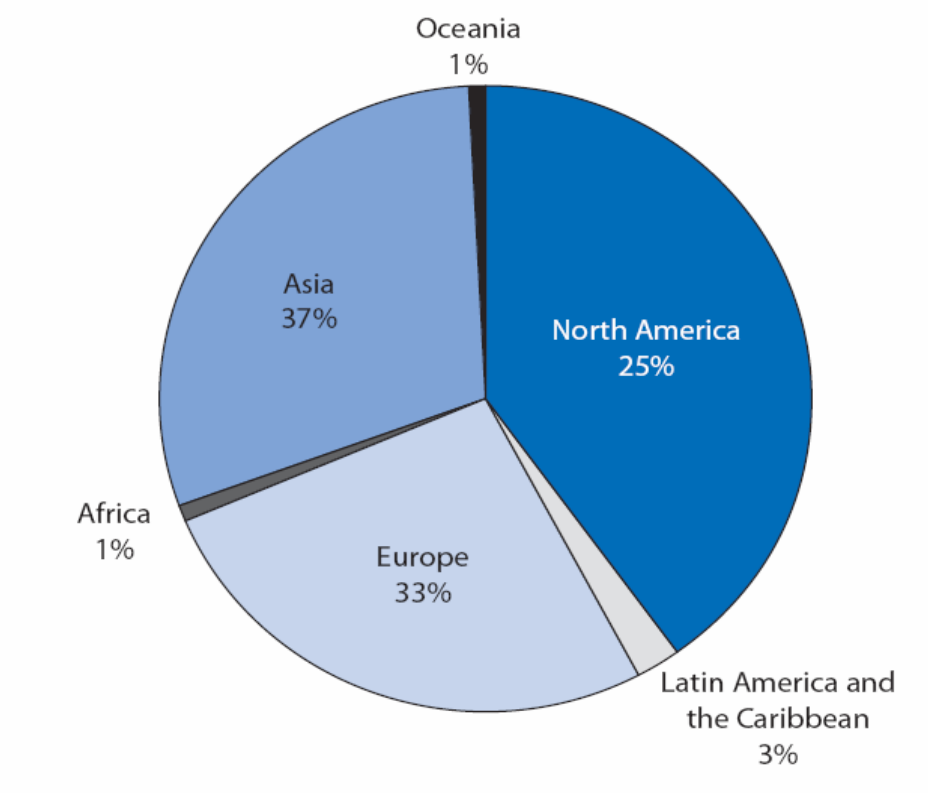


So

Source: UNESCO Institute for Statistics Estimation, December 2004

This low number of researchers per million inhabitants in Africa is positively correlated to the scientific production output recorded in the continent in the last decade as shown in the table below. The world share of scientific output in Africa remains constant at 1.4% in both 1990 and 2000 as compared to other continents for example Latin America and the Caribbean, which have recorded significant growth in scientific output from 1.7% in 1990 to 3.2% in 2000 and Oceania a growth from 2.8% in 1990 to 3.3% in 2000.

Figure 3.k- Share of world researchers by regions, 2002



Source: ECA

A chart illustration of R&D personnel in the continent shows a depressing figure of 1% for Africa comparable only to Oceania region. Asia, Europe and North America represent 95% of world researchers where as the other 5% is represented by Latin America and Caribbean, Oceania and Africa.

Table 3.d R&D Personnel for selected Africa Countries, 2005 or more recent years

Country	Year	Total no of R&D personnel	Researchers	Technicians
Algeria	2005	7,331	5,593	1,134
Botswana	2005	2,140	1,728	412
Burkina Faso	2005	888	247	225
Cameroon	2005	…	462	..
Cape Verde	2002	151	60	15
Congo	2000	217	102	111
Democratic Republic of Congo	2005	33,478	10,411	1,510
Ethiopia	2005	5,112	1,608	779
Gabon	2006	…	150	42
Gambia	2005	84	46	28
Guinea	2000	3,711	2,117	768
Lesotho	2004	51	20	21
Madagascar	2005	1,477	806	119
Mauritius	1997	871	231	145
Morocco	2005	…	24,835	..
Mozambique	2002	2,467	468	1999
Niger	2005	595	101	137
Nigeria	2005	66,574	28,533	10,854
Saint Helena (UK)	2000	33	2	8
Senegal	2005	4,200	2,349	1,751
Seychelles	2005	180	13	53
South Africa	2004	29,696	17,915	5,176
Sudan	2005	23,726	11,208	5,569
Tunisia	2005	16,289	14,650	413
Uganda	2005	1,686	776	472
Zambia	2005	3,285	792	1,240

Source: UNESCO Institute for Statistics estimation, December 2004

Nigeria, South Africa, D R Congo, Sudan and Tunisia including Morocco showed a large number of R&D personnel in Africa. The figure for D R Congo looks exceptional with a publication of 58 million (2004), it has significantly high number of R&D personnel (i.e. 33,478) compared to Nigeria which has registered 66,574 R&D personnel in a population of 139.8 million (2004).

Patent statistics as indicators

Depending on countries and international patent agencies, these statistics may concern the number of patents applied for or reflect the number of patents finally granted. Africa's share of

patents is very low. According to UNESCO Institute for Statistics, sub-Saharan Africa registered 0.2% of the world's patents registered by the European Patent Office (EPO) and 0.1% of the world's patents registered by the United States Patents and Trademarks Office (USPTO) in 1997 **(UNESCO, 2001).**

Often it is claimed that the patent system has contributed to the technology gap between developing and industrialized countries, because it hinders technology transfer and the developing countries therefore remain excluded from new technologies.17 On the other hand it is argued that a lack of IP protection prevents companies from investing in developing countries.18 International organizations such as the World Intellectual Property Organization (WIPO), the European Patent Office (EPO) and the WTO have recognized that the patent system can have negative effects for developing countries and are looking for ways to make the patent system work for them.

3.3.4. R & D Institutional Capacity

R&D institutions in Africa have generally fallen under five broad categories:
(1) Government research institutes, (2) Corporate research institutes in parastatals and other public utilities, (3) Higher education research in universities and colleges of S&T, (4) Private sector research in companies, and (5) International research centres.
There is a fairly reasonable R&D capacity in Sub-Saharan Africa (SSA) though one must hasten to add that the concentrations are inadequate. This capacity exists mainly in public institutions such as universities and government owned research institutes **(see appendix (i)).**
Apart from this capacity held in public institutions, SSA countries have also significantly installed R&D capacity in institutions and facilities owned and funded by international NGOs and other international development agencies. Considerable capacity happens to exist in international agricultural research centers. There is also smaller scale localized research capacity in many countries. Most of these obtain their funding from external sources. The donors include: Australia, Austria, Belgium, Germany, European Union, Japan, Netherlands, Switzerland, United Kingdom and Norway.
Not much R& D capacity in SSA is under private commercial institutions with the notable exception of multinational corporations (MNCs) operating in Africa. These commercial concerns

are mostly in the production of such export commodities as coffee, tea, cocoa, pineapples and minerals, such as copper and minerals.

Table 3.e Specialization of R&D Centres in SSA in 1998 (excluding South Africa)

Field	**%**
Agriculture, Forestry and fisheries	47.00
Health and Nutrition	10.50
Energy, Geology and Mining	5.60
Manufacturing	6.70
Environment	7.40
Basic Sciences	1.60
Social and Human Sciences	12.30
Multi-disciplinary	8.90

Source: African Technology Policy studies 17

3.3.5 Nature of the R& D Capacities

1. Capacity in university and other institutions of higher education

Most public universities and institutions of higher education in SSA have established minimal S&T capacities. However, this capacity tends to be more on the pursuit of research and pure science, mainly for academic reasons. The research is often intended to provide material for publication in academic journals by faculty members and to satisfy degree requirements by the students. Often, such research has little or no bearing to the technology and development needs of the country.

2. R & D capacities supported by foreign agencies and institutions

The little R&D activities that have continued in these public institutions, have been mainly a result of funding from external sources, such as Rockefeller Foundation, the Ford Foundation, Foundation, Japanese International Cooperation Agency (JICA), USAID,

Agencies such as International NGOs (e.g. ICRAF, ICIPE and ILRI), international philanthropic agencies (e.g. Ford Foundation, The Carnegie and Rockefeller Foundation, the Frederick Ebert), foreign aid agencies (e.g. USAID, JICA and FINNIDA, Swedish International Development Agency (SIDA) and Canadian International Development Agency (CIDA)) and UN bodies, support considerable amount of research and development activities in SSA.. International organizations such as United States Agency for International Development (USAID), World Health Organization (WHO), the World Bank, and International Development Research Centre (IDRC) also sponsor a lot of African R&D.

3. Corporate initiatives

Since the beginning of colonialism, many of these corporations have engaged in research and development activities geared mainly to maximize their profit. Such R&D capacities have tended to improve the way they are processed and stored their products, the manner of transportation and handling, and the way they are marketed world-wide.

The MNCs have been involved in these domains over a long time and have developed R&D activities centered mainly on improving the production processes, product quality and the marketing of improved output. Such R&D is therefore commercially oriented and profit driven. Their main objective is to enhance the profitability of these enterprises and not necessarily to address the R&D and development agenda of the countries in which they operate.

Private corporations, for example, undertake and fund considerable research in East Africa on crops such as tea and coffee, but hardly any research on important food crops such as millet, sorghum, cassava and cowpeas.

Most corporations operating in SSA use technologies that are already patented in their mother countries. This is particularly the case in industrial processing, packaging and transportation. Since such technology was developed to suit the conditions in the developed countries, they tend to be inappropriate within the context of the conditions obtaining in SSA societies. When technology is inappropriate in a particular context, it tends to involve higher opportunity costs for the society, leading to resource misallocation.

Many multinational corporations involved in such industrial activities as processing and assembling of products, tend to use capital intensive techniques of production. This distorts resource use patterns, considering the configuration of natural resource endowments in African countries.

4. Public Initiatives

Despite the lack of proper funding and enthusiasm on the part of African governments, public institutions continue to play an important role in maintaining R & D activities in SSA. There have been a number of spectacular achievements coming from these institutions, although the dissemination of the products and processes arising thereof, has been very weak.

5. Some examples of corporate R&D through FDI in Africa

In Africa the R&D component of FDI is overall very small. With a few exceptions such as Kenya, Tunisia, Egypt, Morocco and South Africa, R&D by TNCs is virtually absent. This is partly because of weak domestic R&D capabilities and, in many cases, the lack of institutional mechanisms that provide incentives for investors to devote resources to R&D (Oyelaran-Oyeyinka 2004a). This does not necessarily mean that innovation per se is absent from Africa but rather that such innovation is undertaken outside R&D laboratories.

In the South African auto industry in which all assemblers are wholly or partly owned by their respective parent companies from Japan, Europe or the United States firms spend 2.5% of their total sales on R&D **(UNCTAD 2003b, p. 16).** This is generally carried out in collaboration with the South African Bureau of Standards (SABS) and the engineering faculties of some of the leading universities. Collaboration between SABS and the automotive foreign affiliates has led to the establishment of the Euro Type Test Centre, a state-of-the-art laboratory that has made South Africa one of the world leaders in testing engines and catalytic converters.

In the South African aerospace industry, BAE Systems of the United Kingdom contracted Aerosud South Africa as an exclusive supplier of leading-edge wing components for the Airbus A320 jetliners. In health care, Innovex, a South African affiliate of Quintiles (United States), offers contractual services for clinical testing, health economics, marketing and sales.

North Africa provides some recent examples of FDI in R&D. Morocco has attracted R&D centres, especially in software and electronics, chip design and development and in the Automotive industry: SQLI (France) set up an R&D platform in the country in 2003, Eolane Electronics Manufacturing Services (France) opened an R&D centre in the country in 2004 next

to its manufacturing and distribution unit, and STMicroelectronics has had a chip design Centre in Casablanca since 2000.

The MNCs that have invested in Moroccan R&D through FDI have done so taking into account some basic criteria most MNCs use worldwide. These included a favorable educational and communications infrastructure, the availability of a rich pool of engineering talent, the proximity of Europe and competitive costs. Other North African countries are less targeted for R&D. In Algeria, the Jordanian pharmaceutical firm Hikma opened an R&D centre at its local factory in 2003, while Novell (United States) entered into a strategic alliance with Net-Skills, a local software firm (**Marseille Innovation and ANIMA 2005**).

The rest of the R&D-related FDI in Africa mirrors the resource-based orientation of the continent, focusing on petroleum exploration and exploitation and agriculture. In the petroleum industry, a number of TNCs conducted some R&D in Algeria, Egypt, Morocco, the Libyan Arab Jamahiriya and Tunisia in 2004. In agriculture, the United States-based Agro- Management Group developed pyrethrum flowers in Uganda, for the international market. A large number of MNCs have investments in Mining but no investment in R & D.

Kenya is also home to selected agricultural R&D projects carried out by and for MNCs and their affiliates. Although, Kenya is not a major player in global R&D, in agriculture, which generates a large share of its export earnings, R&D expenditures represented slightly more than 1% of the total for developing countries in 2000. Moreover, the private sector accounted for 3% of total agricultural R&D expenditure in Kenya that same year. There are however several agricultural/ horticultural or related firms, including TNCs, conducting some form of R&D in Kenya.

This part of the review clearly gives a clear indication that FDI and the globalization of R&D has had some impact in Africa. It cleanly shows that where the conditions are right, FDI can play a role in R&D in Africa. It has definitely played a role in the motor industry in South Africa and in the Agricultural industry in Kenya, two instances that have presented the right climate for them. No matter the profit motive but the R&D capacity acquired under such circumstances can only add to the knowledge base of those countries.

The conclusion one can draw from this is that there is room for the development of ICT R&D through FDI especially in the relevant sectors: Telecommunications, Satellite communications and the Internet, provided the conditions are right.

4 Literature Survey of international Best Practice ICT R&D

4.1 Experiences in the US, OECD, Europe and ASIA

4.1.1 Trends in ICT R&D

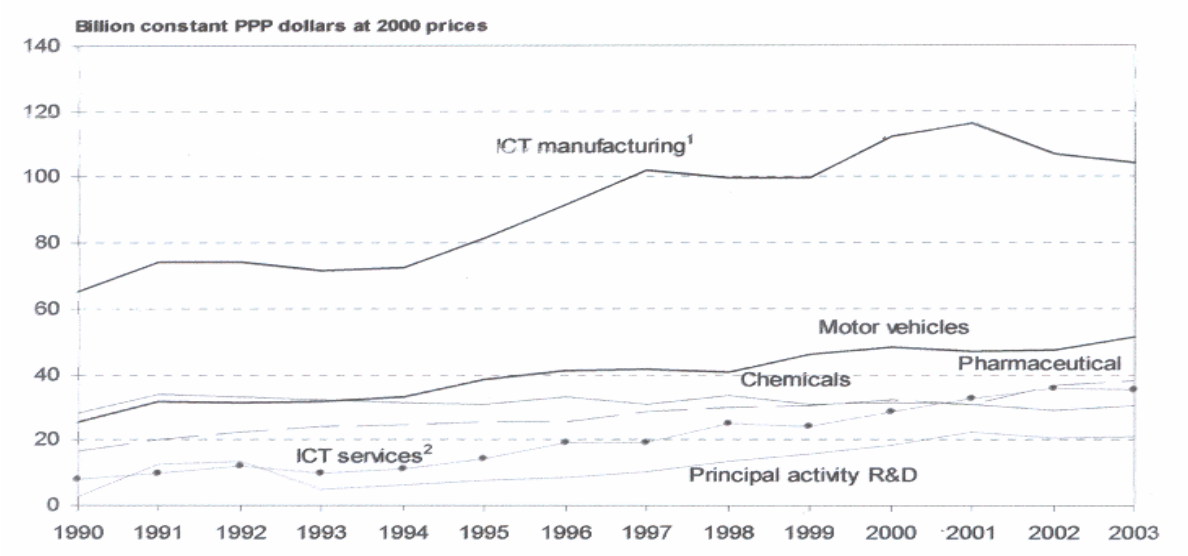
In the last section it was amply demonstrated that 30 OECD countries account for 82% of Global R&D. However, the results of surveys conducted by OECD shows that industrial R&D is becoming increasingly internationalized, and that over the last 10 years, it has become the most dynamic activity of multinational companies.

This section reviews international best practice in ICT R&D mainly in the OECD countries especially those that have done extremely well in utilizing the gains of ICT R&D, the United States, Europe Japan, Canada and South Korea. It also examines in more depth, the concept of internalization of R&D as it applies to ICT and how it has lead to the growth of ICT R&D in other parts of Europe (the expanded Europe), Asia and Latin America.

A number of important lessons emerge from these discussions which are important for nurturing ICT R&D in Africa and the participation of the private sector in the process. The section also examines the work that has been done elsewhere in areas like the scope of private(business/industrial) funding for ICT R&D, the leveraging effect of public sector funding and the creation of the enabling environment, through policies, infrastructural support, capacity building that serves as a catalyst for private sector participation.

In the internationalization of industrial R&D, some sectors have demonstrated greater participation than others. The figure below shows that five sectors play a dominant role in business R&D foremost among them is the manufacturing of Information and Communication Technology (ICT), followed distantly by the automobile industry, pharmaceuticals, chemicals (excluding pharmaceuticals), services to information industries and businesses whose primary activity is R&D. **(OECD, 2008) .**

Figure 4.a Growth of the R&D sectors in the OECD



Source: OECD, ANBERD database, June 2006

In 2003, the 20 public corporations with the largest reported worldwide R&D experiences spent $103.8billion on R&D. Microsoft topped the list with $7.8billion, followed by Ford motor company with $7billion. Companies in the information and communications technologies (ICT) sector dominate this list with nine representatives accounting for 44% of the total R&D expenses which clearly shows the importance of R&D in the development of the ICT sector worldwide**.(Sci. and Eng. ,2006)**

Table 4.a Top 20 R&D spending Corporations 2003

Top 20 R&D-spending corporations: 2003

Company (country)	R&D rank 2003	R&D rank 2002	R&D expense ($ millions) 2003	R&D expense ($ millions) 2002	R&D expense ($ millions) Change (%)	Sales ($ millions) 2003	Sales ($ millions) 2002	R&D intensity (%) 2003	R&D intensity (%) 2002
Microsoft[a] (United States)	1	10	7,779	6,595	17.0	36,835	32,187	21.1	20.5
Ford Motor (United States)	2	1	7,500	7,700	–2.6	164,196	162,586	4.6	4.7
Pfizer (United States)	3	6	7,131	5,176	37.8	45,188	32,373	15.8	16.0
DaimlerChrysler (Germany)	4	2	6,689	7,289	–8.2	163,811	179,595	4.1	4.1
Toyota Motor (Japan)	5	5	6,210	6,113	1.6	157,411	146,121	3.9	4.2
Siemens (Germany)	6	3	6,084	6,987	–12.9	89,127	100,873	6.8	6.9
General Motors (United States)	7	4	5,700	5,800	–1.7	183,244	184,214	3.1	3.1
Matsushita Electric Industrial (Japan)	8	9	5,272	5,015	5.1	68,078	67,368	7.7	7.4
International Business Machines (United States)	9	7	5,068	4,750	6.7	89,131	81,186	5.7	5.9
GlaxoSmithKline (United Kingdom)	10	8	4,910	5,101	–3.8	37,717	37,314	13.0	13.7
Johnson & Johnson (United States)	11	12	4,684	3,957	18.4	41,862	36,298	11.2	10.9
Sony (Japan)	12	14	4,683	4,033	16.1	68,230	68,023	6.9	5.9
Nokia (Finland)	13	22	4,514	3,664	23.2	35,365	36,038	12.8	10.2
Intel (United States)	14	11	4,360	4,034	8.1	30,141	26,764	14.5	15.1
Volkswagen (Germany)	15	25	4,233	3,471	22.0	104,639	104,393	4.0	3.3
Honda Motor (Japan)	16	15	4,086	3,976	2.8	74,293	72,554	5.5	5.5
Motorola (United States)	17	13	3,771	3,754	0.5	27,058	26,679	13.9	14.1
Novartis (Switzerland)	18	24	3,756	3,362	11.7	24,864	25,111	15.1	13.4
Roche Holding (Switzerland)	19	27	3,694	3,298	12.0	24,188	23,030	15.3	14.3
Hewlett-Packard (United States)	20	19	3,652	3,312	10.3	73,061	56,588	5.0	5.9

[a]Fiscal year ended June 2004.

SOURCE: Institute of Electronics and Electronics Engineers (IEEE), IEEE Spectrum Top 100 R&D Spenders, Standard & Poor's data (2004), http://www.spectrum.ieee.org/WEBONLY/publicfeature/nov04/1104rdt1.pdf.

Science and Engineering Indicators 2006

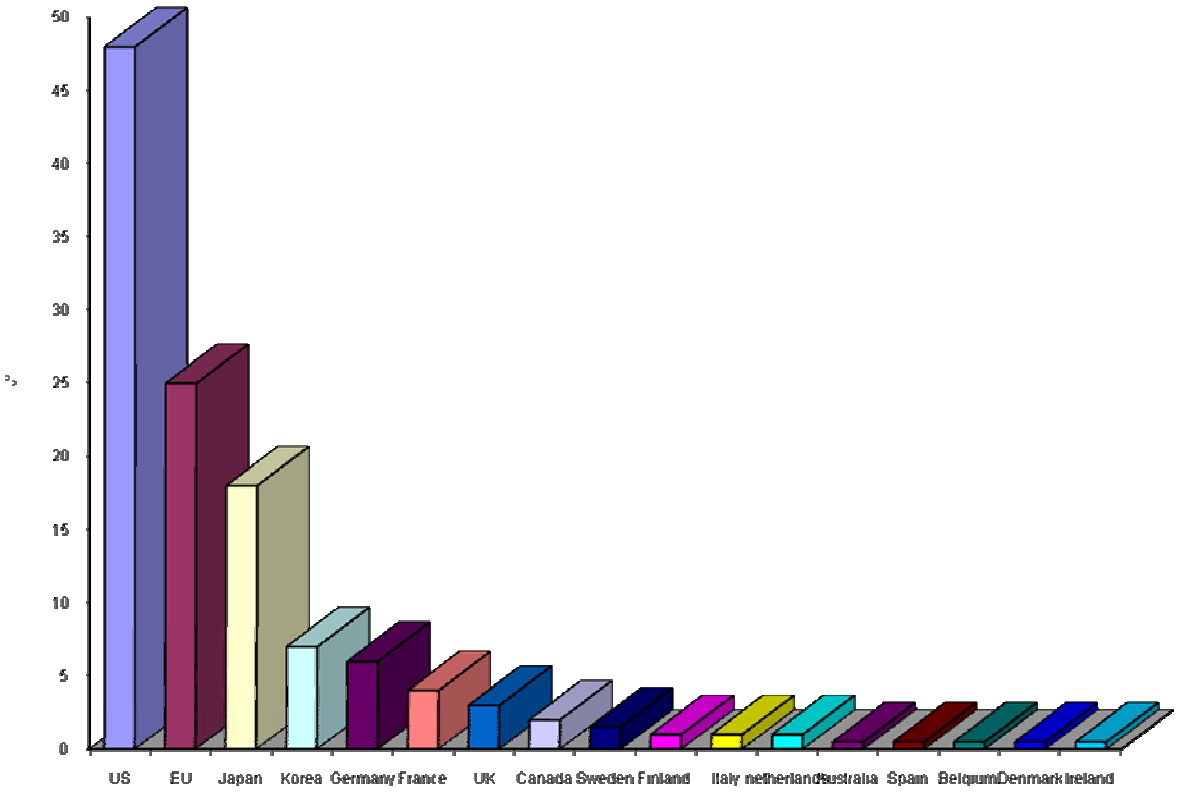
4.1.2 International investment in ICT R&D in the OECD Countries

Most of the new member states had relatively low R&D intensities in 2003, but were catching up rapidly with the rest of the EU countries. Also 2003, the R&D intensity in the EU amounted to 1.93%, well below the US (2.59%) and Japanese (3.15%) intensities, but above China (1.31%).

The chart below shows the percentage share of each of the 17 OECD countries of expenditure for ICT R & D for the year 2006. Clearly the United States has a nearly 50% share of the expenditures, followed closely by the EU. The expenditure shares of Japan nearly 18% and South Korea, over 8% which are outside Europe, are clearly significant compared to the rest of the European group.

Since 2003, the United States accounted for virtually half of the OECD areas aggregate R&D investment in the ICT industries. The EU -15 or EU-25(reflecting the expansion of the EU) nations invested a little over a quarter, whereas Japan's investments accounted for roughly 18% of the OECD**. (OECD,2008)**

Figure 4.c Share of the main OECD countries in Total R&D expenditures of the ICT Sector in OECD areas



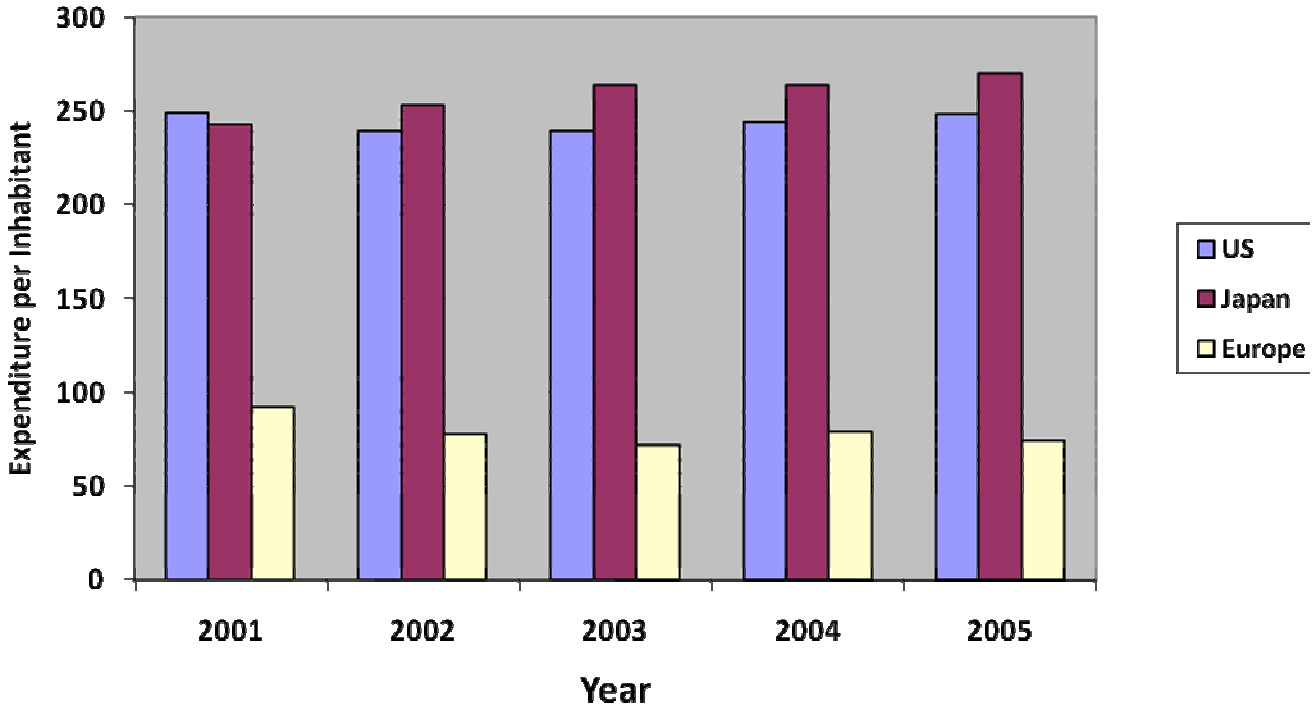
Source: OECD, ANBERD Database 2006

4.1.3 R & D Intensity in the OECD

Comparing the Research and Development intensity (measured as R & D expenditure per inhabitant), countries with the highest figures within the OECD, the United States, Japan and the Europe, there is evidence to show that the US and Japan are more R & D intensive.

Specifically, Europe is three times less "ICT R&D intensive" than Japan and the USA as illustrated in the graph below.

Figure 4.d- ICT R&D Expenditure per Inhabitants in USA, Europe and Japan



Source: OECD, ANBERD Database 2006

Moreover, while the R&D intensity rose in the United States and in Japan, between 2001 and 2005, in Europe it dropped. the EU, Japan and the US between 1997 and 2003.

The R&D intensity gap between Europe and its main competitors is almost entirely due to differences in the share of the contributions from the business sector to financing R&D. In 2002, the business sector financed 55.6% of domestic R&D expenditure in the EU, compared to 63.1% in the US and 73.7% in Japan. Within the EU itself the picture is mixed. Most of the new member states had relatively low R&D intensities in 2003, but were catching up rapidly with the rest of the EU countries. Also 2003, the R&D intensity in the EU amounted to 1.93%, well below the US (2.59%) and Japanese (3.15% intensities, but above China (1.31%). On the other hand, Finland spends 12.7 times what Italy spends for ICT R&D. The larger economies in Europe (Germany, United Kingdom and France) show average values, but are performing better than the rest of Europe**. (CSTI, 2006)**

Outside Europe, since 2002 when ICT sector R&D spending in Canada was $5.3 billion, ICT R&D spending has been on a constant rise, toping just over $6.0 billion in 2007, which represents an increase of 2.5% from the year before. Since 2002, ICT R&D spending has grown at an average rate of 2.8% per year, compared to around 3.1% for total Canadian private sector R&D. ICT sector R&D as a share of total Canadian private sector R&D spending has remained fairly constant, accounting for 38.3% of 2007 total. Nonetheless, the sector remains the largest private R&D performer in Canada. **(Stats, Canada, 2008)**

Table 4.b ICT sector intramural R&D expenditure 2002-2007

ICT Sector Intramural R&D Expenditures, 2002-2007
(Manufacturing and Services)

NAICS 2002	Industry ($'000,000)	2002	2003	2004	2005[p]	2006[p]	2007[i]
	Total ICT Manufacturing	3,439	3,041	2,893	2,877	2,870	2,946
	Total ICT Services	1,693	2,218	2,478	2,585	2,848	2,913
	ICT Wholesaling (NAICS 4173/41791)	144	169	184	173	178	183
	Total ICT Sector	5,268	5,427	5,555	5,635	5,896	6,041
	TOTAL CANADIAN PRIVATE SECTOR R&D	13,541	14,039	14,947	14,928	15,360	15,773
	ICT R&D as a PERCENTAGE of CANADIAN PRIVATE SECTOR R&D	38.9%	38.7%	36.3%	37.7%	38.4%	38.3%

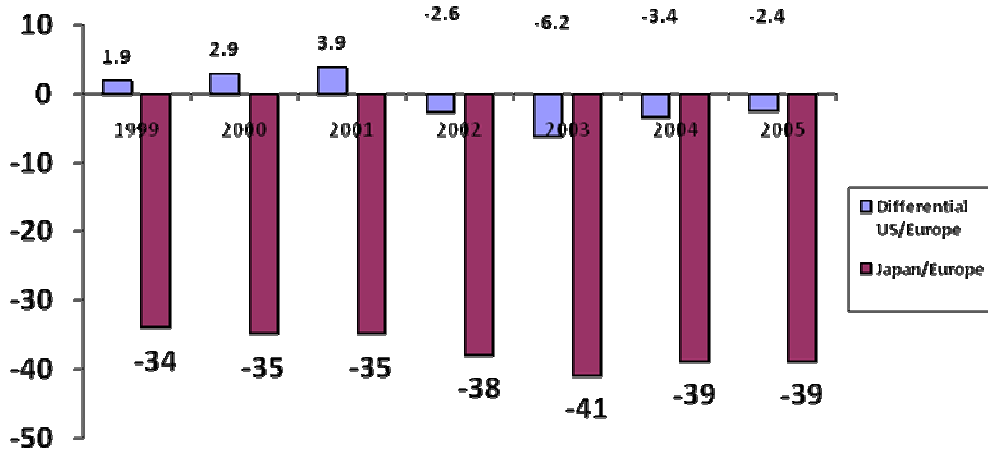
In the figure above, Canada's relative share of all ICT R&D investment compared to other OECD countries seems small, 4.5% in 2000 and 3.7% in 2006. Based on absolute figures, it should be pointed out that Canada's relative share exceeds the shares of Sweden and Finland in Europe also exceeds that of Canadian economy in the Global GDP (2.4%).

The same remarks apply if ICT R&D investment is expressed as fraction of GDP. The ICT R&D investment to GDP ratio differs greatly from one country to another, particularly within Europe; Whereas the average European ratio is low (0.27%), Finland (1.55%) and Sweden (1.09%) rank among the 3 countries which have a ratio higher than 1.0% above the value noted. In this case again, the picture for Europe is mixed.

The gap between Europe and the USA is greater for ICT R&D investments than for R&D as a whole. The intensity differential (measured in expenditure per inhabitant) is 1 to 2 in favour of the united states for R&D as a whole, where as it is 1.33 for ICT R&D. This is also true for Europe and Japan.

As illustrated in the chart below, the ICT R & D investment intensity differences between the US and Europe and Japan have also been changing over time, in this specific case from 1999-2005. The figure shows that the differential between the US and Europe increased from 1999 to 2003 from -34 to -41 and decreased slightly in 2004 and 2005. The differential between Japan and Europe show in absolute terms a positive in favour of Europe from 1999 to 2001 and a slight negative from 2002 to 2005. It has already been stated that Japan is a high R&D intensive country.**(CSTI,2006)**

Figure 4.e ICT R&D Investment differential in ($bn ppp)

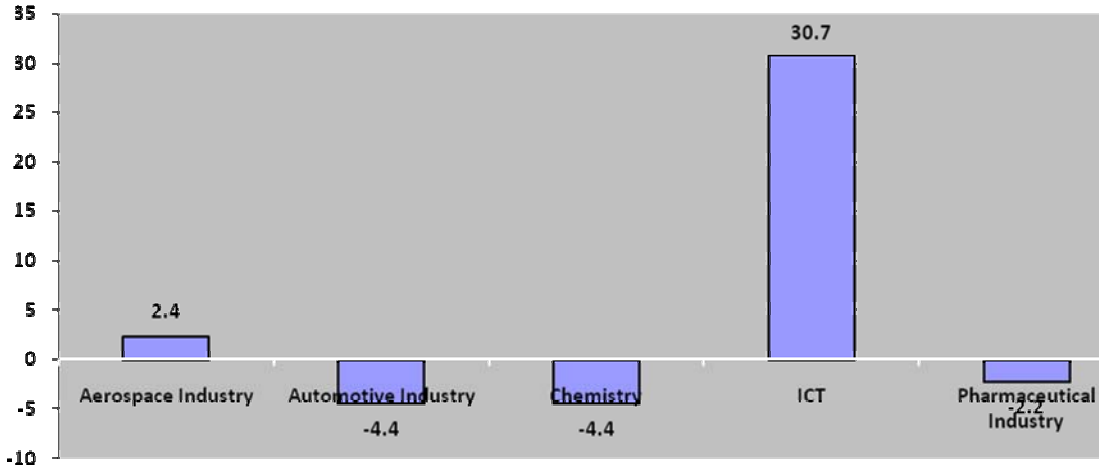


Source: OECD, 2006

The huge differential in investments between the US and Europe which is attributable to the low level of European private sector investments is even more pronounced in the ICT sector.

ICT is the only sector in which such a huge differential in the volumes of R&D investments can be observed between Europe and the USA. In no other industrial sector is there such a huge negative difference observed, despite the fact that ICT technologies have a direct impact on performance in all other sectors. In the figure below, a positive corporate investment differential of 30.7 in ICTs between the US and Europe followed by a distant figure of 2.4 in the Aerospace industry is indeed a strong indicator of US supremacy in ICT investment. **(CTSI, 2003)**

Figure 4.f Corporate R&D investment differential US/EU (in $ bn PPP, data 2002



Source: OECD 2006

Evidence in the literature indicates that insufficient investment in ICT R&D by European companies as a whole is the main factor behind these differences. The private sector in the United States' expenditure amounting to 82% as against 18% for government spending, and with Japan giving even much lower subsidies than the US. Although the structure of investment in ICT R&D in the United States closely resembles that of Europe, European businesses invest two times less in ICT R&D than those in the United States and three times less than Japanese businesses. **(CSTI, 2006)**

Furthermore, the table below compares the human resource availability in 2003 between the EU, Japan and USA. The findings also clearly show that the overall researcher's deficit in the EU is

mainly due to the shortfall seen in the business sector, which nevertheless accounts for the bulk of R&D performed.

Table.4. c. Comparative view of Degrees Awarded.

Country	No. of Researchers per 100 labor force	% age of Researchers employed by the Business sector	% age of degrees awarded in S&T fields
EU	5.4	49%	24.2
Japan	10.1	67.9%	18.5
USA	9	80.5%	23.1

Source: International Comparison of Human resources in Science and Technology

In addition, the ageing of the highly-qualified S&T labor force is becoming a concern in many EU member states. In 2003, 34.7% of highly qualified S&T employees in the EU were in the 45-64 year old age group, compared to 30.8% in the 25-34 age groups. Therefore, it remains crucial to ensure a sufficient replacement rate of the S&T workforce, and to further expand it. However, the EU is producing more S&T graduates than the US and Japan.

On the other hand the public funds for ICT R&D allocated to U.S. companies are four times larger than in Europe. This is due to the importance the U.S. attaches to defense related contracts of which a large part goes to ICT R&D

4.14 Public Sector funding for the Private Sector ICT R&D

The government's policies for ICT R&D funding can be analyzed taking in account the amount of these funding which support private ICT R&D activities. The United States is the front runner both in terms of absolute value (way ahead of all other countries taken together) and in terms of progression of this parameter. But Korea, Finland, Spain and the United Kingdom also show important increases in the 1999-2005 periods in ICT R&D funding performed in the private sector. All the other countries, including France, where the business sector investments in ICT

R&D have stagnated or fallen, a significant increase in public funding for ICT R&D has not counterbalanced this loss as public funding has benefited mostly State research institutions.

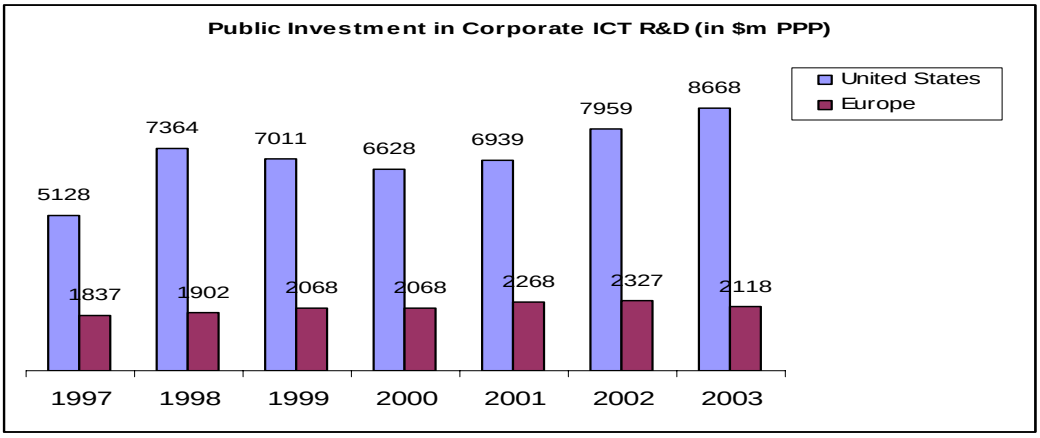
Government financing of R&D remains important as substantiated by the fact that the highest levels of business R&D funding go hand in hand in most cases with high level of government funding R&D intensity, as seen in Sweden, Finland, Germany and the US. In low R&D intensive countries such as the new EU member state, government funded R&D in relation to GDP remains higher than the intensity of business funded R&D. However, direct government funding of business R&D declined significantly in Europe.

The public funds allocated to ICT R&D increased by an average 58% between 1999 and 2005 in the twelve countries studied, but by only 27% in the European Union. In some countries (including France, the United States, the United Kingdom and Europe as a whole) there was a distinct discrepancy between the relative good health of State-funded R&D and the paucity of private investment, as shown right.

This however is specific only to the U.S. The high ICT R&D spending in Japan is done mainly by the private sector. **(OECD, 2008)**

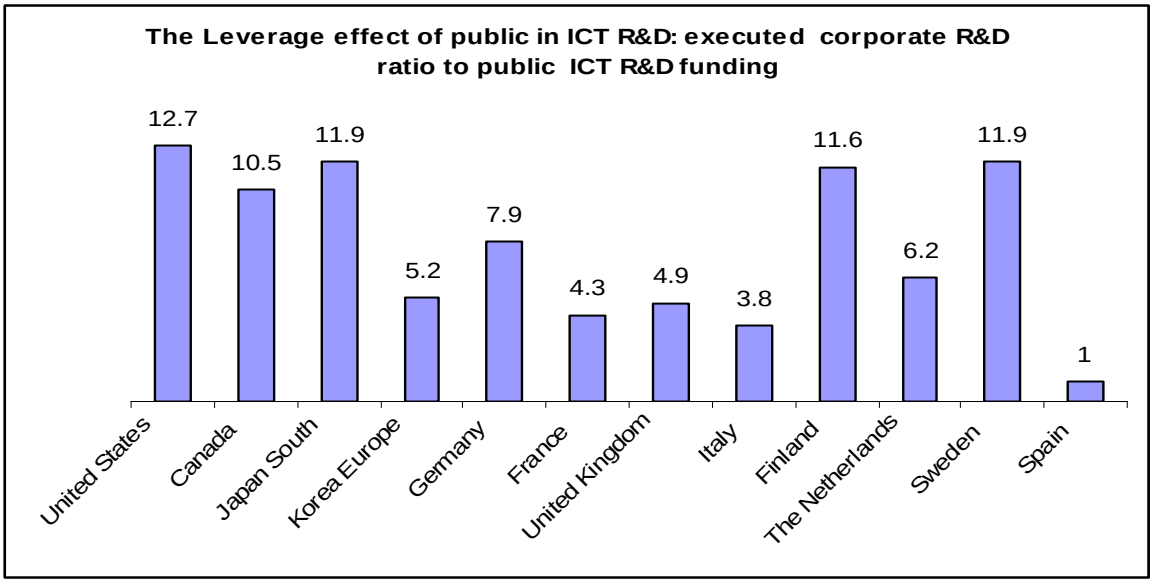
What is obvious however is that public investment in ICT R&D acts as a leverage to stimulate R&D investments from the private sector, although the effect may vary from country to country? In Europe the leverage effect of public ICT R&D funding on private funding is relatively small, except in Finland and Sweden.

Figure 4.g Public investment in Corporate ICT R&D (in $m PPP)



Source: OECD, 2006

Figure 4.h- the leverage effect of public in ICT R&D: executed corporate R&D ratio to public ICT R&D funding



Source: OECD, 2006

The figures above gives an indication of how much leverage effect public ICT R & D investment in OECD countries, is having on corporate R & D. Major European players like (France and Germany) relative shares are steady. Other countries such as the United Kingdom with an

increase of 42% over 7 years, South Korea (+98%) Spain (65%), Finland (+47%), score far more than the average increase of the 12 countries.

The leverage effect of Canada of 10.5 is relatively high compared to most European countries as shown in the chart above but slightly less than in the US and Japan. This has resulted in increased investment by the private sector in ICT R&D and the table below also shows the high percentage of private sector share of ICT R& D funding.

Table 4.d Canada: trend of the ICT R&D budget structure in Canada

	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
ICT R&D financed by business	95.0%	94.9 %	94.3 %	93.6 %	93.5 %	93.2%	93.5 %
ICT R&D financed by public funds	5.0%	5.1%	5.7%	6.4%	6.5%	6.8%	6.5%

However, the oversized nature of private funding for ICT R&D can be explained by a bold research tax credit policy as well as the leverage effect of government funding that puts the country in the lead of developed countries for its appeal to non Canadian business investment in R&D**. (CSTI, 2007)**

Consequently the country has become an R&D platform in North America for numerous non-Canadian (mainly US) companies, foreign funds account for about 18% of the Canadian (gross domestic expenditure on R&D GERD), inclusive of all sectors.

South Korea's relative share of Global ICT R&D investment led the highest growth 1999 to 2005. South Korea's relative share of global ICT R&D investment rose from 5.5% to 8.8% is more than 3 point increase, a considerable rise of relative share. The increase chiefly mirrors business's ICT R&D effort. South Korea's business relative share of the total envelope of private funding for ICT R&D within the OECD countries climbed from 5.7% to 9.5% which gives South Korea the highest rise.

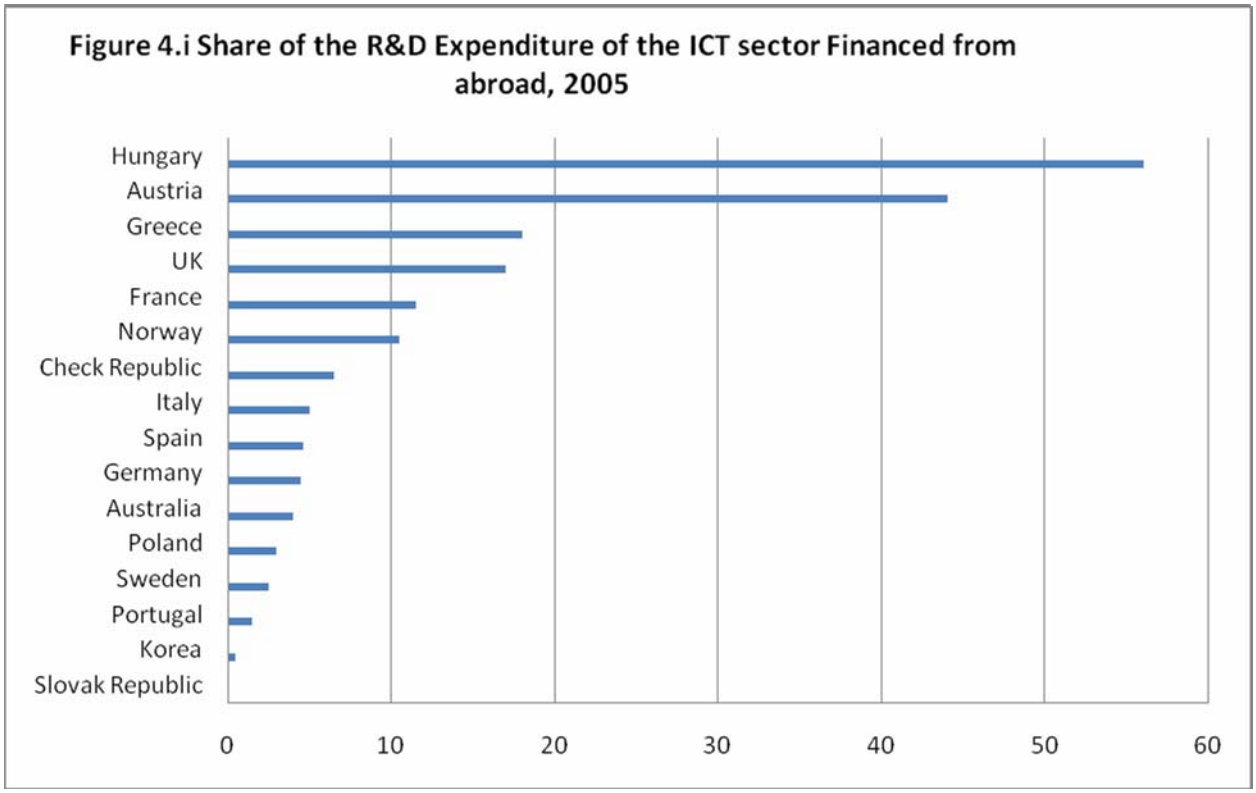
As in the Canadian case, South Koreas relative share of ICT R&D investment greatly exceeds its relative share of economic weight (20% of Global GDP, but 8.8% of Global ICT R&D).

4.1.5 NEW TRENDS IN ICT R&D

As has been observed in the globalization of R & D investments from major industrialized countries, investments have been shifting across continents and hither to unknown destinations have now become R & D investment centres. Between 1999 and 2005, the United States share of world investment in ICT R&D decreased by over 5 points. The reason may be due to what is referred to as" delocalization" of R&D activities or internalization as it is more appropriately called. Between 1997-2002, R&D expenditure by EU companies in the US increased in real terms much faster than R&D expenditure by US firms in the EU (+54% against +38%). Furthermore, US outward R&D investment grew over recent years in all major regions of the globe, but growth has been fastest outside the EU-15, particularly in emerging countries such as China and India. Europe benefits less from the increased globalization of R&D than its main competitors. As a result, a project such as INCITE (Indian Networks Co-operation in Information Society Technology with Europe) has been formed to facilitate R&D cooperation between India and Europe in the ICT sector**. (OECD, 2008)**

Countries such as Korea, Finland and Sweden within the OECD and India and China in the non OECD categories have pursued deliberate policies aimed at making them specialize in ICT R&D. In these countries both public and the private sectors increased their investments in ICT R&D. Over the period (1999-2005), South Korea has become the third, if measured by its contribution to Global R&D effort, just behind U.S. and Spain.

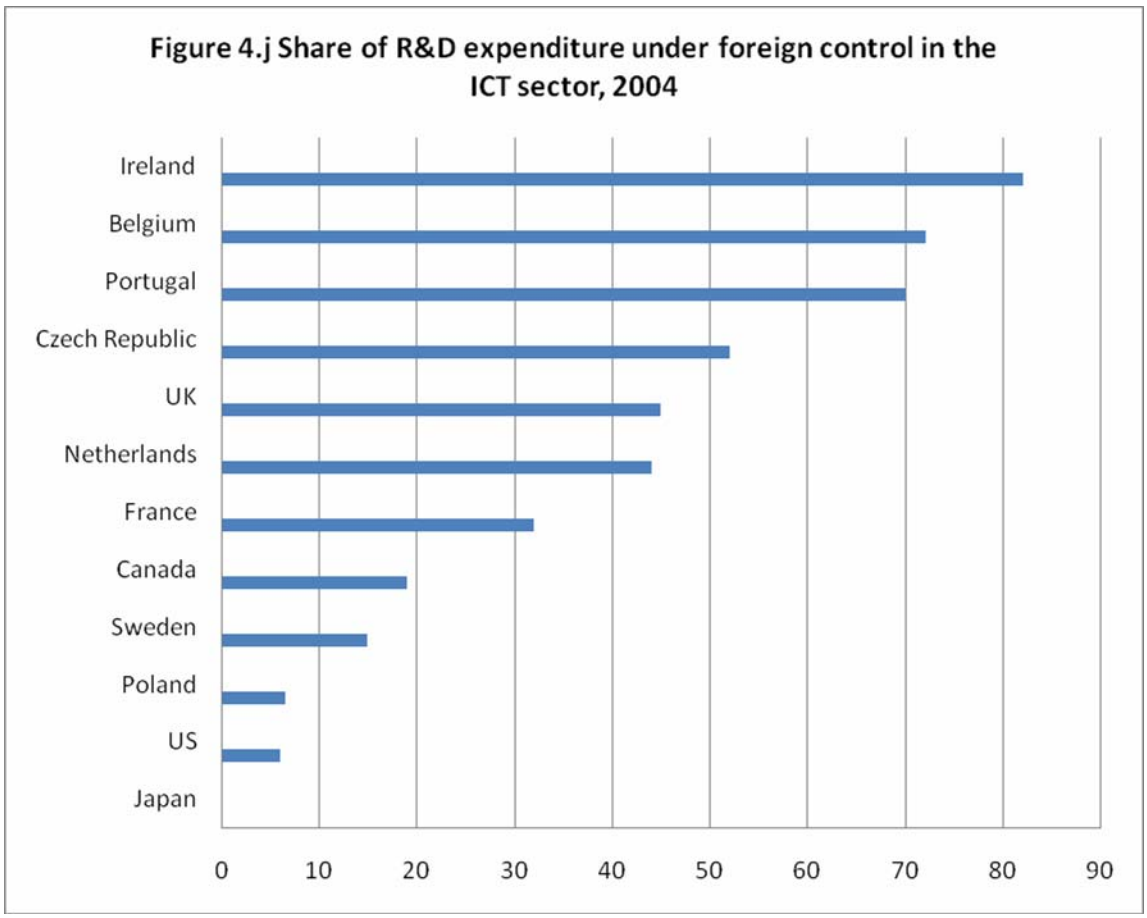
Germany, United Kingdom, Japan have tended to respond to the lag they have suffered over the same period but only by increasing public investment. In the OECD, there are two indicators that reflect the international nature of R&D; the ICT R&D from abroad and the share of R & D under foreign control. The figures below give an indication of the movement of ICT R&D within the OECD in the two categories described above.



Source: **OECD, R&D database, May 2007**

The UK and France are among the large European Countries in which foreign controlled R&D is greater than 30%. (**OECD, 2008).**

In small countries, the proportion of aggregate R&D in these sectors that is foreign controlled exceeds 70%. This is the case for Ireland, Hungary and Belgium, where in the case of Ireland a majority of R&D is controlled by the US affiliates and in Belgium the R&D of foreign – controlled affiliates, are of European origin.



Source: **OECD, AFA database, May 2007.**

A drop in the business ICT R&D in the lager economies can only be explained by the trend of internationalization of ICT R&D occurring within and outside the OECD. Both European and American relative share of global ICT R&D investment has dropped.

4.2 Policy and the Enabling Environment in the OECD

As we come to the end of this section, it may be useful to examine in some detail the specific policy scenario of the OECD countries that are both within and outside **Europe on** ICT R&D that have lead to the significant results described above. Canada and South Korea fit bill for countries outside Europe. But first let's examine the European experience.

4.2.1 The EU Policy Experience

The two main objectives in driving the EU ICT R&D guideline are as follows:

- Supporting the International competitiveness of European industry so that the demands from ICT by its citizens, businesses, industry and governments and economy are all met.
- Facilitating Europe to be at the forefront of ICT future developments, so that its big ICT firms like Alcatel, Siemens, Nokia and Ericson are spearheading new technology advances. Europe needs to maintain its leadership in the sector and the ICT R&D guideline is driven with these in mind.

As Europe has also been expanding its territory, it is believed these activities will also help reduce the digital divide and social exclusion of the new joining nations.

Between the 70s and 2000 the EU GDP per capita has remained at only 70% of GDP per capita to the US, i.e. roughly the same relative level at 30 years ago.

From a growth accounting perspective, this is seen as a serious threat for the international competitiveness of business activities in Europe. The key answer to the above threat lies with Europe's ability to leverage science, technology and innovation to create higher productivity and economic growth with more and better jobs.

The EU had developed policies of macro-economic stability and convergence which delivered significant results over recent years. However, the macro-economic stability alone was not sufficient for sustainable and long-term economic growth.

It is widely accepted that productivity gains, sustained economic growth and employment are largely driven by technological progress, innovation and human capital development. These key elements are in turn largely dependent on investments in knowledge (e.g. investments in education and R&D) and their outcomes. As a result:

- The 2000 Lisbon Strategy to make Europe a competitive knowledge-based economy by 2010 was formulated.
- The Barcelona objectives agreed upon in 2002 to increase R&D investment in the EU to approach 3% of GDP was also developed.

- The European Commission also put forward an action plan themed "Investing in Research" adopted in April 2003, which promotes increasing both R&D investment and reviewed the efficiency with which new ideas are turned into new products processes, services, and solutions, as well as creating an environment which makes it more attractive for firms to increase investment in R&D.
- These objectives and orientations were confirmed and strengthened in the review of the Lisbon strategy undertaken on March 22 and 23, 2005.

One of the key elements in the European Integrated approach to ICT R&D among a number of others is referred to as 'Knowledge and Innovation for Growth'. In pursuing this concept some targets were set to ensure that the overall objective of the EU was achieved:

1) Increase and improve investment in Research and Development
2) Facilitate innovation, the uptake of ICTs and sustainable use of resources, and
3) Contribute to a strong European industrial base.

Funded by the European Commission, the IPR-Helpdesk (http://www.jpr-helpdesk.org) has been setup to assist potential and current contractors taking part in Community funded research and technological development projects on intellectual property rights (IPR) issues. The IPR-Helpdesk also advises on Community diffusion and protection rules and other issues relating to IPR in international research projects. Another more global objective of the action is to raise the European research community's awareness of IPR issues, by emphasizing their European dimension.

Finally, the EU sees ICT as the key answer to create higher productivity and economic growth while creating more and better jobs by leveraging science, technology and innovation. Lessons learnt include:

- By consistently setting and monitoring key performance indicator (KPIs) for every element of ICT use and ICT R&D, Ethiopia can shape the way ICT is utilized in the country and the impacts it is bring to the nation both in terms of growth in the economy as well as achieving the MDGs.

- The value of utilizing tools like IPR-Helpdesk to inform the public on how to apply and follow up on new IPRs, as well as disseminating new findings with regards to IPRs as well as ICT R&D projects.
- Developing and nurturing the private sector to participate in ICT R&D through funding, tax incentives.
- Partnering with international governmental and/or non governmental agencies as well as helping the private sector to form partnership with international players to participate in increased globalization of the R&D market.

A study conducted under the EU programme with the main objective to sketch the European ICT R&D landscape by identifying national R&D policies, priorities, and programmes or other support mechanisms in the field of ICTs. **(Uotila,2006).**

The Study indicates that there seems to be a strong consensus across the studied countries of the importance of ICT as a R&D policy priority. Furthermore, the analysis on national policy priorities has helped to identify the following ICT sub-themes that could provide fertile ground for cooperation: telecommunications, micro- and nanotechnology, software technologies, optoelectronics, eGovernment, eHealth, eBusiness and eCommerce, e-Education and eLearning, as well as Security and Safety.

There is, however, major variation in how the importance of ICT is operationalized in different countries. In addition, the way in which each country uses their palette of different tools to support R&D is inextricably linked with national realities and the needs identified in the countries' industrial base. There are also countries where R&D policy is more likely to raise different ambitions across the political arena. In such countries, changes in party political fortunes can thus often entail radical swings in the official focus of R&D policy. Alternatively, in those countries where a strategic view of national R&D policy is to a large extent shared, irrespective of political party, this may be seen to better facilitate the long- term development of R&D policy.

The study also indicates that the landscape is very variable in terms of national programmes.

Firstly, no one universal definition exists for what is perceived as a ‘programme’. Secondly, national approaches vary according to whether programme-like instruments are characteristically directed at funding basic research or applied/industry- driven research. Thirdly, ICT seems to have a multitude of definitions in national contexts. This heterogeneity makes it difficult to compare the different programmes, while also hindering collaboration between national ICT programmes.

In principle, the national programmes entail a fairly similar set of general procedures. The depth of implementation however often varies to a significant degree.

In the EU there are ‘Eureka-type’ programmes, where the level of collaboration, the number of countries involved does not seem to be critical to the success of the programme, as the level of complexity and funding matters remain at the project level rather than gravitating towards the programme level and the harmonization is only in the timing of national decision-making.

On the other hand, in joint programmes, there is normally a stronger commitment from participating countries, as common rules of procedure are agreed and ear-marked budgets are defined between the funding agencies before the programme is launched.

In addition to programmes, there are other national support mechanisms identified in this study: enabling networking, equipment and the establishment of new infrastructures, general research and development funding, incubation services, venture capital and other schemes. In addition to programme level cooperation, these support schemes can also provide opportunities for cooperation in the future.

Based on the findings of this study it is evident that common European ICT R&D policy priorities do exist. This creates a solid basis for future cooperation activities, and current CISTRANA activities are already striding out in this direction. (**Uotila,2006).**

4.2.2 Canadian Experience

Canada is one of the most advanced nations in ICT. The Canadian government through its Ministry of Industry articulated a strategy to make Canada the most connected country in the world.

The strategic vision of making Canada the most connected country in the world was implemented in 1993 and this vision permeated the planning and implementation of all areas of development.

The key to the success of the implementation has been the firm commitment by the Canadian government. Through this commitment, the government has created institutions that will carry out the strategic objectives and detailed initiatives. These organs such as The Ministry of Industry, Canada S&T, Advanced Council on Science and Technology, Council of Science and Technology Advisors, Federal Partners in Technology Transfer, Industrial technologies Office, Technology Partnerships Technology Transfer, Industrial Technologies Office. Technology Partnerships Canada oversees several aspects of high technology R&D, of which ICT has a major role.

Furthermore, the Canadian government has been using technology to link researchers and provide them with the R&D information as well as funding availability.

The federal government also works with the provincial governments very closely to encourage the promotion of ICT R&D by providing them with funding and expertise.

The government created the enabling environment by building the necessary infrastructure while at the same time providing private industry with tax breaks and R&D incentives. Funding was also made available for the academia to promote R&D research. The goal of providing the highest quality, lowest cost information network in the world to give Canadian economy the most competitive were the driving forces behind what was subsequently achieved in making Canada among the leaders in ICT and ICT R&D**. (Ernest and Young, 2005).**

The Communication Research Center, which is an arm of the Canadian Science & Technology program, was made as the coordinator for ICT R&D. It was given the following strategic initiatives:

1. Facilitate international S&T partnerships for the ICT sector;
2. Promote Canadian ICT knowledge and expertise globally in partnership with the private sector, academia and other government departments;
3. Improve overall competitiveness of the Canadian ICT sector;
4. Strengthen the ICT infrastructure across Canada;
5. Assist new investments by collaborating with bodies responsible for trade and investment;
6. Provide an opportunity to subscribe to the Canadian ICT R&D database where information on workshops, conferences and events will be available. Current ICT R&D proposals from organizations seeking international partnerships will also be published.

The firm commitment of the government of Canada to ICT R&D has been demonstrated in the various programs that it has put in place to support innovation in the ICT sector. Canadian ICT Companies contributed 5.6% of GDP in 2005 which amounts to CDN $60.7 billion while in the same year investing CDN $5.7 billion in ICT R&D. The ICT sector takes the lion's share and R&D performed in Canada**. (Ernest and Young, 2005).**

The result of this elaborate policy framework and financial commitment was sustained ICT growth led by a robust ICT R&D. In a survey conducted from May to November 2006 on the ICT sector Intramural R&D expenditure by (Statistics Canada.), the data recorded showed an impressive commitment on the part of the Canadian government.

The case of Canada clearly demonstrates what is possible when a government sets clear strategic objectives and is fully committed to implement these objectives with a full cooperation of the private sector.

4.2.3 South Korean Experience

The Republic of Korea, or as commonly known South Korea, has been the development miracle of the last couple of decades since the advent of ICTs into Asia. Today, South Korea has become dominant exporter of high tech products. In 2007, the ICT sector is expected to accounts for 17% of South Korea's GDP. Technology R&D has been the engine of the nation's rapid growth. South Korea took the high tech electronics R&D route to ICT advancement and has now become a global powerhouse in ICT R&D. According to the US Patent and Trademark office some 27,000 patents were issued in twenty-five years between 1976 and 2002, a high income country for the same period**. (Ernest and Young, 2007).**

These achievements have been made possible by the strategic leadership provided by the South Korean Government. In the 1980s the strategy was centered on "measures to nature the IT industry". In the 1990s the strategic direction was funded within the process of "National Basic Information System" with five fundamental pillars: administration, national defence, public safety, finance, education and research. From the 90s to 2005, the objective was to develop the nation's telecom and broadband network.

The Government also simultaneously was pursuing other parallel programs to reinforce the foundation of ICT development within the country. There was the "Cyber Korea" plan intended to create network balance; the government incentive which included the home tax service, the ex-government system, the financial/educative information system and personal management were all intended to enhance the use of government application programmes.

In order to carve a position of privilege for itself, it further established the Electronics and telecommunication Research Institute (ETRI) as a non-profit, Government funded research organization to concentrate on highly advance National (HAN) projects. The institute brought together the nations researchers to work together in creating innovation technologies while exchanging vital information on developments in the sector. This organization has also worked closely with the private sector and assisted small and medium sized enterprises. ETRI'S role in dissemination of basic research information has been a key factor in technology transfer.

There is indeed a number lesson to be learned from Korea. A third world country with a GDP of less than $100 has now become an upper middle income nation and in the process has achieved a leadership status in ICT R&D.

The policy framework described above has been supported by an exemplary commitment on the part of both Government and the private sector in providing the necessary financial resources for the realization of the Korean dream.

Clearly South Korea's long term vision of huge investment in ICT R&D was designed to take control of future market needs. The strategy apparently paid off as South Korean has seen its relative weight in global ICT equipment trade grows fast at the expense of Japan market.
The South Korean example clearly high lights the existence of a direct correlation (albeit overtime) between increased ICT R&D effect and increased markets.

Lessons to be learnt from Korea

- Government as a driving force in development Technology.
- The Public/Private partnership in ICT R&D.
- *Institutions such as ETRI* to lead ICT R&D and create dissemination mechanisms for national as well as international development in highs tech.
- Focused spending on infrastructure based on the country's strategic goals.
- Funding schemes for use of government seed money for innovation and using royalty funds generated from this innovation for further R&D work creating a growing funding cycle.
- Cooperation of government, industry and Academia for work behind the national goals.

4.3 ICT R&D in Non- OECD Countries

In previous sections, the study highlighted a decline of corporate ICT R&D performed in-house

and financed by US businesses, and to a lesser extent, by European businesses. The hypothesis drawn from this was that business R&D activities are increasingly being internationalized and are opening up in non-OECD. **Section 111** of this study has an extensive analysis of the internationalization of R&D with no specific details on ICT R&D. There is, however no reason to believe that the trend in the specific case of ICTs will be any different. In this section the internalization of ICT R&D within Europe as well as in some parts of Asia clearly indicates the extent of ICT R&D globalization which is beginning to creep into new and emerging economies. The strong growth of R&D activities in emerging countries marks:

1. The determination of firms to redeploy the 'global breakdown' of their R&D effort (by making inroads into high growth potential markets, among others) rather than a transfer of their resources and activities.

2. The determination to harness the high numbers of well-trained low-cost workforce that are available in those countries whereas the human resources available in developed countries are now scarcer and more expensive.

The following should be underscored about the above figures, which reflect overall R&D funding as well as the proportional share of each of the countries in the Non-OECD countries.

Average annual increase in R&D investments over the past 12 years in China have roughly ranged between 4% and 5% for the U.S., Japan, and the EU-25 (25 European countries). This has contrasted sharply with the 17% annual growth in R&D spending for China, which has accelerated over the past five years; registering in excess of 20% average annual increases**. (Battelle, 2006)**

4.3.1 Estimate of business ICT R&D in non-OECD countries

Thus, the estimate (%) of the ICT R&D share of total business R&D for the 7 non-OECD Countries vary, as can be seen in table 4.e below.

Table 4.e Estimate of ICT R&D of the 7 non-OECD countries

Country	Recalculated ICT R&D ratio
China	35.5%
India	32.0%
Brazil	32.0%
Russia	22.40%
Taiwan	41.3%
Israel	38.4%
Singapore	57.6%

4.3.2 Performance in ICT R&D in the Non-OECD countries

In PPP (purchasing power parity) exchange rates, China's R&D investment actually equaled that of Japan in early-2006, and is expected to surpass it in upcoming years. China's R&D investment as a percent of its GDP (gross domestic product) over the past several years has similarly grown from less than 1.0% to nearly 1.6% now. This, however, is a long way from the 2.6% of GDP that the U.S. invests and still further from the 3.2% of its GDP that Japan continues to invest**. (Battelle, 2006).**

China has ranked fourth among the 'major powers' in terms of gross domestic expenditure on R&D and its overall GERD volume is about to exceed Japan's. The GERD for China is indicating an upward trend based on the level of expenditure for all sectors in the country. China's rapid advance on the R&D investments compared to both the U.S. and Japan is unprecedented in recent history. These figures are underscored by the growth of China's industrial research workforce, which expanded from 16% of those in the U.S. in 1991 to 42% in 2002.

A country such as India has a gross domestic expenditure on R&D (GERD) roughly at a par with France's. Over the last decade, India has transformed itself as one of the global powerhouses of the ICT sector. Its development in the sector is even clearer to see when compared to its Asian

competitors. In the software exports market, India has a commanding lead at over 6 times that of China and 15 time that of Taiwan, This is despite the fact that India compares unfavorably with China and Taiwan on most of the development indicators including internet penetration as well as high-tech manufacturing and exports. In 2005, exports by India in ICT were close to USD 17 million (~10% of the global market. India today boasts the fourth largest GDP in the world. Furthermore, ICT has had a profound impact in its overall economy, with ICT providing only 5% of the total GDP and about 20% of its exports.

R&D in India has expanded significantly since the 2000s. R&D expenditure has grown at an annual rate (CAGR) of 45 percent in the 2002-2004 periods. Expenditure has more than tripled between 1997 and 2004, reaching about 6.8 billion dollars in 2004. On a private-public partnership (PPP) basis, R&D expenditure has actually increased by a factor ranging from three to five times.

Although the public sector has traditionally been the major source for R&D funding, the following table for the 2005 funding shows the expenditure by the private sector is also growing.

Table 4.f Expenditure of ICT R&D in India

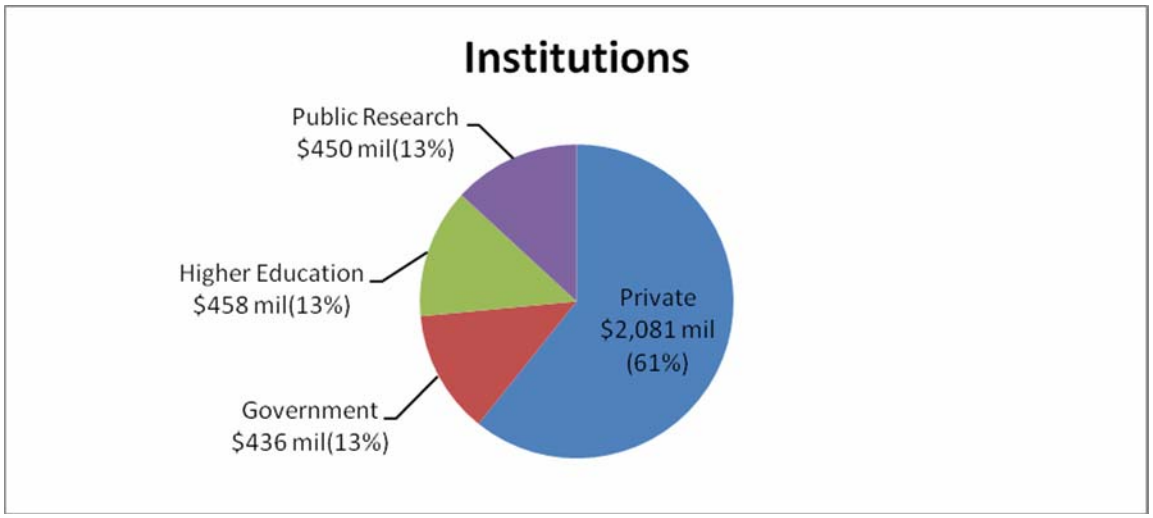
Funding body	**% age of the total ICT R&D fund**
Central Government	62%
State Government	8.50%
Higher Education	4.20%
Public sector industries	5%
Private sector industries	20.30%

Source:

In Singapore the ICT sector contributes about 18% to the DGP compared to the US (7%), Finland (5.8%) Canada (4.7%) etc. The Gross Expenditure on R&D (GERD) increased in

absolute terms to $3.424 billion last year and maintained at 2.15% of GDP. Private sector R&D expenditures continue to lead accounting for 61% ($2.081 million). The Government sector, higher education and public research institutes each accounted for about 13% of total expenditure on R&D.

Figure 4.k R&D Expenditure in 2003 by Institution



Source: Agency for Science, Technology and Research, Singapore

The manufacturing sector contributes almost three quarters of 2003s GERD and remains the main contributor.

In the manufacturing sector electronics continues to play a critical role, contributing 72% of manufacturing private sector R&D.

The services sector in Singapore was contributed mainly by ICT R&D. The main thrust of the ICT industry in Singapore is in the following areas:

1) Third party telecom/value added network operators (2) web trusting services (3) Cyber and café (4) Development of e-commerce application and R&D (**A* STAR, 2004)** foreign companies conduct R&D in developing countries.

Although countries such as Brazil and Russia have not reached the same magnitude, they exceed the $20 billion threshold for GERD, thus ranking them ahead of all European countries, except for Germany and France.

Although they are under the 10 billion-dollar threshold, countries such as Taiwan, Singapore, and Israel, where the ICT R&D effort is known to be sizeable, have attained high R&D intensities (volume of business R&D as a % of GDP), which are higher than the reported intensities for the 9 OECD countries analyzed in the first part of the study.

If we compare only for 2004, the estimates for business ICT R&D in the 9 OECD countries to those in 7 non-OECD, it shows that China and India in non-OECD countries compare favourably with OECD countries but that businesses in OECD are still spending twice as much as non-OECD.

A term-to-term comparison of the two series of figures (7 non-OECD countries: series 1; 9 OECD countries: series 2.) cannot be done since the first series is in billions of current dollars while the second is in dollars at parity of purchasing power (except the figure for the United States that is the reference country).

Table 4.g Business ICT R&D in the 9 studied countries

Series 1	Current $, billion	**Series 2**	PPP$, billion
China	38.7	**United States**	54.9
India	10.7	**Japan**	28.6
Brazil	7.3	**South Korea**	11.5
Russia	3.9	**Germany**	8.2
Taiwan	4.9	**France**	6.3
Israel	2.3	**Canada**	4.9
Singapore	1.3	**United Kingdom**	4.3
		Sweden	2.7
		Finland	2.4
Total 1	***69.1***	***Total 2***	***123.8***
		EU-25	***25.6***

Source: CSTI (2004 data)

However, by comparing the series generally, we can make the following deductions, with little

margin of error.

- The ICT R&D of the above 7 non-OECD countries accounts for about half of the intramural ICT R&D performed and financed in the 9 studied countries, which account for more than 90% of the R&D of OECD countries.
- A country such as China has an ICT R&D that may already be higher than Japan's, thus ranking China second worldwide.
- A country such as India with an ICT R&D to the order of €10 billion is already ahead of all the European countries.
- A country such as Taiwan weighs as much as Canada as and more than the United Kingdom.
- A country such as Israel weighs as much as a country such as Finland and yet the Finnish ICT R&D effort is exceptional.
- In Singapore, the Gross Expenditure on R&D (GERD) is maintained at 2.15% of GDP

4.3.3 Measuring Output of ICT R&D in non-OECD countries

Due to very acute differences in business cultures regarding patent protected innovation, non-OECD countries only account for a small share of total ICT-related patent applications worldwide. For instance, in 2003 (latest available data in the literature), Japan's relative share of the world total of ICT-related patents accounted for 17.9% whereas China's share was a mere 1.8% (ratio of nearly 1 to 10). Yet in 2003, Japan business-enterprise expenditure on R&D was only 30% higher than China's (ratio of 1 to 1.3), **(OECD, 2008).**

The table below compiles the ICT-related patents share of total patent applications in several non-OECD countries.

Figure 4.h ICT-related patent share of total patent applications in several non-OECD countries

	% ICT-related patents	Gap with global mean
Singapore	62.70%	1.80
Taiwan	45.00%	1.29
Israel	41.80%	1.20
China	38.80%	1.11
Russia	23.80%	0.68
Brazil	15.70%	0.45
India	14.80%	0.43
Global mean	34.80%	1.00

The level of patenting activities continued to show a steady trend of moderate increase in 2003. The number of Patents filled increased by 6.9% from 936 in 2002 to 1001 in 2003 and the number of patents granted increased by 2.0% from 451 in 2002 to 460 in 2003**. (A* STAR, 2004)**

The above table highlights that some countries (Israel, Singapore, Taiwan, and to a lesser extent China) have ICT-oriented R&D (similar to Finland or South Korea in the 9 OECD countries in the Table above) whereas other countries (Russia and Brazil) have a weaker 'ICT orientation' than the global mean.

India is probably a special case. While the ICT-related patent share of total R&D patents in the country is fairly low (14.8%), this is probably because ICT R&D in India is focused on software development, which is not patentable under international patent applications. Therefore, the share of ICT R&D may be largely underestimated in this country, if one only looks at this patent indicator.

4.3.4 Future outlook for R&D growth in non-OECD countries

R&D growth rates in non-OECD countries are consistently much higher (except in the case of Brazil) than the reported growth rates for the 9 OECD countries**. (Battelle, 2006**)
This means that not only are these non-OECD countries already producing a sizeable share of the global R&D (and specifically of the ICT R&D) but, due to this growth differential, the non-OECD countries (if growth continues at this rate) will also eventually be generating in 5 to 8 years ICT R&D volumes very similar to the volumes reported for all the developed countries. The build-up of ICT R&D in the non-OECD countries is hardly marginal and, in the short run, not taking account of the ICT R&D in these countries would mean seriously underestimating global ICT R&D volumes.

4.4 ICT R& D Policies and Strategies in some Non OECD Countries

4.4.1 The Enabling Environment

China is by far the primary choice for offshore R&D outsourcing. India is a prime source for computer and software R&D outsourcing, but even here China is making inroads to become more competitive. Gartner reports that both India and China will generate $27 billion in software outsourcing in 2006**. (Battelle, 2006).**

In summary, Chinese government incentives, infrastructure, academic relationships, and scientific capital investments continue to draw interest from the international R&D community.
China's government has a long-term goal to address all aspects of R&D across all technology sectors. They continue to support both internal growth and science and technology partnerships with all countries. Their overall strategy is to build their technological capabilities in whatever method they can, recognizing that they are starting from a lower point than most other countries. This strategy has worked quite well over the past several years, with substantial growth seen across the board in life and physical sciences, engineering, software development, materials sciences, and theoretical physics. China's researchers are regularly recognized for their

technological discoveries and achievements, their intellectual property (in terms of patents) continues to increase, and they continue to be a source of attraction for major science and engineering conferences. Their manned space program has gained professional credibility and their long-term dedication to meeting technical schedules is backed up by the financial growth and health of their economy**. (Battelle, 2006).**

The central government through the Council of Scientific and Industrial Research (CSIR) and the department of Science and Technology (DST) has been the driving force behind ICT R&D in India.

The Government's role in supporting the ICT sector has been through the improvement of India's policies towards IT, infrastructure, HR development and training. Some of these policies include:

1. The creation in 1988 of a World Policy, with a focus on software development for export;
2. The telecommunications policy reform; privatization of the national long-distance and mobile phone markets. ICT diffusion, as a result has risen quickly, as demonstrated by the rise in the number of internet users from les then one million in 2000 to over 50 million in 2006. This number is projected to reach over 80 million by 2010.
3. Supporting the ICT sector; much of the initial domestic demand stimulus for ICT and ICT related services in India has come from the government.
4. Important reform in a number of areas, such as: the tax regime, liberalization of foreign ownership and exchange regulations.
5. Improvements in industrial and other regulatory frameworks and the intellectual property rights regime, have contributed to accelerate growth in foreign trade and investment.
6. The Indian government also initiated a wide range of initiatives targeted at specific industries such as software, electronic hardware and telecoms, biotechnology-pharmaceuticals and automotive. Specifically, the Indian government has moved to ensure that:

- Zero custom duty on items bound under the IT agreement for the software sector.
- Increase in telecom FDI equity stake limit from 49 percent to 74 percent.

India has also witnessed its export-oriented expansion program bringing in domestic and foreign corporate R&D investments, particularly in the information ICT sector.

The Indian Diaspora has also played a key role in attracting R&D activities to India, especially from the U.S., Canada, the U.K. and South-East Asia. The Indians' Diaspora role in the U.S. R&D community is reflected by the large number of Indians in leading academic institutions and high-tech companies in the U.S.

Since 2003, the Indian parliament has passed a series of laws developing and protecting the intellectual property rights (IPRs) coming out of the country. In 2005, it passed a patent regime that is compliant with WTO standards.

Jordan, one of the leading Arab countries in the development and acquisition of ICT technological capability has identified the following as expected accomplishments in its efforts to create an enabling environment for the development of the sector:

- A National ICT R&D committee was established, with members from the Ministry of Information and Communication Technology (MOICT), Higher Council of Science and technology (HCST), Jordan Investment Board (JIB), Ministry of Higher Education and Scientific Research (MOHESR) and the private sector, championed by MOICT, HCST and national R&D body.
- Venture capital incentives included under the country's investment law.
- Awareness created about intellectual property rights.
- Mechanisms developed by the National Committee to review and harmonize the nation's policies and strategies that have strong links to R&D.

Enhancing access to funding sources and mechanisms for ICT R&D has also been a key policy priority of the Jordanian government

After the enactment of the policies and the recent development of the socio-economic environment, the following were identified as key targets to be achieved:

1. Reviewing and finalizing of the general policy and guidelines for financial resources available for the country's ICT R&D.
2. Creation of ICT innovation fund which will focus on ICT innovation using both shared cost and full grants mechanisms.
3. Enacting law that promotes tax incentives for companies engaged in ICT R&D.
4. Making information about funding available to interested parties, specially using the website of the National Committee to be established.

A common phenomenon fundamental to all of these policies and strategies is that the Governments involved have recognized the need for them to play a role in the form of a deliberate and direct intervention to create the right climate for the development of ICT R&D and for private sector participation.

4.4.2 Capacity Building for ICT R&D

In India, the government has also had a major role in education and R&D institutional capability building, by giving priority to the provision of free higher education and the establishment of a large number of research institutions within the public sector. Since the 1990s the private sector institutions in India have started to play a more significant role in higher education, training and research. This is illustrated by the speed of growth in education and training, especially in software and IT –enabled services, and business administration.

India's priority for capacity building and its natural advantage of population size has made it achieve the following:

- A huge educated workforce with an attractive wage structure that makes it ideal for exporting knowledge; about 6000 PhDs, 14 million university graduates (twice that of US) and 2.5 million graduating every year.
- India also has a decent quality of education with huge pool of English speakers.

Jordan possesses 10 public and 14 private universities which constitute an essential element of the basic R&D infrastructure. When compared to its region, Jordan has a higher proportion of universities and graduates in technological fields. It ranks 14th out 110 countries for the number of engineers and scientist it has according to the Global competitiveness report 2004-2005.

Jordan has also given a lot consideration to the development of human capital, as a driving force behind the development of national R&D in ICT. Expected accomplishments in this area by the Jordanian government include:

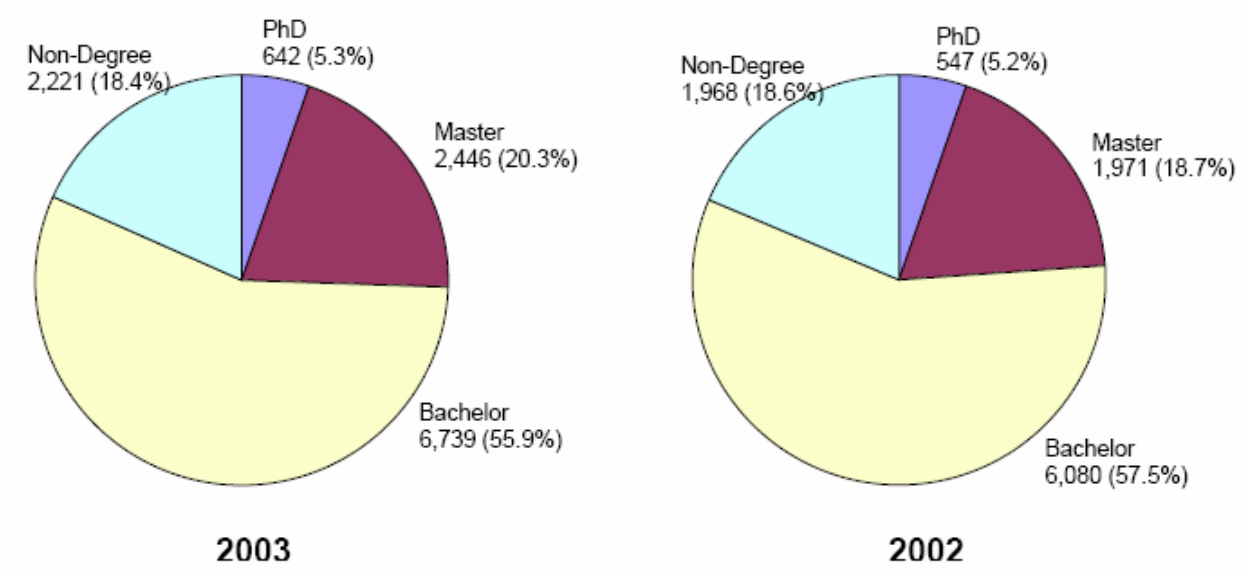
- Establishment of at least one center of excellence in collaboration with the different stakeholders.
- PhD programmes in ICT in at least in one university in cooperation with an internationally recognized university.
- Introducing research based intensive courses in undergraduate curricula in at least one university.
- Forming guidelines for enhancing research culture and documenting research work and the dissemination of publication through the internet.
- Promotion incentive schemes for the promotion of University Research
- Increased cooperation with foreign universities in research and development work in ICT.
- Training investment officers in financial institutions to appraise innovation ICT enterprises and private investment ICT products.

The results of the 2003 R&D survey in Singapore released by the Agency for Science, Technology and Research (A*STAR) in 2004 shows that Private Sector R&D investments continues to grow as more companies are engaging in R&D and employing more PhD trained researchers.

The demand for PhDs in the private sector continues to grow. The number of PhD researchers employed by the private sector increased significantly by 17.4% from 547 in 2002 to 642 in 2003. Overall the total number of researchers employed by the private sector grew by 14.0% from 10,566 in 2002 to 12,048 in 2003. The Government sector higher

education sector and the public research institutes each accounted for about 13% of total expenditure on R&D. The increase in demand for PhD researchers is most evident in the technological sectors including 'R&D' and 'ICT' sectors under the services industry. Overall, the five industry groups collectively registered an increase of 88 PhD researchers in 2003.

Figure 4. l Researchers in the Private Sector by **Qualification**



Source: Agency for Science, Technology and Research, Singapore

4.4.3 Private Sector participation in ICT R&D

NASSCOM, funded entirely by its member ICT-related companies, is the Indian Chamber of Commerce of the ICT software and services industry. It was set up to facilitate business and trade in software and services and to encourage advancement of research in software technology as well as ensuring quality of service and to enforce IPRs in the Indian software Market.

Furthermore, there have been several developments that have multiplied the potential for the Industry, namely:

- Multinational companies' that have a base in India are expanding their R&D operations.
- Indian companies R&D spending has also increased, albeit from a low base.
- Indian public sector, state enterprises, education and research institutions have increased spending although not at the same rare as corporate R&D.
- Government research labs have gradually become more inclined to develop partnerships with foreign and India private corporations.
- Much of the foreign corporate R&D growth in India continues to be based on in-house operations, but outstanding to Indian companies or contract-based R&D collaboration with local research institutes is also expanding.

The expansion of the outsourcing business into more advanced high-technology areas and establishment of foreign company R&D centers in India undertaken both by the private sector and the Government are helping develop technology and innovation capabilities of Indian companies.

Believing R&D activities will have to eventually to driven by the private sector, Jordan has put the following under its strategic plan of promoting the sector;

- the commercialization of Jordanian locally developed ICT products
- Incentives for companies engaged in ICT R&D.

Jordan has long identified ICT as a major enabler of economic and social advancement. Jordan has been investing in innovation ventures in the field of ICT. Different innovation centers of technology incubators were setup amongst which is found the IPARK ICT business incubator which has built up many firms that specialize in different technological services such as ICT consultancy, Security applications, Banking solutions, etc.

Singapore's R&D progress has shown encouraging results when benchmarked against countries with economies of similar size. In terms of private sector's expenditure on R&D (also known as business expenditure on R&D, BERD) as a ratio of GDP, Singapore is ahead of Ireland and Netherlands but trails behind the leading R&D intensive countries such as Israel, Sweden, Finland and Switzerland**, (A* star, 2004).**

4.4.4 Lesson learnt from Indian ICT R&D for the African Private Sector

Indian has achieved very impressive growth in the ICT sector. This has been mainly driven by the private sector with the help of the Diaspora, coupled with systematic government support.

Specifically;

- The opening up of the telecom market, specially internet and broadband services. Indian has managed to increase penetration from 1million in 2000 to 50 million in 2006.
- The Indian government has played a major role in education and ICT R&D institutional capability building, by giving priority to the provision of free higher education and the establishment of a large number of research institutions within the public sector.
- The development of a more comprehensive approach to ICT.
- Zero custom duty on items bound to improve the ICT sector.
- Assessing the various ways of funding ICT R&D at the central government level, at the local administration level, bringing in NGOs, public private partnerships, higher education funding, etc…..
- Tax incentives for private in-house ICT R&D expenditures
- Understanding the values of IPRs, and utilizing them appropriately.

5. ICT R&D in Africa

5.1 Introduction

The current African situation and its future direction can be summed in the following words by Dr. Joseph Okpaku, Sr, a member of the UN ICT Force for Africa in his article ,"The role of Information and Communications Technologies in the African Development Agenda". **"In Africa, we have tried to address the issue of the cost acquiring the tools and services for ICT. However, we have done so merely on the level of creating shopping lists and the money to buy. This is contrary to how others have addressed the challenge. To build its communication capacity to meet its needs, China has invested heavily in Research and Development, and with that in manufacturing. As a result, it was able to roll out more telecommunications lines per year than we have had throughout the continent, and is today, the world leader in the use of mobile phones. Now Chinese salesmen have joined the long line of American and European merchants who travel all over African selling us every tiny bit of ICT tools and equipment.**

India is another example. Despite having one of the highest poverty levels in the world, India has become a leading exporter of ICT technology and software.

I have argued that the only way to create affordable ICT access in Africa is to build our own industrial capacity in R&D and manufacturing in Africa. It is quite a simple proposition. We buy the equipment. If we shift these funds to manufacturing them, we not only get what we need cheaper, in much greater quantity, and more attuned to our specific needs, we create industries in the process, with jobs, benefit and pride to our people."

Professor Clement Dzidonu, Professor of Computer Science and consultant to the Economic Commission of Africa also had this to say, while chairing one of the nine sessions of EU- Africa ICT workshops in Accra," **Governments need to take ICT serious beyond deployment**," Dzidonu lamented that "**Africa's refusal to concentrate on building a knowledge army of people who have acquainted themselves with advanced ICT knowledge through research. Because Asia has paid that price, it is part of the process at drawing out the blueprint for Internet 2, the next level in Internet connectivity and science. But there is virtually no**

African presence in this think-think on the future of human communication and networking."

These quotes emphasize the importance of R&D in ICTs if they should play a catalytic role in Africa's development. A number of examples cited in the OECD, in Asia and in Latin America clearly underline the R&D focus in the promotion of ICTs.

The AU as a continental organization has developed the AU consolidated Action Plan for the development of Science and Technology in the continent. A part of the outline of that plan reads as follows:

"While there is increasing acquisition of use of information and communication Technologies (ICTS) in Africa, The rate of Technical change is still low compared to other regions in the World Africa is to a large extent a net importer and consumer of ICT. Its contribution to global software research is limited furthermore, the continent has not really adapted the content of ICT to suit its social and economic systems, with emphasis on poverty reduction and economic growth".

Higher educational Institutions in Africa which should be in the forefront of ensuring Africans participation in the resolution one severely under resourced and the ICT infrastructure poor developed. One area with potential for African higher Education in the innovation is the development, maintenance and support of free and open source software (FOSS).

An important area of investment for Africa is software innovation.

The AU programme will aim at establishing a continental research network on ICTS. It will bring together leading universities and research centers to design and implement projects that generate software with Africa content.

Furthermore, the private sector is becoming a major investor in R&D. This is partly due to globalization, the opening up and integration of natural economic systems as well as liberalization of trade, which is changing the locus of R&D. Also there are also pressures towards privatization with developing countries simply due to national macro economic

reforms and new entrepreneurial opportunities that have begun to present themselves. This is foreign national R&D system to seen attractive financial sources for their work. ".

What then is the state of ICT R&D in Africa? What are the obstacles in the way of making progress in Africa? Who are the active players and what have they been doing? The section below attempts to answer some of these questions and discusses other relevant issues.

5.2 The State ICT R&D in Africa

5.2.1 ICT R&D in Africa in problems and Constraints

Africa's place in the information society has always been bridged on its green market which is increasingly becoming a rentable ground for 16% solution s providers. (**Rouame ,2008).** At the "EU – Africa – ICT Awareness and Exchange " workshop aimed at exposing funding and partnership opportunities between EU and Africa in the FBI generate framework programme for research and technological development a member of problems were highlighted that are critical to ICT R&D development in Africa.

Firstly most international donors like Europe have as a priority for funding issues like malaria and HIV Aids and Hunger, which obviously affect more people and are much more visible.

Even Africa countries themselves with a heavy debt burden and a poor infrastructure that needs a huge investment will find it extremely difficult to divert resources to issues of ICT R&D.

Secondly, there is very low public sector funding for Universities, so called Research Institutions and educational infrastructure in general in many African countries that have led to the poor performance of R&D within the Academic sector in the continent.

Thirdly, there is no definable research culture in the continent – Therefore little or no research takes place in Africa, whether inside the universities, the public sector, and the indigenous private sector or the MNCs.

There is a serious lack of human capacity. While Asia and Europe have developed their human capacity to tackle ICT R&D, Africa has neither simple nor taken advantage of this. Some of the great minds in ICT R&D are Africans. But virtually all live abroad. There are more than 20,000

Africans or people or African descent living in the Diaspora. The low level of ICT R&D is exacerbated by the limited collaboration between the private sector and research institutions, particularly the universities. Contrary to experiences in developed countries, there is limited interaction between firms in the ICT sector and universities or research institutions concerning technology transfer. A few Countries such as South Africa, Kenya, Nigeria and Mozambique have set up incubators and have started the concept of Science Parks.

Very few or no African country perhaps with the exception of South Africa have a clear cut policy on ICT R&D. Ethiopia has only recently put together a national ICT R&D policy and strategy framework.

African countries in formulating policy often make the mistake of confusing deployment for ICT R&D. Mobiles phone and internet diffusion in Africa do not constitute the knowledge economy.

Third World countries in Asia and Latin America have been able to scale up on ICT R&D and occupy important positions in the software and chip industry. South Korea, Japan, India are playing important roles in the evolution of internet 2. While Chile, Mexico and India are attributing to the changing landscape of the business processing outsourcing (BPO) industry there countries have moved from rendering low end back office to high-end innovative service development and delivery.

ICT-Related research at National level is weak, often spearheaded by individuals and donors rather than academic institutions or the private sector. The low level of ICT R&D is exacerbated by the very limited collaboration between the private sector and research institutions, particularly the universities. Contrary to experiences in developed countries, there is limited interaction between firms in the ICT sector and universities or research institutions concerning technology transfer. A few countries such as South Africa, Kenya, Nigeria and Mozambique have set up incubators and the concept of science parks is emerging, (**EU-Africa)**

The lack of engagement of the African private sector in R&D might also be explained through constraints by the legal and policy environments that are not enabling. There is very little or no financing as well as high taxation (**EU-Africa).**

ICT curricula, particularly in computer science and engineering, fall far behind market needs and graduates generally lack understanding of the business environment, often entering the job market without the necessary skills to be used effectively in the ICT sector without considerable training. The private sector has not been able to capitalise on the theoretical strengths of academic institutions, although there have been recent attempts by multinationals to engage in partnerships such as the Cisco Networking Academies, Microsoft's ICT graduate programmes, and the Bell Computer University in Nigeria.

The majority of computer Science and engineering schools lack staff with a strong research orientation. There are few Africa ICT researchers. Universities generally continue teaching courses with outdated curricula not relevant to private sector requirements.

It is difficult to find postgraduate programmes at the masters and particularly at the PhD levels. Some efforts are underway at Makerere University, Uganda and the National University of Rwanda. There has been no comprehensive assessment of research capacities in African Institutions. Africa's ICT human resource base is a small circle of researchers and practioners, and it is male dominated field in Africa.

In the absence of research, the ICT sector is clogged with anecdotal and best practice evidence that does not stand scrutiny and emulation.

The ICT sector has been prioritised by government policy in almost all African countries, but the mention of ICT R&D in most national policy and strategy documents is generally generic and in some cases vague and has generally not resulted in increasing technological capabilities in other sectors, nor contributed to increased competitiveness for countries.

For example, the Ghanaian policy document talks about **"enhancing capacity for R&D of Ghana to meet the demands and requirements for the nation's information and knowledge based economy and society"**

When one examines the Bangladeshi ICT policy document, there are very explicit references to ICT R&D.

"The Bangladesh computer council along with the ICT industries will assist in formulating plans to conduct need –based R&D activities in the University and the public and private sectors R&D institutions and encourage the younger generation in these activities. The ICT industry may funds R&C activities for new ICT products and services through industry/Academic collaboration. Technology corporations like Microsoft, Computer Assonated, Grade, SAP etc will be approached to set up their R&D centers in Bangladesh."

Little work has been published in traditional international research journals; much of the quoted work is only available through reports to founders and presentations at conferences; there are limited academic peer review processes. This is a very serious challenge. African ICT researchers cannot publish because the quality of research is generally low and reports cannot substitute for peer-reviewed publications. Few journals encourage authors from the South.

5.2.2 Policy and Strategy

Most African countries have developed national ICT policies and strategies that encourage the use of ICT in education, health and agriculture and promote research and development in ICT.

However, the rhetoric around ICT R&D has not been realised in almost all African countries, largely due to lack of research funding and insufficient human resources to carry out research. Besides, not all countries have developed frameworks for ICT research and development at national and regional levels.

Research agendas for ICT and sustainable development can be defined from various perspectives including applied research aimed at improving computing hardware and software, network and connectivity research, content and human capacity, ICT in different development fields (e.g. ICT in education), investigating the social implication of computing on individuals and organisations, especially on development and the community.

While some research is underway in the applications of ICTs in development and policy areas, as well as in value addition, there is limited activity in the core hardware and software, connectivity and networking streams. Research on the social implication of computing is also minimal, even though it seems to be a focus area for most research activities.

ICT-related research at national level is weak, often spearheaded by individuals and donors rather than academic institutions or the private sector. Much of the ongoing research cannot be regarded as innovative and is often no more than repackaging of innovative solutions developed outside of Africa**. (EU-Africa).**

African countries and regional structures have also developed policy frameworks and plans for the use of ICT to develop their economies. The huge challenges facing the higher education and research community in Africa have been widely recognized and a few pan-African initiatives have been launched in the past five years to find solutions. They are key enabling instruments in raising the profile of African research in general (and ICT research in particular). Introduced below are some of the major cooperation plans related to S&T cooperation and having developed a focus on ICT.

A. The NEPAD Africa's S&T Consolidated Plan of Action (CPA)

The S&T Consolidated Plan of Action (CPA) was released in 2005 and is a consolidation of the actions of NEPAD and the African Union (AU). Its intention is to strengthen the S&T basis in Africa, having been weakened by a lack of investment and too much emphasis on short-term activities in developing human S&T capacity. The ICT cluster has identified two key research projects (with a strong emphasis on the development of software, and
Free and Open Source Software (FOSS).

The first focuses on e-learning, building on the KEWL (Knowledge Environment for Web-based Learning) next generation platform which was developed by the University of the Western Cape (South Africa). The project aims to:

- Develop new generations of e-learning systems
- Train users on new e-learning systems
- Improve infrastructure for ICT software research and development

The second project will focus on e-health applications and particularly on the development of software to support the administration of anti-retroviral drugs to combat HIV/AIDs. A total of USD 2 million has been budgeted for these activities.

The Plan of Action makes provision for the strengthening of S&T decision-making capacity on the continent, through focused interventions on increasing regional cooperation, building common strategies including a pan-African biotechnology strategy, the creation of technology parks, and the raising of public awareness about S&T.

B. The African Regional Action Plan on the Knowledge Economy (ARAPKE)

The ARAPKE framework developed upon request from the Second African Regional Preparatory Conference for the World Summit on the Information Society (WSIS - Tunis, 2005), held in Ghana in 2005 is based on the “Accra Commitments for Tunisia 2005”.
The vision is defined by both the African Information Society Initiative (AISI) and African Union. The action plan is designed to:

- Define an African approach and positions in the process of preparation of the second phase of WSIS, to become the African approach in the current debate on the main issues of the WSIS
- Create a foundation for national, regional and international cooperation over a period of 10 years, up to 2015, with the aim of improving the life of the African populations.

This Action Plan aims at building a region fully benefiting from ICTs by the year 2015. R&D has been recognised as one of key areas of the framework for an African Regional Action Plan on the Knowledge Economy (ARAPKE).

C. Initiatives by the Economic Commission for Africa

Within the framework of the ALN to facilitate the improvement of ICTs in the learning and teaching process, ECA has been collaborating with the Ford Foundation to provide a platform and space for leading African academics to reflect on issues for enhancing the role of academia (academics and institutions) in the Information Society. An Academia Research Network (ARN)

was created as a WSIS activity to engage African researchers and academics on key issues emanating from the Geneva Summit in 2003.
As part of the recent ECA repositioning, more emphasis is being put on strengthening Member States' capacity to harness Science, Technology and Innovation potentials for their socio-economic development.

In the same vein ECA is also developing the "Access to Scientific Knowledge in Africa (ASKIA)" initiative to support and promote access to scientific knowledge by the African scientists, decision makers, students and researchers. It will mainly provide a mechanism for African scientist to tap into global scientific knowledge as well as the production of indigenously owned that supports economic and industrial growth.

ECA continues to help in articulating science, technology and innovation systems for Africa's development and promoting the establishment of Science & Technology parks and incubators in member States. Research and development activities are also being undertaken on selected emerging issues and topics of importance to member States. As part of its work to promote the application of S&T for Development, ECA provides support to selected Centres of Excellence in the various sub-regions and facilitate networking among them.

As part of its work to promote the application of S&T for Development, ECA has continued to provide support for universities, research institutions and Member States in various ICT education and research areas.

Programs underway include:

The ALN was launched to provide a platform and space for leading African academics and researchers to enhance their role, and to reflect on intellectual issues related to the Information Society. Varsity Net, is part of the Africa Learning Network (ALN), created to build the R&D academic capacity in the Information Society. ECA in collaboration with the Ford Foundation, the government of Finland has since taken the lead in the consultative processes with key academic figures in the African continent and launched four Academia Research Networks (ARN).

The AISI Academic Research Network (ARN) and varsity Net have been engaged in a series of research and development activities since its inception in 2003. Research and innovation activities are underway in the areas of:

a) African languages and content development (Cameroon),
b) Open Source Software (OSS)
c) localization and health & commerce information system (Ethiopia),
d) ICT industrializations (Mozambique), and
e) Information Society indicators (Tunisia).

i. ICT Industrialization in Ethiopia, Mozambique and Tanzania

Mozambique (the Eduardo Mondlane University and the Mozambique Information and Communication Technology Institute), in collaboration with Ethiopia (the University of Addis Ababa) and Tanzania (University of Dar Es Salaam), is leading one of the four thematic research networks established during the ARN brainstorming, the "Industrialization of ICTs in Africa". Based on conclusions from the ARN, Centres of Excellence were identified as crucial for the development of the human resources both in ICT and entrepreneurship development and this can be achieved by the implementation of Centres of Excellence on ICT education and in-house software applications development. These centre of excellences will be used for the development of "flagship projects" for the future ICT entrepreneurs to be incubated within the Mozambiquan Institute for Information, Communication Technology (MICT), Technology and Business Incubator.

ii. Promotion of Local Languages in Cameroon

In response to the need to promote local languages in the cyber space, the second phase of the research activities applied to Cameroon intends to experiment a model for the utilization of ICTs in African Languages, particularly in rural schools, during a period of three years.

The short-term research activities on African Languages noted that only a few African languages have online resource materials, such as dictionaries, translated documents, library content, audio file and news programmes. In fact, only 2% of the African local languages are made available

online. These languages include Swahili, Hausa, Yoruba, Igbo, Luganda, Masai, Sesotho, Shona, Ndebele, Xhosa and Upkila.

Rural Electronics Schools in African Languages (ERELA) is an application to Cameroon of a part of the recommendation made by the Academic Research Network working on promoting African Language and local content in the cyberspace. Two computer based learning and teaching local language systems have been installed in the two pilot's primary schools. (i) Obout based at 80 km form Yaoundé and Metsa base at 350 km from Yaoundé. Teacher was trained and a curriculum developed for the course.

iii. OSO Localization: Health & Commerce Information System for Ethiopia

Varsity Net is implemented at Department of Computer Science at Addis Ababa University, with the support of ECA's Varsity Net programme. The project has been able to show how this new mobile telephone infrastructure can be used for two areas critical for the development of African countries, which are health and commerce. In addition, it followed-up on researches done in the area of on-line character recognition for Ethiopic characters, which is crucial for the use of local languages on mobile devices. The research outputs are expected to be showcases that would enable policy makers to see better how the mobile telephone infrastructure can be used to address the development problems of their countries. The project has successfully accomplished its objectives and as a result has made some significant breakthroughs.

iv. Information Society Indicator for Tunisia

The ARN is also working on the Information Society indicator to look at socioeconomic impact indictors in the Information Society by using Tunisia as a case study. So far the team has successfully established a collaboration framework with Tunisia's existing statistics bodies including, the National Statistics Council, the National Institute of Statistic, Statistic training Institution and other specialized statistics bodies. This collaboration framework has successfully finalized the following four sub-research activities;

- Assessing the "state of the art and benchmarking of the indicators of impact."
- Define and compile "Core composite indicator for Information Society measurement and benchmarking (indicators of penetration, using and impacts),

- Develop a Manual of the index cards of indicators (every index card includes a definition and the method of calculation for every indicator),
- Develop core: Partial indicators and composite indicators definition and methodology of calculation.

v. The Inter-University Council for East Africa (IUCEA) Varsity Net R&D Project

The Inter-University Council for East Africa (IUCEA) Varsity Net project was jointly implemented by the Universities of Nairobi (Kenya), Makerere (Uganda), Dar-es-Salaam (Tanzania) and the Jomo Kenyatta University of Science and Technology (Kenya).

Activities of the first part of this phase mainly involved the establishment of a clear understanding for the requirements that will assist in developing a system to mange students' academic records at the IUCEA member universities through consultative meetings with various stakeholders. The requirements established in the first part were then utilized in the second part to develop a software prototype for managing university students' information systems.

The prototype has been developed by Makerere University using the requirements collected from stakeholders from a sample of universities in East Africa. After the in-house teaching at Makerere University, implementation and testing of the software prototype was undertook in other universities. Two universities in each of the three East African Partner States country (One public and one private) have been selected for the testing and implementation phase of the software prototype. The system has been implemented and tested at the six universities. Two day training of trainers by developers from Makerere University was organized in and the system implanted in each university.

Member Universities recognize that the students' Information Management System (SIMS) is integrated application software for managing Student Academic and Curriculum data, Degree programmes, Academic Departments and Academic staff data. It has been accepted because it is developed using the Open Source Software, so there is no need for licenses.

These activities in particular and the project as a whole have enhanced the research capacities of universities, especially with respect to software development using open source software (FOSS). It has assisted in the development of cost-effective software systems that solve real

problems at the universities. The IUECA Community of developers has been established to maintain and upgrade the system.

D. Connectivity Africa

In partnership with ECA managed by IDRC, Connectivity Africa applies Canadian expertise in affordable, sealable, and appropriate information and communication technologies (ICTs) to African challenges in Education, health and Community development.

Many Connectivity Africa projects target African universities as catalysts for research and education, as hubs for innovation, and as place's that attract and enable Africa's future leaders, innovation and entrepreneurs**.(IDRC/UNECA).**

Some connectivity Africa projects create networks of ICT expertise in Africa, or help develop a capacity for research and development in ICTs among others things and are carried out in consultation with African partners to ensure that local needs are addressed.

There are four Connectivity Africa program areas:

- Innovation in the use of ICTS in helping Africans adapt new, low cost ICTS that have particular relevance to African development:
- Building R&D capacity in African ICTS - helping Africans build the capacity to develop uniquely African ICT innovations tailored to local needs and preferences.
- Africa Regional ICTS-Breaking down the technical barriers that prevent Africans from connecting easily to one another.
- Partnerships and net workers - Encouraging African institutions, communities and individuals to increase their inference and impact by working together.

Connectivity Africa has carried out specific projects that have made meaningful impact on the communities in which they have been set up. For example:

(i) Bandwidth Optimization for African Universities

Bandwidth Optimization for African Universities aims for widespread improvement in how African research and education institutions manage their Internet bandwidth. Because African

universities spend up to 100 times more for access compared to their counterparts in industrialized countries, these institutions have far less access to ICTs and online research resources. To begin to close this "digital divide," the International Network for the Availability of Scientific Publications (INASP) is delivering a series of capacity-building workshops on bandwidth management, as well as developing and publishing freely available training resources on bandwidth management.

(ii) Senegal ICT Resource Centre: Creating R&D Capacity

Senegal's ICT Resource Centre is developing ICT applications that address the needs of village communities. This research and development focuses on new human-machine interfaces that allow illiterate populations to access information using voice or graphic icons on portable telephones and PDAs. It is also an opportunity for students in the Department of Mathematics and Computer Science at Cheikh Anta Diop University to participate in research into wireless technologies and shareware, thereby gaining skills and experience that will help to popularize these tools for development projects in Senegal.

(iii) African Virtual Open Initiatives(AVOIR)

African universities are increasingly using the Internet to collaborate and share information and resources. By developing a locally designed, low-cost online Learning management System derived from an existing FOSS system, AVOIR will give universities a powerful tool for harnessing the educational potential of the Internet. It will also create a body of FOSS best practices and a community of developers whose expertise can be leveraged to create other collaborative, Internet-based applications in areas such as health care and government services.

AVOIR brings together nine African universities to establish a virtual "centre of excellence" for developing Free and Open Source Software (FOSS) that can help address African development issues and create African business opportunities.

AVOIR is initially focusing on software for education, but over time will develop expertise and best practices in FOSS development and deployment that will be applicable in many sectors.

(iv) Mozambique ICT Institute- Technology Incubator

Hosing in a converted warehouse next to the Centre for Information at the University Eduardo Mondlane (UEM) in Maputo, the Mozambique ICT Institute (MICTI)- Technology Incubator is helping a new generation of technology entrepreneurs access the resources and skills they need to launch e successful companies. By nurturing entrepreneurial skills and helping fledgling ICT companies get off the ground, MICTI will create employment and generate wealth in a sector of the economy critical to Mozambique's future.

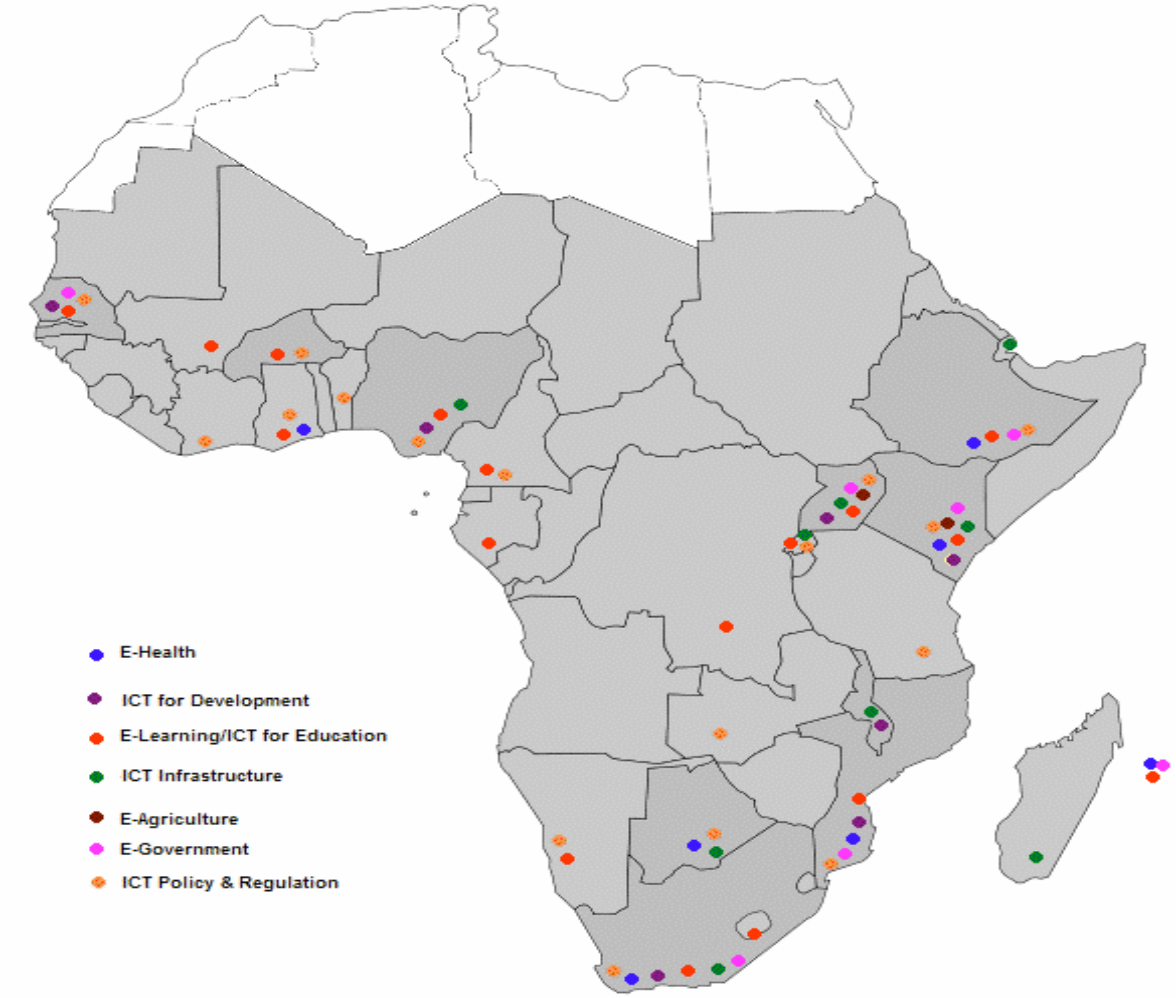
5.2.3 The African ICT Research Priorities.

At the African national and continental levels, significant progress has been made to identify, but also implement important research and development themes and domains.

African priorities are influenced by the social and economic development challenges that in turn inform research priorities in the ICT sector. Recent international focus on promoting ICT applications in support of MDGs particularly in the e-governance, health care, education, agriculture, environmental protection and infrastructure development has had a major bearing on the directions of ICT research in developing countries. African research priorities mirror the overlapping ICT priorities devised at regional levels including that of the African Information Society Initiative (AISI), the New Partnership for African Development (NEPAD) and the African Regional Action Plan for Knowledge Economy (ARAPKE) endorsed both member states of the ECA and the African Union.

The illustration below shows the key research priorities in Africa as seen by the EU - Africa Framework Programme 2007

Figure.5.a. Research priorities in Africa 2007



Source: START Consortium

5.2.4 African ICT Research Capacities

ICT research in Africa is already a reality, with the existence of a strong ICT research community in South Africa and to a lesser extent other countries in the continent.

Moreover, a growing ICT research capacity exists beyond South Africa. Ghana, Nigeria, Kenya, Mozambique, Tanzania, Senegal and Mauritius have for instance a long-standing involvement in ICT research whereas Rwanda, Uganda, Ethiopia, Burkina Faso, Cameroon and Botswana are emerging as countries where ICT research is receiving attention. Most of the research capacity is

embedded in universities and public research institutions, with increasing involvement from the private sector through the establishment of research and training support**. (EU-Africa).**

COUNTRY SPECIFIC INITIATIVES

South Africa

i. The ICT R&D and Innovation Strategy for South Africa

ICT has been identified by the South African President, as well as by a number of other government strategic and policy initiatives, as a "key technological platform" that has a pervasive impact on government service delivery in domains such as education, health and social facilities, and broad aspects of industrial and economic development.

The National R&D Strategy (2002) sets the agenda and framework for maximising the contribution of research, development and innovation in S&T in South Africa. It specifically identifies ICT as a key mission to bring about improved quality of life for all citizens and boost the economic competitiveness of industry. The ICT R&D and Innovation Strategy have been developed by the Department of S&T (DST) in conjunction with national experts and international advisers. The strategy aims at examining the current state of ICT R&D in South Africa and proposes a number of objectives, strategies, actions and interventions to realise a vision for ICT R&D and Innovation that will optimally position South Africa to take advantage of the benefits of ICT and the associated Knowledge Society.

The ICT R&D and Innovation strategy of South Africa has three clear priorities:

- Develop focused and strengthened ICT research activities to achieve world-class research competencies in South Africa
- Build a strong and robust ICT innovation environment in South Africa
- Build advanced human capital (ICT skills base) for research and industry

ii. Specific programmes

(a) The Digital Doorway

The Digital Doorway started as a joint initiative between the Department of Science and Technology (DST) and CSIR in South Africa with a vision to make a fundamental difference to

computer literacy and associated skills in Africa. This is happening through the innovative approach of minimally invasive education (MIE).

MIE differs fundamentally from other ICT provision interventions and relies on the premise that practitioners have different inherent cognitive abilities to when it comes to self-learning. This experimental approach focuses on making computers easily accessible to training facilities and creating an environment in which individuals can learn at their own pace.

(b) Wireless Africa

Wireless Africa is about researching ways and means to develop sustainable information and communications technology in developing countries. The focus is to address the challenges of closing the digital divide that exists within and between developing countries.

Research within Wireless Africa follows two distinct but related tracks. The first component is social research, which is investigating how a number of projects in communities around South Africa, Angola and Mozambique are able to create community owned wireless infrastructure that is sustainable.

This research uses outcomes mapping to closely monitor the progress made by these projects towards the goal of self-sustainable community owned communication technology. Most of these projects are specifically looking at applications in health, education and related service delivery areas.

The second component of wireless Africa is looking at ways in which technology barriers can be removed or minimized to enable bottom-up creation of wireless access infrastructure. The group is performing research in the areas of mesh networking; low cost voice/messaging devices, low cost access points and antennas, and network security. Mesh networking research is particularly interesting in that a community can grow a wireless network in an ad-hoc manner without the need for large capital investment in radio masts. Two experimental test bed mesh networks have been installed in Pretoria and Mpumalanga and are continually increasing in size to understand issues such as scalability and quality of service.

c. Human Language Technologies (HLT)

Human Language Technology (HLT) develops ICT tools that make it easier for people to interact with machines. This can benefit a wide range of people - from illiterate farmers in remote villages who want to obtain relevant medical information over a cell phone, to scientists in state-of-the-art laboratories who want to focus on problem-solving with computers.

The HLT research group investigates how HLT can be adapted and applied to benefit a developing country and pursues basic and directed research relevant to the local context. This goal is considered from two perspectives:

- HLT as an enabling technology; an example is telephone-based systems using HLT that can provide much useful information.

- HLT as a support for language diversity in an affordable and equitable fashion, assisting to make services and documents available in the 11 official languages and has a role to play in rectifying the historical discrimination against specific languages.

(d) ICT in Education Research and Innovation Group

ICTs encompass a whole realm of new technologies; including human language technologies; “smart” devices; wireless and handheld devices; merging media devices and high-performance computing concepts and facilities. It focuses specifically on the application of these technologies in an educational context and environment, and should thus be seen as a tool or platform to support education, and not an end in itself.

The Meraka Institute's emerging ICT in Education Research Group directly supports the South African National Department of Education’s e-Education White Paper published in September 2004. There are currently two major research and innovation areas within the group. The formal application of innovative ICTs to support teaching and learning in schools and a more informal approach of creating hands-on exposure for children aged 3 -18 years to science and technology careers. Examples of specific research topics within the group include:

EGYPT

The Egyptian government, in particular the Ministry of State for Scientific Research (MoSSR) and the Ministry of Communications and Information Technology (MCIT), recognize that advanced scientific research and development are the keys to success in this regard. The primary goal is to facilitate the introduction of world-class ICT research, which will raise the overall caliber of research and development in Egypt.

MCIT's outline of R&D priorities for the ICT sector provides the basis for the Egyptian action plan with the following research focus areas:

Research and Development in e-Learning: Open source learning management systems arabization “sakai”- E-Learning is the modern model of education, transferring the classical text books to an electronic medium.

Research and Development in e-Health: The Health Record Network (HRN) Initiative was launched in 2004 to implement a pilot in 400 family health units, distributed in 4 of Egypt's 26 governorates. The main objective of the HRN is to provide the necessary tools to create an electronic medical record for every citizen. In addition, MCIT is introducing an e-health research program to complement the project.

Natural Language Processing and Text Mining: The Data Mining and Computer Modeling Centre of Excellence, through the involvement of an interdisciplinary group of experts, is interested in a variety of topics in the area of natural language processing, as well as its application to text mining. This research stems from the fact that large companies, organizations, and enterprises often have a wealth of information and knowledge locked up in huge amounts of electronic resources that are continuously being generated.

Research and Development in e-heritage: The Center for the Documentation of Cultural and Natural Heritage is a research center with a mission to digitize the Egyptian Heritage using electronic systems. CULTNAT established a research plan to develop advanced computer systems and applications to make the best use of the wealthy heritage-related contents created by different programs.

BOTSWANA

Botswana hosts the Botswana Technology Centre (BOTEC) whose aim is to carry out R&D work in the field of electronics and IT, designs and develops electronic products for manufacture and sales. The ICT Health initiative runs with the Department of Computer Science at the University of Botswana. This project investigates wireless and mobile technologies that will enable user to access health information using PDAs (Personal Digital Assistants).

ETHIOPIA

Ethiopia participates in the Indian and African Union sponsored Pan-African e-Network that aims to link 12 universities (7 from India and 5 from Africa), 17 Super Specialty Hospitals (12 from India and 5 from Africa) and 53 telemedicine centres. The pilot project on telemedicine in Ethiopia was set up at the Black Lion Hospital.

Connection between the Black Lion hospital and CARE hospital in Hyderabad was established to conduct one-hour live tele-consultation in Cardiology and Radiology. A continuing medical education for students in Ethiopia was also established between the Indira Gandhi Open University and Black Lion Hospital. Links with local hospitals in Ethiopia and more specialized hospital in India are envisaged.

KENYA

Kenya’s African Medical and Research Foundation (AMREF) is working with Accenture - a global management consulting, technology services and out sourcing company - and the nursing council of Kenya the country’s professional organization for nurses to provide the resources for an innovative electronic training programme to address Kenya’s critical nursing shortage. The goal is to bring 26,000 nurses to diploma-level certification in five years, a number that would take 100 years under traditional methods.

MOZAMBIQUE

The Mozambique Information and Communication Technology Institute (MICTI) is a multi-faceted initiative aiming at addressing the challenges of skills shortage, post secondary education and a weak ICT sector in Mozambique.

MICTI aims, through ICT applications and ICT research foci, to serve broader governance, social services delivery and economic development needs of the country. It has several components including learning, research, technology incubator and a S&T park. The long term goal is to place the institute and job incubation activities into a science park environment. MICTI is now in its second intake of ICT entrepreneurs. It is housed on the campus of the University of Eduardo Mondlane and has strong linkages to the Centre for Informatics at the University (CIUEM).

ZAMBIA

LinkNet is an ICT cooperative in Zambia that is focused on research and development in Zambia's rural areas. It provides for cost-based building, operations and maintenances of communications infrastructure and aims to grow local expertise. It is collaborating with the University of Zambia to allow students to gain experience in rural areas.

There are several flagship projects underway in African countries (Appendix iii) and a number of them are located in Universities and are supported either under schemes developed by the ECA or through international collaborative where funding is provided by international organizations. These projects are discussed in more detail in the next section.

6. The State of Private Sector Support and Contribution to ICT R&D –African and Global Perspectives

6.1 Introduction

The Private Sector in Africa

The Private sector in Africa is small and consists of two broad categories, the Indigenous Private Companies and the Multinational private sector.

The indigenous private companies which basically consist of businesses developed through local initiatives are generally run by a small number of people, small in size with a small capital and little or no budget for Research and Development. However, in the recent past Small and Medium Enterprises have not only become an international catch phrase but have dominated the African private sector landscape.

The Foreign Private Sector on the other hand consists of Multinationals which have their parent company normally located outside Africa but have a presence through a subsidiary company in the host country. Generally, Multinational companies have a big capital investment with a large number of staff and budget. The ownership of the company is usually diversified and R& D activities are carried out at the headquarters located outside Africa. The globalisation of R&D has now forced some of these multinationals to invest in R&D either through their Affiliates or directly. The ICT sector in Africa consists of both aspects of the Private Sector.

Local and multinational ICT companies have a crucial role to play in the development of ICT products and services. The African ICT industry is characterised by numerous small ICT companies **(small and medium enterprises)** involved in the development of innovative applications suitable for African markets. Although the initial emergence of the knowledge economy in Africa was prompted by public sector research efforts, the recent trend has moved towards greater contributions in R&D coming from the ICT sector, particularly in South Africa where business investment in S&T research and development has overtaken public sector investment **(EU-Africa).**

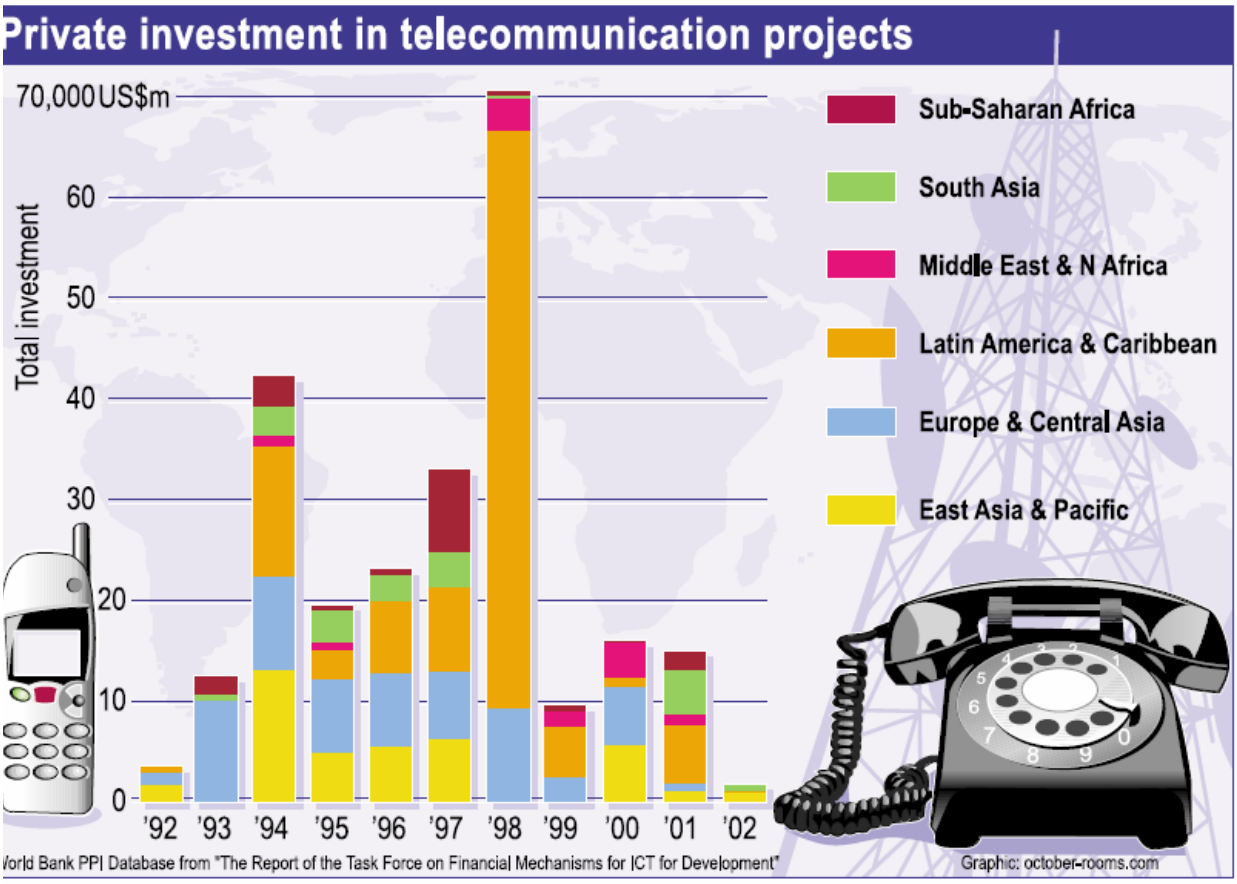
Recent experience has shown that the private sector often provides services more effectively than governments in many respects, and this is certainly true in the telecommunications sector. Witness the phenomenal spread of mobile phones in the past decade, particularly in Africa. For example, in Uganda mobile phone subscribers multiplied by a factor of 131 between 1996 and

2002 and are now seven times more than the number of fixed-line users. This rapid spread was driven by the private sector's ability to move quickly to satisfy a pent-up need for telephony, as soon as private providers were allowed into the market**. (Sagstetter, 2007)**

Telecommunications used to be run by state-owned monopoly companies in most countries, but private companies have proved themselves to be more efficient, and more flexible in keeping up with new technological developments. Competition between them also brings lower prices. The success of the private sector in meeting many ICT needs does not mean that governments and development aid donors should withdraw from ICT provision altogether.

Private sector success often depends on support from governments and donors, and some development needs continue to require public investment.

Figure 6.a Private investment in telecommunications projects 2008



Source: European Union

Governments are responsible for creating conditions that will attract private sector investors. That is, they must make laws, regulations and start-up processes for private companies as simple, transparent and predictable as possible; ensure fair competition; and ensure that back-up services, skilled personnel and capacity are in place to enable operations to run smoothly.
The UN Task Force on Financial Mechanisms for ICT for Development emphasised throughout its report that an enabling environment is key. Without it investment will not be made, or once made it will not be effective in providing services efficiently and at the best price.

Public-private partnerships have emerged as the best strategy to promote economic growth. There are however challenges for the African private sector - the sometimes restrictive policy and regulatory environment; the lack of financial resources to participate in R&D activities, particularly for small businesses; and the lack of supporting mechanisms to facilitate international cooperation. **Ajayi (2007)** is of the opinion that while scientific innovations are generally publicly funded, technological innovations are privately funded. Among the challenges listed by the report are poor public and private sector funding, poor academic/industry linkages, poor Intellectual Property Protection, deteriorating quality of University education.

Africa Countries however must put in place in a deliberate manner certain plans and programmes in order to attract R&D off shoring. African countries must improve on the quality of university graduates particularly postgraduate scholars. Governments have the responsibility to put policies in place and to plan for creating the conducive environment for investment.
Equally well they should develop appropriate policies for R & D and Intellectual Property Protection and provide necessary funding for local R&D activities which may in turn attract R&D off shoring **(Ajayi, 2007)**

6.2. Case-study scenarios of ICT R&D in Africa –Findings and analyses

A. SOUTH AFRICA

Most of these are South African and they include but are not limited to the list below:

- Meraka African Advanced Institute for ICT is Africa's biggest public-funded ICT R&D organization
- South Africa's new Centre for High Performance Computing
- South African National Research Network
- South African information security initiative
- KSG is a research group within Meraka focusing on the development of ICT-based technologies for constructing, maintaining and using ontology. The group aims to conduct high quality research, develop strong links with local universities, maintain an extensive network of international partners, and strives to have significant impact by engaging in projects on topics of crucial importance to South Africa.

The above companies and organizations are involved in the following ICT programmes and initiatives Wireless and satellite technologies

- High performance computing
- Development of human-computer interface
- Open source software development
- Development of e-health, e-learning, e-commerce (includes procurement and accounting and management) and e-government etc systems
- Future-web applications
- Geo-information science and other domains

Some of the specific examples of R&D activities going on in South Africa include:

- The application of mobile technologies in collaborative formal and informal learning environments
- The application of gaming and blended media environments to support formal and informal learning activities
- Designing innovative, graphical learning environments for children
- Assessment and evaluation techniques for measuring learning outcomes resulting from ICT interventions in the educational domain
- The use of multi-modal technologies in child-computer interaction environments
- Designing and developing physical/tangible learning objects (“intelligent e-toys”)

- Alternative learning devices and technologies to support education in a developing world context

B. EGYPT

The Ministry of Communication and Information Technology (MCIT) is taking strides to promote and modernize innovative scientific research and development and implement partnerships between the public and private sectors and multinationals on both the industrial and academic levels- a platform for performing Research and Development conducted by Egyptian experts. The following initiatives have been undertaken:

- In order to achieve the objectives of the MCIT, R&D centres of Excellence, each with a specialized area and created in the form of consortia consisting of leading local and multinational industrial organizations operating in Egypt from both the private and public sectors as well as universities and research institutions. These centres of excellence bring together professionals, private sector initiatives and educational bodies to provide Egyptian researchers with the collaborative environment and support to make breakthrough innovations in the application of ICT in established and new industries.

- The Technology Development Fund (TDF), a public-private partnership, whose board is chaired by MCIT established to invest venturel capital in Egyptian starting companies. Leading companies contributed 50 million (Egyptian) pounds to the fund during the first round of invitations. During 2005, the fund's capital grew up to 150 million (Egyptian) pounds**. (MCIT, 2006).** The TDF primarily offers venture capital financing to Egyptian startups in the ICT sector. It complements its offering with and array of strategic and incubation services to help its portfolio or investments in their early phases or development and ensure their success in the critical start up phase. The financial contribution is injected into selected companies primarily against shares in such companies and their fund becomes a full partner in the new company. The fund also offers strategic and financial planning, partner's identification management consulting, and legal resulting.

- IDEA Developers, a finance, venture development and incubation firm, assisted a portfolio of companies in developing successful and profitable operations. The funds capital is expected to increase.

C. MOROCCO

ST Micro electronics design and software center in Rabat has headquarters in Switzerland is located to design activities in Morocco. The Rabat design centre is part of a global network of 16 advanced R&D centres and 39 design centres. With this network, the primary mission of the Rabat design center is to develop advanced system-on chip products for digital TVs, DVD players and flat-screen displays, along with digital still and video cameras The Rabat design centre employs 170 people – 700 by 2009. **(WIR, 2005)**

The firm has established a training centre to train teachers and students from engineering schools. In 2001 it launched its firs cooperative activity with the Mohamed V-Agdal University in Rabat which included scholarships exchange programmes and sponsorship of micro electronics courses. It also established a design centre at the Mohamedia School of engineering with Mohamed V. Agdal University. Morocco was chosen as the location for the design centre for the industry because of favourable educational and communications infrastructure, the availability of a rich pool of engineering talent, the proximity of Morocco to Europe and competitive costs. Rabat was chosen because of its schools and universities that train engineers specialized in computers/IT domains. SQLI (France) set up an R&D platform in the country in 2003; Eolane Electronics manufacturing services (France) opened an R&D centre in the country in 2004.

D. GHANA

To create an enabling environment for the use of ICT, foster information exchange among local scientists, and facilitate the interactions and collaboration between researchers in institutions and the world, a Wide Area Network called the Research and Educational Network (REN) was established in 2000 with the help of the World Bank INFODEV project. REN uses fibre optic as the main backbone (inter-city links) and radio network from a fibre optic access point in each

city to the end-user. Presently, the basic infrastructure is functioning satisfactorily with the University of Ghana, Legon-Accra, hosting the main server and a VSAT link to the Internet. Additionally, the following institutions have been linked to serve as nodes for the broad network:

University of Cape Coast (Central Region)

Kwame Nkrumah University of Science and Technology (Ashanti Region)

University College of Education, Winneba (Central Region)

Center for Scientific and Industrial Research (CSIR), Accra.

Ghana Atomic Energy Commission (GAEC), Accra

University of Development Studies, Tamale (Northern Region)

The Kofi Annan ICT Centre of Excellence which is a joint Ghana/India project was commissioned in December last year with the responsibility to produce the human capacity needed for the emerging ICT Industry in Ghana and the Sub-region. The Multi-Media Centre located in Ghana House (the former GNTC Building renovated by the previous government) is also to serve as an incubator where new private companies in the industry can be nurtured and later relocated to the Technology Parks business Centre which is to be set up in the Free-zone area of Tema. The present government plans to expand telecommunication industry by a credit facility arranged for Ghana Telecom from Alcatel Shanghai Bell Company Ltd (Sinosure Facility).

Some specific institutions in Ghana responsible for development of scientific and technological capabilities, research and development and the provision of essential services such as Kwame Nkrumah University of Technology (KNUST),Council for Scientific and Industrial Research (CSIR), The Ghana Atomic Energy Commission, the public and private Institutions and the Kofi Annan Centre for Information and Communication Technology . are currently undertaking minimal R&D **(Opoku, 2004) .**

A number of African countries (Benin, Botswana, Cameroon, Ghana, Kenya, Mozambique, Nigeria, Rwanda, Senegal, Uganda, Tanzania, and South Africa) have developed flagship projects to nurture ICT R&D (see Appendix iii). Most of these projects are currently hosted by various university departments and are funded either by those departments or jointly by governments and international aid agencies. A few of them are projects supported by ECA under their various umbrella schemes for nurturing ICT R&D.

Apart from the projects in South Africa and the incubation experiment in Mozambique, there is hardly any private sector funding for the flagship projects. The specific areas of research pursued under those projects are indeed Africa's priority areas but somehow they do not seem to have received the necessary attention that they deserve. It is therefore imperative that a lot effort be put into developing strategies to attract private sector funding for Africa's ICT R&D.

What is also evident here is that if one sets out to look for data on private sector funding and support for ICT R&D through research into primary data, one would hardly find any. The data simply does not exist either in private companies or research institutions. Even if it does then no research evidence exists to support it.

6.3- The Global Perspective: International Best Practices and how they apply to Africa

6.3.1 Private Sector Investments in ICT R&D

It should be evident by now, from the scope of literature reviewed in this study that there is enough reason to support the claim that the private sector is in the "Drivers' seat" for ICT R&D in most developed countries especially within the OECD. The lead role of the private sector is manifested in the form of the level of R & D expenditures in various countries. Although the level of expenditure varies from country to country, it is clear however is that there is a sustained level of commitment on the part of the private sector as a source of funds and the proportion of expenditure on the part of the private sector relative to other sectors –Governments, Universities etc. is fairly high. The private sector also appears to be the highest performer for ICT R&D.

In 2003, the 20 public corporations with the largest reported worldwide R&D experiences spent $103.8million on R&D. Microsoft topped the list with $7.8billion, followed by Ford motor company with $7billion. Companies in the information and communications technologies (ICT) sector dominate this list with nine representatives accounting for 44% of the total R&D expenses. Generally, the United States private sector expenditure on R&D is nearly 50% that of the developed economies.

In the United States, private sector spending amounts to 82% as against 18% for government

spending, and in Japan almost all ICT R&D is provided by the private sector. European businesses invest two times less in ICT R&D than those in the United States and three times less than Japanese businesses. The low level of investment by the European private sector has a huge impact on overall ICT R&D investment in Europe compared to the investment in the United States. The overall R&D investments in the United States are about three times those of Europe. This of course is responsible for the outstanding performance of the United States in ICTs.

In Canada, since 2002, ICT R&D spending has grown at an average rate of 2.8% per year, compared to around 3.1% for total Canadian private sector R&D. This means the ICT R&D is growing at a slightly slower rate than R&D in the private sector as a whole.

ICT sector R&D as a share of total Canadian private sector R&D spending has remained fairly constant, accounting for 38.3% of 2007 total. Nonetheless, the sector remains the largest private R&D performer in Canada, accounting for an average of 97% of ICT R&D expenditure in the country. Consequently, the country has become an R&D platform in North America for numerous non-Canadian (mainly US) companies, foreign funds account for about 18% of the Canadian (gross domestic expenditure on R&D GERD), inclusive of all sectors.

South Korea is another OECD country where the private sector has had a significant contribution on ICT R&D expenditure. South Korea's business relative share of the total envelope of private funding for ICT R&D within the OECD countries climbed from 5.7% to 9.5% which gives South Korea the highest rise.

As in the Canadian case, South Koreas relative share of ICT R&D investment greatly exceeds its relative share of economic weight (20% of Global GDP, but 8.8% of Global ICT R&D).

In Non-OECD countries, the level of Private Sector ICT R&D expenditures are not so high, except for Singapore, where Private sector R&D expenditures continue to lead, accounting for 61% ($2.081 million) with the Government sector, higher education and public research institutes each accounting for about 13% of total expenditure on R&D. Equally significant in Singapore is that Private Sector R&D investments continues to grow as more companies are engaging in R&D and employing more PhD trained researchers.

The number of PhD researchers employed by the private sector increased significantly by 17.4% from 547 in 2002 to 642 in 2003. Overall, the total number of researchers employed by the private sector grew by 4.0% from 10,566 in 2002 to 12,048 in 2003.

In India, the share of Private Sector expenditure on ICT R&D hovers around 20%, quite small for the significant strides India has made especially in the service sector of ICTs. The private sector institutions have started to play a more significant role in higher education, training and research, especially in software and IT –enabled services, and business administration.

NASSCOM, a group funded entirely by its member ICT-related companies, is the Indian Chamber of Commerce of the ICT software and services industry. It was set up to facilitate business and trade in software and services and to encourage advancement of research in software technology as well as ensuring quality of service and to enforce IPRs in the Indian software Market. In general businesses in OECD still spend twice as much on ICT R&D as Non-OECD countries. What then are the factors responsible for such massive private sector response to ICT R&D? The answer can be found in the policies and strategies that have been put in place in the OECD and in the Non-OECD countries which today amount to international best practice. Reflecting on this study you would have noticed that the bulk of it has been reviewing such international best practice with the aim of drawing useful lessons for Africa. Below is a summary of such a review.

6.3.2. Critical Factors in Mainstreaming the Private Sector in ICT R&D

A. Government and the State

An important element that serves as a cross-cutting issue for harnessing of ICTs in both developed and developing countries are the catalytic role played by Governments and state actors in the process. In general, the review reveals that the role of government takes two distinct forms, namely:

1. Public Sector Leverage ; Government ensures the initial critical funding required for the development of ICT R&D where it is non-existent and /or due to the critical or strategic nature of the industry or sector concerned, government provides the larger percentage of ICT R&D to ensure sustainability and private sector motivation.
2. The Enabling Environment; Policies, progammes and plans that facilitate, guarantee and in some cases provide incentives to create a conducive environment for ICT R&D to grow.

(1) Public Sector Funding Leverage

The United States leads the world in public funding for ICT R&D. In a study conducted for twelve OECD countries (page 60) it is evident that public funds allocated to ICT R&D increased by an average of 58% between 1999 and 2005 but only by 27% in the EU. ICT R&D public funds provided by the US government for private companies are also fairly large, amounting to four times funds provided in Europe. This is due to the importance the US attaches to defence related contracts of which a large part goes to ICT R&D.

What is obvious however, is that public investment in ICT R&D acts as a leverage to stimulate R&D investments from the private sector, although the effect may vary from country to country. In Europe the leverage effect of public ICT R&D funding on private funding is relatively small, except in Finland and Sweden. Figures **4.g** and **4.h** above give an indication of how much leverage effect public ICT R & D investment in OECD countries, is having on corporate R & D. Major European players like (France and Germany) relative shares are steady. Other countries such as the United Kingdom with an increase of 42% over 7 years, South Korea (+98%) Spain (65%), Finland (+47%), score far more than the average increase of the 12 countries.

In figure **4.h,** the leverage effect of Canada of 10.5 is relatively high compared to most European countries and the table **4.d**. also shows the high percentage of private sector share of ICT R& D funding. South Korea also maintains a strong public/private partnership. One of the schemes under such a partnership is the use of government seed money for innovation for further R&D works which in the end creates a growing cycle.

In most non-OECD countries, the bulk of the funding is provided by the public sector. The huge investment for ICT R&D in China is from public funds and most of it is utilized by the private sector. In general, the lesson one can draw from this section is that public funds are vital not only to kick-start the process of ICT R&D but also to serve as motivation to attract more funds from the private sector.

(2) The Enabling Environment

The advantages many OECD countries have over the developing countries in the pursuit of ICT R&D are their level of development in terms of available policies, the physical infrastructure, and other relevant areas like human resource capacity including of core leadership and management skills, a stable socio-economic environment an investment capital. These advantages notwithstanding, many OECD countries still pursue specific and deliberate policies and programmes when it comes to the nurturing and developing ICTs in general and ICT R&D in particular.

For example, the Canadian government created the enabling environment by building the necessary infrastructure while at the same time providing private industry with tax breaks and R&D incentives. Funding was also made available for the academia to promote R&D research. The goal of providing the highest quality, lowest cost information network in the world to give the Canadian economy the most competitive edge was the driving force behind what was subsequently achieved in making Canada among the leaders in ICT and ICT R&D. Furthermore, the government created institutions that carry out the strategic objectives and detailed initiatives of the sector and has been using technology to link researchers and provide them with the R&D information as well as funding availability using various locally created websites.

Such support has been pivotal in the private sector development and making Canadian companies very competitive in the world in terms ICT R&D. This also resulted in Canadian ICT Companies contributing 5.6% of GDP in 2005.

South Korea is considered the development miracle of the last couple of decades since the advent of ICTs into Asia. Today, South Korea has become dominant exporter of high tech products. The achievements in South Korea have been made possible by the strategic leadership provided by the South Korean Government. The strategy was centered on funding basic national information infrastructure under five pillars: administration, national defence, public safety, finance, education and research. From the 90s to 2005, the objective was to develop the nation's telecom and broadband network.

The Government also simultaneously was pursuing other parallel programs to reinforce the foundation of ICT development within the country. There was the "Cyber Korea" plan intended

to create network balance; the government incentive which included the home tax service, the ex-government system, the financial/educative information system and personal management were all intended to enhance the use of government application programmes.

It further established the Electronics and telecommunication Research Institute (ETRI) as a non-profit, Government funded research organization to concentrate on Highly Advance National (HAN) projects.

There are important lessons to be learnt from the experience by African countries that are trying to create the necessary conditions for nurturing private sector ICT R&D:

- Government as a driving force in development Technology.
- The Public/Private partnership in ICT R&D.
- Focused spending on infrastructure based on the country's strategic goals.
- Funding schemes for use of government seed money for innovation and using royalty funds generated from this innovation for further R&D work creating a growing funding cycle.
- Cooperation of government, industry and Academia for work behind the national goals.

In the non- OECD countries, the effort of creating the enabling environment is equally intense. In pursuance of best practice, many developing countries have followed path of the developed countries in creating the necessary conditions for the development of ICT R&D. As a general rule many countries are putting special emphasis on human resource development, tax breaks and other incentives for budding companies, providing a more conducive regulatory environment, various funding schemes in partnership with the private sector, etc.

Below are some examples:

a) The Indian government's role in supporting the ICT sector has been through the improvement of India's policies towards IT, infrastructure, HR development and training. Some of these policies include: the development of the "World Policy", with a focus on software development for export; the creation in 1988 of the

telecommunications policy reform which privatized long distance and mobile phones; initial domestic demand stimulus for ICT and ICT related services in India by the government; Improvements in industrial and other regulatory frameworks and the intellectual property rights regime; Important reforms in the areas of, the tax regime, liberalization of foreign ownership and exchange regulations; the provision of free higher education and the establishment of a large number of research institutions within the public sector;

b) In developing its ICT R&D policy framework, Jordan identified the following as expected accomplishments in its efforts to create an enabling environment:

- Establishing a National ICT R&D committee Venture capital incentives included under the country's investment law;
- creating awareness about intellectual property rights;
- the development of human capital by developing centres of excellence and research capacity in the universities;
- Enhancing access to funding sources and mechanisms for ICT R&D.

Believing that R&D activities will eventually have to be driven by the private sector, Jordan has put the following under its strategic plan of promoting the sector;

- Promote the commercialization of Jordanian locally developed ICT products
- Develop incentives for companies engaged in ICT R&D.
- Promote innovation culture

B. Multinationals-Globalization of ICT R&D

A very important element which has led to the development and expansion of ICT R&D in countries that have been surveyed is the internationalization of ICT R&D by Multinationals which is today referred to as the Globalization of ICT R&D.

Globalization of R&D has generally been vigorously pursued by Multinational corporations. This has been carried out either through their affiliates or other partners in some cases by direct investment in R&D and in some cases knowledge spillovers and technology transfer arising from Multinational Corporation investment. International R&D links are particularly strong between

U.S. and European companies, especially in pharmaceutical, computer, and transportation equipment manufacturing. More recently, certain developing or newly industrialized economies are emerging as hosts of U.S.-owned R&D, including China, Israel, and Singapore. The globalization of corporate R&D has been mainly limited to location of R&D units between developed countries but, globalization of corporate R&D continues to evolve as a phenomenon. In recent years, the globalization processes have been encompassing more industries, as well as more geographical areas. Hitherto uncommon locations are attracting R&D-related FDI by Multi-National Corporations **(Reddy 1993)**.

Since the mid-1980s, as an offshoot of the globalization of corporate R&D, Multinational corporations have started performing some of their strategic R&D in some developing countries. Multi-National Corporations involved in this new trend seem to be mostly those dealing with new technologies like ICTs. This strategic move by Multi- National Corporations is facilitated by the availability of large pools of trained manpower, at substantially lower wages compared to their counterparts in developed countries and, an adequate infrastructure. These investments also serve as channels of knowledge spillovers and technology transfer that can contribute to economic growth and enhance competitiveness.

The performance of strategic R&D, aimed at developing products for global/regional markets or mission-oriented basic research by Multi- National Corporations, has implications for the innovatory capabilities of developing host countries. More recently, certain developing or newly industrialized economies are emerging as hosts of U.S.-owned R&D, including China, Israel, and Singapore.

Going beyond product adaptation to local environments, multinational enterprises are undertaking innovative R&D abroad to tap into local expertise, relatively inexpensive and highly skilled workforce and centers of innovation (“asset-seeking” FDI). Such activities are undertaken increasingly in developing countries in collaboration with the parent firm, other multinationals around the world (strategic alliances), or with the local private sector and public entities (universities, research centers), with important benefits for the host country in terms of linkages and spillovers. Nevertheless, while the incidence of the location of such R&D activities in intra-

firm networks located in the developing world is increasing, it is a small number of countries (mostly in South East Asia) with the appropriate ICT infrastructure that allows coordination across borders and the easy exchange and flow of information and knowledge.

South Korea, Finland and Sweden within the OECD and India and China outside the OECD have pursued deliberate policies that make them attractive for international investment for ICTR&D. Within the OECD, there are two indications that reflect the internationalization of ICT R&D; ICT R&D from abroad and the share of ICT R&D under foreign control. In the case of ICT R&D from abroad, the percentage of funding is as high as 60% in the case of Hungary for example. In the other case of foreign affiliates, the percentage ranges from 30% in the UK and France to nearly 70% in Ireland.

In the non-OECD countries like India, China and Singapore in Asia, reforms and appropriate policy adjustments have attracted considerable multinational investments in ICT R&D. In Latin America (Brazil, Argentina and Chile), ICT R&D has benefitted tremendously from investments by multinational corporation from the United States.

Another new trend whereby developing countries are connecting to global knowledge networks is the emergence and fast growth of foreign R&D activities by TNCs from developing economies. As the phenomenon is very recent, the top R&D spenders of developing countries are still relatively small.

Some developing-country MNCs such as the IT Company, Ingenuity Solutions (Malaysia), have targeted the knowledge base of developed countries such as the United States, when investing in R&D abroad. There are also examples of South-South FDI in R&D. A number of firms from Malaysia, the Republic of Korea, Singapore, and Thailand have set up R&D activities in India related specifically to software development **(Reddy 2000, pp. 97-103).** LG company (Republic of Korea) has expanded its R&D activities into India; and Bogasari International (Indonesia, food processing) chose Singapore, in part due to the country's favourable R&D incentive schemes for foreign investors. A recent study of large Chinese TNCs found that they operated 77 R&D units at the end of 2004, including a surprisingly high 37 units abroad (**von Zedtwitz 2005**). Of these foreign R&D units, 26 are located in developed countries, predominantly in the United States (11) and Europe (11), mostly serving as listening posts or in product design roles.53 The remaining 11 units, located in developing countries, are typically small in size .

Two Chinese TNCs, Huawei and Haier, are illustrative of the trend of ICT R&D units being located mainly in developed countries.

Other Chinese companies from the electronics industry, such as ZTE and UTStarcom, have also established ICT R&D centres in India aimed essentially at offshore software development.

Indian TNCs are also globalizing their R&D, focusing mainly on serving their customers in specific regional markets. The leading software firms have all invested abroad, mostly in developed countries.

In Africa, the R&D component of Foreign Direct Investment (FDI) has been extremely small. FDI has been driven in the past by the profit motive of multinational corporations and R&D has only been performed in cases where the performance and therefore profit of the companies involved is enhanced. This is partly because of weak domestic R&D capabilities and, in many cases, the lack of institutional mechanisms and the necessary infrastructure that provide incentives for investors to devote resources to R&D **(Oyelaran-Oyeyinka 2004a).**

The rest of the R&D-related FDI in Africa mirrors the resource-based orientation of the continent, focusing on petroleum exploration and exploitation and agriculture. In the petroleum industry, a number of TNCs conducted some R&D in Algeria, Egypt, Morocco, the Libyan Arab Jamahiriya and Tunisia in 2004. In agriculture, Multi-nationals have invested in R&D in East African countries like Uganda and Kenya. A large number of MNCs have investments in Mining but no investment in R & D.

A few investments in ICT R&D have occurred in the some North African countries like Egypt and Morocco and to some more serious extent in South Africa. Morocco's and Egypt's attraction as a centre for multinational investment in ICT R&D is due to their proximity to Europe as well as the local capacity available in those countries.

What has emerged from this discussion is that in all cases without exception the internationalization of ICT R&D through the contributions of Multinationals has been invaluable in the development of ICT R&D within as well as outside the OECD. The Asian countries that have made substantial progress in ICTs have done so by putting in place deliberate policies that have made attractive destinations for ICT R&D. Government policies of tax incentives,

development of appropriate infrastructure, adequate funding for Research and development as well for the development for the human resource capacity have provided the enabling environment for the progress made in the Asian countries and other developing countries.

7. The Way Forward

7.1 Nurturing African Private Sector support for ICT R&D in Africa

A. Lessons from International Best Practices.

1. Multinational Investment.

One can easily add to Dr Okpaku's and Professor Dzidonu's assertions that have been quoted above, that evidence in the literature also suggest that in most of those countries it is the private sector that has played the dominant role in funding ICT R&D. Within the OECD (the United States, Japan and the European block), the lead provided by private sector funding is evident in all sectors. In fact the discrepancies in the funding pattern for ICT R&D within the OECD have been attributed largely to the relative importance some of the OECD countries attach to the role of private sector funding. Europe has been lagging behind Japan and the United States, simply as a result of differentials in private sector funding.

Even in the non-OECD countries, ICT R&D funding has largely been catalyzed by the globalization of ICT R&D through investment by Multinationals. Currently one of the greatest opportunities for African Private Sector participation in R&D is Off-shoring or the internationalisation of R&D activities by multinational companies. Extensive literature surveyed in the earlier chapter clearly indicates that many companies within the developed world which hitherto restricted their activities only within the OECD are now venturing into new areas in the developing world. South Africa and to a lesser extent countries in the Maghreb seem to be the main beneficiaries in Africa. The movement of ICT R&D funding by Multinationals not only within Europe but to Asia, Latin America and to very few African destinations; South Africa, Morocco and Egypt, has invariably been critical in the progress recorded in ICT R&D in those regions. The liberalisation of telecommunications markets, the increased interest in Free and Open Source Software (FOSS), and the rapid uptake of mobile telephony, all present opportunities for strengthening the inclusion of businesses in the development of ICT R&D. Currently one of the greatest opportunities for African Private Sector participation in R&D is Off-shoring or the internationalisation of R&D activities by multinational companies. Extensive literature surveyed in the fourth section of this study clearly indicates that many companies within the developed world which hitherto restricted their activities only within the OECD are

now venturing into new areas in the developing world. South Africa and to a lesser extent countries in the Maghreb region of Africa seem to be the main beneficiaries in Africa. The rest of Africa is completely excluded from this picture as at now simply because they are not attractive enough as a destination. In the earlier part of this report a list of factors critical for attracting international R&D were discussed. Most African countries are currently lacking in those critical factors. Other developing countries like India and China have not only benefitted from the relocation of R&D activities of multinationals but have themselves been relocating some of their R&D activities elsewhere. There are examples of South to South movement of ICT R&D in China, India, Singapore, Chile, etc which Africa can now also benefit from.

The challenge is to access the companies involved in producing innovative technologies,. This can be achieved through the numerous national ICT-related industry associations as well as regional bodies such as the African ICT Association (AFICTA) and the African ISP Association (AFRISPA) as well as the active ICT players in the continent.

There is need for African countries to position themselves for R&D off-shoring. Off- shoring can have tremendous benefits for developing countries, technology transfer , high skill Job opportunity, capacity development for the host country nationals and the availability of R&D activities can lead to further foreign direct investments, especially in manufacturing.

2. The Role of Governments

What is equally clear is that there have been deliberate policy mechanisms and other forms of intervention by Governments, other State and non state actors to create the right ambiance for the private sector to play a greater role in supporting ICT R&D.

- Governments all over the world have been spearheading the process of ICT R&D by providing seed funding to kick start the process. Apart from the strategic interest of the United States, manifested in Defence related spending for ICT R&D, the United States also funds ICT R&D purely from the point of view of the fact that it is a key industry. Federal Government funding under any of the circumstances above, are meant to leverage private funding. The same Leveraging mechanism is used in the Europe Union and in many other non- OECD countries. In India and China Government funding, as a leveraging component is also substantial. African countries cannot by any means escape

the responsibility of providing such leverage mechanisms as a means of luring the private sector into ICT R&D no matter how cash strapped they are.

- Government's responsibility for providing the necessary infrastructural base and policy initiative for Foreign Direct Investment general is assumed within the developed countries. It is over and above such provisions that Governments in developed and emerging countries have endeavored to put in place the special requirements for ICT R&D.

In non- OECD countries, the effort of creating the enabling environment is equally intense. In pursuance of best practice many developing countries have followed the path of the developed countries in creating the necessary conditions for the development of ICT R&D. As a general rule many countries are putting special emphasis on human resource development, tax breaks and other incentives for budding companies, providing a more conducive regulatory environment, various funding schemes in partnership with the private sector.

Sound educational systems with a rich climate for research have been prevalent in countries that have made progress in the field. The Asian countries in particular have shown enormous potential in this area. Research facilities in and out of University establishments have been supported by Governments funds even in highly industrialized countries. The progress recorded in Asia has been due partly to a large reservoir of skills in those countries. The dismal state of the African educational system and the large numbers of Africans who have escaped into the Diaspora for greener pastures need to be tapped into. India has made contribution of the Diaspora to ICT R&D an important policy issue. Funding for higher education, specifically targeted at research cannot continue to be an appendage in university subventions. Special line items should be created in government budget profiles to address research and development with a carefully designed programme as a critical issue.

In Canada, the European Union and in many parts of Asia and Latin America, the countries strategic interest in ICT R&D is manifested in the institutional framework it designs to address the issue. Special strategies with the appropriate institutional mechanisms have been found to exist in Canada, South Korea, India, Jordan and China to nurture ICT R&D with appropriate in built provisions for private sector participation. A few countries in Africa like Egypt, Tunisia, South Africa, Seychelles, and Ethiopia have either strategies or Intuitional frameworks to

coordinate ICT R&D. In a continent where public institutions'' are general weak and uncoordinated, it is important for Governments to pay special attention to ICT R&D is to make the necessary impact.

Coupled with the setting up of the necessary intuitions, Governments are making efforts to improve their regulatory environment. The ECA has designed and implemented programmes to help a number of African countries to improve on their policies and regulatory environments in in the Telecoms sector and this has lead to a significant growth in the sector within the continent in the shortest possible time. The private has now assumed the dominant role in the Telecoms sector. The private sector is also in most cases the only player in the provision of IT services especially the internet. With some amount of ingenuity, it is not difficult to see how the private sector which already dominates the provision of goods and services in ICTs can be made to play its part in area of ICT R&D.

Tax incentives of all types abound in both the developed and developing world as policy tools for attracting the private sector to invest in ICT R&D. In Canada, it constitutes a very important component of the policy mechanism. It is also a vital policy tool in Europe, Latin America, India, Singapore and South Korea. Tax incentives have been critical in the review and reformulation of many Regulatory Frameworks in the Telecoms sector in Africa. They have been critical in creating the recent massive surge in ICT investments in the continent. Tax incentives no doubt can contribute significantly in attractive private sector investments in ICT R&D.

B. Harnessing information for Development

Harnessing Information for Development is a sub-programme of the ECAs division of Science, Technology and ICTs designed to help Africa leapfrog traditional stages of development and uplift Africa onto the global economic scene. It is also the overall attempt by many actors on the global and African scene to coordinate the efforts of all players on the ICT scene for Africa to realize maximum benefit for its development. A number of these actors have been listed in earlier parts of this study.

At the ECA, the AISI spells out a role for the private sector, stating***…"in developed countries, the private sector has assumed a vital role in establishing the information society. It is crucial***

in Africa that a critical mass of local business ventures arises, capable of supporting and using the information infrastructure". In the next decade of implementing AISI, indeed, greater efforts must be put into strengthening the Information Society Private Sector (ISPS) if the gains made in the last decade are to be sustained. ECA's interaction with the African private sector under the AISI framework thus far has revealed the need for the following:

- the need to organize within countries and at the sub-regional level round tables for the private sector, government and civil society to develop actions plans to promote a better participation of the private sector in the process of building the Information Society.
- Develop forward-looking policies to promote the local private sector in strengthening their Involvement in various national ICT investment and procurement programmes.
- Create sound financial mechanisms and incentives to support SME and their use of ICTs for business and entrepreneurship development.
- Development incubations centers in countries as part of the NICI implementation process to nurture the local private sector.
- Develop and implement a continuous capacity building, mentoring activities for the development of Small and Medium Enterprises (SME); SME play a vital role in economic development, and are key to promoting job growth and innovation in Africa.

The concept of business and technology incubation is gaining currency in some countries and is seen as a way for nurturing local private ICT entrepreneurs to support Information Society activities. An example is the Mozambique ICT Incubation Centre (MICTI) concept from entrepreneurship aptitude development to business incubation for the Global market. Other examples involving the creation of Technology Parks are also evident in other countries like Ghana, Botswana, Tunisia to name a few within the continent.

RECCOMMENDATIONS.

The way forward focuses and highlights different strategies to encourage the Private Sector to contribute more effectively to ICT R&D and is discussed within the overall AISI strategy and the specific role of ECA. It will conclude by recommending a Vision.

Specifically, the study takes note of the rapid expansion of ICT usage and diffusion in Africa and the role the private sector has played in that process, albeit from the point of view of the profit motive. The study also notes that the African private sector cannot be compared with the multinationals that have played such a key role in other parts of the world in promoting ICTR&D. Further, although it is the private sector that is in the lead in ICT R&D elsewhere, application of the public sector leverage and the creation of the enabling environment no doubt, carves out a unique role for governments in encouraging the private sector in supporting ICT R&D.

The study therefore concludes as follows:

1. The private sector must be the main driver for R&D particularly in the ICT sector where substantial gains are to be made from incremental innovation and local adaptation. Incentives should be strengthened for both producers of ICT as well as major users or consumers who often need to invest in R&D for adaptation and effective assimilation of the new technology. Having the private sector in the lead would augment national resources available for R&D as well as ensure that R&D activities remain relevant to local needs and/or global markets. The recruitment of foreign companies in ICTs to place some of their R&D activities in Africa, at least for regional adaptation, should also help access cutting-edge R&D practices and make Africa an attractive destination for a host of other ICT activities.
2. The private sector (Multinationals) in Telecommunications and mobile phones, in Radio and Television, in satellite communications, in computer software development and in Internet service provision are to be encouraged with the same sort or even better incentives that have made in the first place to invest in Africa. They are better placed than any other players in the sector.
3. Governments, regional bodies; ECOWAS, SADEC, etc, should be encouraged to prepare a regional platform for private sector players to share resources and views on this important topic under the auspices of the ECA. Individual governments, on their own are not capable of providing such a platform.
4. The regional bodies in collaboration with ECA can also target investors present on the ground in their regions with specific proposals for collaboration between them and Governments of the region and for them to invest in ICT R&D with the promise of them benefitting from regional policies. The strategy will rely on the setting up of an e-Sector innovation fund as a key instrument to facilitate private sector participation in R&D. Most ICT enterprises in Africa are small and thus unlikely to invest adequately in R&D on their

own. Several other reasons also justify the use of this innovation fund for seed money or cost sharing private enterprises that are common to R&D and imperfections of the market. Incentives to enterprises will be augmented further through income tax credit or exemptions for companies who invest in R&D. Information on R&D opportunities, on locally developed ICT products and other measures to address information market imperfections will be carried out.

5. While some of the countries highlighted in this study use tax incentives to promote R&D, it should be noted that such incentives should be administered with caution in order to ensure against abuse and fraud. Tax credits or double deductions are the most typical mode of concession. They are generally more effective in environments where R&D is more prevalent and somewhat less effective in environments, such as Africa, where private sector R&D is not well developed. The administration of such incentives also needs to be closely monitored to ensure against abuse/fraud.
6. Out-sourcing and Off-shoring have now become global phenomenon as the examples from Asia have clearly shown. Small and medium enterprises that are active in ICTs should be made to collaborate with larger investors in the field for the setting up of incubators and technology parks. Governments may come up with specific proposals and recommendations to regional bodies on how such a collaborative effort can be undertaken.
7. The survey clearly shows that the most important element in R&D is the human resource capacity. Universities in Africa need massive restructuring to reflect the new trend and importance of ICTs as a cross cutting issue in tertiary education. All university curricula not only need ICTs but ICT R&D as vital components and because the private sector stands to benefit massively in such a process it should be encouraged by governments to collaborate with Universities, as has been the case in Singapore. This will give the private sector a bigger say in the universities. A key role for government is to help private enterprises and universities to partner, to bridge the common gap between researchers, educators and practitioners. This ensures that investments in R&D and higher education would be market-driven and the results would be translated into increased competitiveness and socio-economic benefits. This often requires strong incentives and institutional mechanisms to ensure that universities and research institutions function as a part of a national innovation.
8. An innovation culture should be nurtured through various awareness building measures. The media can play an important role. Several countries have used innovation or study tours to innovation centers and dynamic ICT clusters as a potent tool to promote innovation culture and build commitment to creating the enabling environment for and innovation-driven economy. This is common practice among U.S. companies, but also used by counties such as Chile, Ireland, Israel, India, Czech Republic, and many others. As an example of such efforts, the U.S. and Czech Government jointly established the US-Czech Republic Cooperation to Advance High Technology, led by the private sector whose mandate has been to share US experience in commercialization of high technology products, in

order to contribute to Czech initiatives for improved innovation and to identify new opportunities for international cooperation in high technology growth.

9. The programmes rolled out by ECA for harnessing information on the continent have largely been supported by International organizations and bilateral donors or by the ECA itself. The private sector should be encouraged to take part in these initiatives especially because it is these initiatives that have made the difference in the nurturing of ICT R&D. The ECA forum for the private sector should be expanded to include the participation of world renowned Multinationals like Microsoft, CISCO, IBM etc,. After all, these multinationals have a lot philanthropic projects that can be more meaningfully applied to R&D projects in Africa which is the fastest expanding market for their products.
10. However, lessons of international experience indicate that the enabling policy and business environment is the most critical element of ICT sector growth strategies and even more critical for ICT-enabled development strategies. There is undoubtedly a role for government in supporting R&D and training for ICT and other high-technology. There is also a role for governments to induce and facilitate the formation of clusters, incubators and shared support services for innovative ICT enterprises - promoting innovation, external economies and joint action. But the most pervasive impact will come from improving the policies and business environment to promote ICT adoption, to promote ICT innovation among local enterprises, and to encourage franchising, joint ventures, collaborative research and exchanges among local and international companies.
11. It is acknowledged that African Governments do not have the resource to fund ICT R&D. Best practices also suggest that government's role should be primarily as enabler, not a substitute for private sector initiatives. R&D initiatives should be private-sector driven, market-facilitating, and based on clear comparative advantage. African Governments should however be encouraged to provide funding that will serve as a 'Public Sector Leverage' for the private sector. International best practice however suggests that governments be cautious in financing flagship projects that focus on complex and disruptive innovations. Government role should be primarily aimed at incremental innovations for adaptation of ICT to local needs and for overall upgrading of ICT education. To capture opportunities of leading-edge products and disruptive innovations, the government will facilitate R&D partnerships between local and international companies.

In conclusion therefore, one can safely say that the process of developing private sector support for ICT R&D should be led by those private enterprises that have already ventured to invest in the continent i.e. companies in telecommunication, the Radio and Television, the internet and Satellite communications. It should be a collaborative one where all actors; the Private sector itself, Governments, Sub regional organizations, the universities and of course the ECA all have a vitals roles to play. Creating the right synergy among all these actors remains the critical element of the overall strategy that can only be done by ECA in collaboration with the AU.

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Appendices

(i) Established domains of R&D capacities in Africa

Agriculture Sector:

Country	**Field of Research**	**Institution**
Ethiopia	sustainable farming systems.	Ethiopian S&T Commission Institute of Agriculture Research, (ILCA),
Kenya	- Maize, tea, pyrethrum, coffee fruits, horticultural crops	KARI, Kenya Forestry Research Institute (KEFRI), International Crop Research Institute for the Semi-Arid Tropics (ICRISAT), UON,JKUAT
Uganda	- Research on beans, other legumes, soya beans and groundnuts	KARS, (Nyunda), Makerere University
Senegal	- Forestry	Senegalese Institute for Agricultural Research, ORSTOM
Mali	- Paddy development	West Africa Rice Development Association (WARDA)
Cote D'ivoire	oil palm, cocoa and Rubber	French Institute of Scientific Development Cooperation (ORSTOM),
Niger	Biological nitrogen fixation in cowpeas	National Research Institute of Niger (INRAN)

Ghana	- Cocoa improvement through elimination of viral and bacterial diseases	Faculty of Agriculture, University of Ghana
Nigeria	- Agricultural improvement of maize, millet, sorghum	ICRISAT
Gabon	- Focuses on propagations of food and fruit crops	Centre for the introduction, adaptation and propagation of plant material
Zimbabwe	- Manufacture of Polythene trays	Brookfield seedlings, Wattle company, Glenburn seedling company
Mauritius	- Sugar - cane cultivars	Mauritius Sugar Industry Research Institute (MSIRI)
Tanzania	- Dodoma wine company - Endangered forest	University of Dar-es-Salaam, Tanzania Commission of S&T
Burundi	propagation for rice ,maize and sorghum - Potato and banana improvement	Agricultural and Zoo Technical Institute (IRAZ)
Rwanda	- Increasing productivity of food legumes	Rwanda Institute of Agriculture and Science
Zambia	Soybeans project- led inclusion of other legume inoculants	Mt .Mukuler Research Station

Livestock sector

Country	**Field of Research**	**Institution**
Nigeria	- Breeding trypanasomiasis resistant cattle	National Livestock Research Institute, National Animal Production and Research Unit (NAPRI)
Ethiopia	- Development of diagnostic kits and nuclear probes to identify leprosy, leshmamasis and trypanosomiasis antigerms	ILCA
Kenya	- Improvement of disease diagnostic	National Veterinary Research Centre,ILRI, UON, KARI, KETRI

	techniques and vaccine development	
Uganda	- Livestock improvement programmes	ILRI, Makerere University, Kawanda Agricultural Research Station

Health sector

Country	Field of research	Institution
Nigeria	natural resources for pharmaceuticals and drugs development	Institute for Medical Research University of Ibadan
Gabon	human and STDs	International Centre for Research Franceville (CIRMF), Regional Centre for Research and Training in Human Reproduction.
Kenya	- Research into control of sleeping sickness	ILRI
Kenya	malaria, schistosomiasis, leshmaniasis, hepatitis B, diabetes, hypertension, Aids, sleeping sickness	KEMRI, UON, NASCOP, KETRI

Energy Sector

Country	Field of Research	Institution
Ethiopia	Assessment of energy supply demand and current pattern of consumption	Ethiopia Energy Committees The S&Y Commission, Rural Technology Department of MOA
Kenya	- Alternative forms of energy	University of Nairobi, Kenyatta University, Ministry of Agriculture, Ministry of Energy, Electricity Regulatory Board
Nigeria	- Ecowas Energy Survival Project - Ajaokuta steel plant	Individual energy exports, Nigerian University, Energy Commission of Nigeria
Tanzania	appropriate technology project	Tanzania National Research Council (UTAFITI)
Zambia	- African energy programmes	Department of MechanicalEngineering, University of Zambia
Nigeria	- Coal industry	Nigeria Coal Company
Sierra Leone	- Technological capability acquisition for oil refining	Sierra Leone Petroleum Mining Company

ii

Work Plan																					
Step Person	Activity Period-Dates	Time Line in weeks																			
		Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9	Wk 10	Wk 11	Wk 12	Wk 13	Wk 14	Wk 15 -	Wk 16	Wk 17	Wk 18	Wk 19	Wk 20
																	16 - 21	23 - 28	30 - 5/7	7-12	14 - 19
MK	Review of the literature and desk study																				
MK	- Using the internet to establish a database of ICT companies/institutions in Africa - Establish a list of private sector companies/institutions in ICT in Africa. Develop a profile of such companies - summarize existing studies and existing available data on such companies to determine how much support and contribution they give to ICT R&D - Examine data																				

	on Centres of Excellence ,University R and D for possible private sector support in ICT	
MK	Analyze data to establish Trends and Differences across Economic sectors etc.,	
MK	Write-up and submission of initial draft report	
	Comments, corrections, validation, and submission of final report	
	Validation	
	Regional consultants draft reports	
	Remarks to regional consultants	
	Regional consultants final reports	
	Coordinator global draft report	
	Validation by ECA	
	Coordinator global final report	

COUNTRY	INSTITUTION FOR	AREA OF RESEARCH	TYPE OF FUNDING

(iii)

	RESEARCH		
Ghana	AFNOG	Promotion of discussion on implementation issues that require community cooperation	Private funding http://www.afnog.org/
Ghana	AITI – KACE (Advanced Information Technology Institute – Kofi Annan Centre of Excellence in (ICT)	-Scientific Computing & Industrial Automation Department -Distributed and Embedded System Design -Networking and Communication Systems -Personal Health Systems	Private and International Funding http://www.aiti-kace.com.gh/
Ghana	Cape Coast University	Computer Science Department/Initiative; establishing a Knowledge Centre for Education & ICT	University Funding http://www.ucc.edu.gh/
Mozambique	Cento Information Universities Eduardo Mondlane (CIUEM)	-Information Services & Content Development (AVOIR) Project -Development of an integrated system for planning and monitoring of the justice sector in Mozambique	International Funding http://www.ciuem.mz/

Benin	College Polytechnique Universitaire – CPU (Campus Universitaire d'Abomey-Calavi)	Computer Department	University Funding http://www.bj.refer.org/
Ghana	CSIR	Industry and Service Division	Government Funding http://www.csir.org.gh/
Cameroon	Ecole Nationale Superieure Polytechnique – University of Yaoundé	Electronics & Signal Processing Laboratory (LETS)	University Funding
Senegal	Ecole Superieure Multinationale des Telecommunications de Dakar (ESMT)	ICT Departments LABTIC Laboratory	University Funding http://www.esnt.sn/
Nigeria	Federal University of Technology, Owerri, Imo State	Department of Crop Science	University Funding http://www.futoeduportal.com/abo'utus.asp
Senegal	FERLOSA	Electronic Money Institution	International Organizations htt://www.ferlo-sn.com/
Kenya	Jomo Kenyatta University of Technology	Institute of Computer Science and Information Technology (ICSIT)-Department of Electrical and Electronic	University Funding htt://www.jkuat.ac/ke/
Rwanda	Kigali Institute of Science and Technology (KIST)	Department of Computer Engineering	University Funding htt://www.kist.ac.rw/
Ghana	Kwame University of Science and	The Energy Centre	University Funding

	Technology (KNUST)		htt://www.knust.edu.gh/
Uganda	Makarere University – Faculty of Technology and Institute of Computer Science	ICT Departments)	University Funding htt://www.cit.ac.ug/
South Africa	Meraka Institution of CSIR	-Intelligent Environments for Independent Living -Wireless Africa -Real-time Video Coding Group -ICT in Education, Youth and Gender -Knowledge System -Human Language Technologies -Remote Sensing Research Unit -ICT for Earth Observation	Private Funding http://www.meraka.org.za/
Mozambique	Mozambique Information and Communication Technology Institute (MICTI)	MICTI/Development of low cost wireless solutions for last mile connectivity	Private and International Funding
Nigeria	Obefemi Awolowo University, Ile-Ife	Adoption of e-learning in Nigeria Universities (MoA-ELINU)	University Funding http://www.oauife.edu,ng/

South Africa	Parsec	Development of electronic hardware and software products	Private Funding http://www.parsec.co.za
South Africa	Tellumat		Private Funding http.//www.tellumat.com/
Senegal	University Cheikh Anta Diop (UCAD)	Laboratoire de traitemnets informatiques (L.T.I)	University Funding http://www.ucad.sn/
Botswana	University of Botswana	Department of Computer Science	University Funding http://www.ub.bw/
South Africa	University of Cape Town (UCT)	-Department of Computer Science -Centre for IT and National Development of Africa (CITANDA)	University Funding http://www.uct.ac.za/
Ghana	University of Ghana	ICT Directorate	University Funding http://www.ug.edu.gh/
Nigeria	University of Lagos	Information Communication & Technology	University Funding http://www.unilag.edu.ng
Kenya	University of Nairobi	-Information Systems Research Group -Distributed Systems Research Group -Artificial Intelligence Research Group	University Funding http://www.uonbi.ac.ke/

South Africa	University of Pretoria (UP)	ICT Departments	University Funding http://web.up.ac.za/
South Africa	University of Stellenbosch	Department of Computer Science	University Funding http://web.up.ac.za/
South Africa	University of Western Cape (UWC)	-Information and Communication Services (Free Software Innovation Unit) -Biodiversity and Conservation Biology	University Funding http://web.up.ac.za/
Tanzania	University of Dar es Salam – Department of Computer Science	University of Computing Centre	University Funding http://www.udsm.ac/tz
Ghana	Winneba University	University of Education's Teaching and Learning Innovation Group (TELIG) & Winniba Linux's Users Group (WILLUG)	University funding http://www.uew.edu.gh