ICTs and Industrial Development: Transformation and Employment Generation

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1.0 Introduction

This framework paper presents a state of the art review of the role of Information and Communications Technologies (ICTs) on industrial development, structural transformation and employment generation. The paper focuses on how ICTs influence the nexus of economic development and industrial structure. There is increasing evidence of the connection of structural characteristics and industry-specific factors on the intensity of ICTs adoption in business applications (Oyelaran-Oyeyinka and Lal, 2004; OECD, 2006; OECD, 2002). The rate and ease with which ICTs are adopted is influenced not only by industry-specific factors, but also by the level of the country's economic development. The reason countries at different levels of technological and economic development access and participate in the ICT revolution differentially is determined by three set of factors namely: the nature of institutions (formal and informal rules that provide incentives), the policies of the government including and particularly telecommunication regulation and the nature and knowledge base of key actors (individuals and organizations that populate sector and countries). For instance, universities are key actor that have traditionally been the 'gate keepers' of technological knowledge and in most countries have been at the vanguard of ICT adoption. Another set of agents are industrial enterprises although these are a highly segregated group separated in terms of size structure (small, medium, large), ownership (Multinationals, and locally owned), and sector specificity (traditionally and so-called 'hi-tech').

In addition to macro factors reflected in national ICT infrastructure, we review the factors that influence the adoption of "internal" IT technologies, that is firm-level ICT variables. Clearly there are considerable differences in the types and levels of technologies utilized in firms and across countries even after controlling for sectoral differences, Oyelaran-Oyeyinka and Lal (2004).

This paper will therefore answer to and examine the following set of issues:

1. What factors determine the adoption of ICTs by firms at different levels of economic and technological development? There is increasing evidence in the literature that adoption and complexity of ICT use depends on economic and technological structural factors.
2. How does the structure of industry and sectoral specific factors affect the rate and nature of ICT adoption in Africa? Institutions that promote information dissemination and reduce transaction costs tend to foster adoption and diffusion of technologies.
3. What is the nature and quality of physical and technological infrastructure available to industrial actors and how do these impacts on the adoption of ICT tools at different levels of industrial development?
4. What is the impact of ICTs on employment generation and industrial transformation through new skills and new technologies?
5. How do industrial policies affect the adoption of ICTs and how do these policies affect industrial transformation and employment generation?

6. Finally the paper will propose a methodological approach including instruments for data collection and analysis.

The paper is organized as follows: In the section that follows we provide a brief background on the status of ICTs in Africa albeit partially. Africa is largely disconnected from global markets due in large to the digital inequality that affects Africa more that other regions of the world. To this end we present a short discussion of digital inequality in the section that follows because this has implications for industrial development. This is followed by the impact of ICTs on industrial production and the way sectoral differences are marked by ICTs. We then take up the issue of ICT infrastructure followed by the skills, employment, and export impacts of ICTs. The final two sections take up the role of national policies and conclude with a proposed methodology.

1.1 The African ICT Picture

ICTs, best represented by the Internet have diffused rapidly but its spread has been highly asymmetrical across regions and countries and within regions and countries. Although the Internet as a commercial technology has only been around for less than two decades, its diffusion across all societies has been phenomenal, particularly the OECD have witnessed the fastest spread. Current estimates show that not surprisingly the most industrialized countries have benefited the most riding on superior infrastructure on which the internet thrives. Regional distribution of the Internet users in Table 1 shows that in the first quarter of 2002 worldwide users of the Internet reached 580.78 million with only 6.31 million in Africa, only about 1 percent of world total. By 2006, this figure has doubled for Africa, although in quantitative terms the number of Internet users have increase five-fold in Africa making it the area with the biggest gain although apart from the middle East it is still the region with the smallest number of users. In accounting for the growth of the Internet, the most crucial infrastructural spending has been the growth of investment in telephone services. According to Wellenius et al (2000), information infrastructure in developing and transition economies - represented by main line telephones plus mobile phones per 100 inhabitants - is less than 15 percent the size of those in OECD countries with only 19 percent of world's population. What has most deepened the so-called digital divide is the historical poor infrastructure that characterizes the poor areas of the world. However, digital inequality is not just about investment in telephone but a combination of factors. This is discussed in the next section.

Table 1: Regional Distribution of Internet Users (Millions)

Region	2002		2006		Region
Africa	6.31	1.09%	32.8	3.0%	Africa
Asia/Pacific	167.86	28.9%	394.9	36.4%	Asia
Europe	185.83	31.9%	308.7	28.4%	Europe
Middle East	5.12	0.9%	19.0	1.8%	Middle East
Canada & USA	182.67	31.5%	229.1	21.1%	North America
Latin America	32.99	5.7%	83.4	7.7%	Latin America/Carribean
NA	NA	NA	18.4	1.7%	Oceania/Australia
World Total	**580.78**	**100%**	**1,086.3**	**100%**	**World Total**

Source: www.internetworldstats.com Nov15-2006 and Bridges.org (2002), Spanning the Digital Divide, www.bridges .org

1.2 Digital Inequality Breeds Income Inequality

DiMaggio et al (2001) defines the digital divide as the "inequalities in access to the Internet, extent of use, knowledge of search strategies, quality of technical connections and social support, ability to evaluate the quality of information, and diversity of uses". The current picture in SSA has improved somewhat from the dismal figures of the late 1990s. Of all the regions, only East Asia seems to be keeping up with the developed nations while others tend to be falling behind or barely keeping up. What best explains the substantial growth differentials are the close association of investment in knowledge and physical infrastructure. The rich countries invest several folds in knowledge infrastructure compared to developing countries. Regional and cross-country comparisons reveal basic and fundamental scientific and technological divide. A look at global R&D spending shows that overall global R&D spending was US$729 billion in 2005 (NSF, 2006). Half of this spending was accounted for by the USA and Japan alone. Notably, 95% of global R&D is performed in North America, Asia, and Europe; even here, only a few countries carry out the bulk of R&D. R&D spending is highly correlated with national wealth; notably, the highest spending is found within the OECD countries although a number of Asian countries are beginning to spend substantial amounts on R&D[1].

In effect dgital inequality seems to correlates with income inequalities which has also exacerbated with time as predictions of historical income convergence prove to be incorrect. As well, per capita income between the rich and poor countries remains extremely wide. Studies have shown some association of ICTs and income gaps, with research in the United States showing that ICT adoption lead to inequality among social classes, races and educational divides, DiMaggio et al (2001). There are also qualitative differences in the requirements for continuing access to the Internet depending on the quality of use sought by the user. ICT applications for everyday tasks such as word processing, and electronic mail may require no more than basic literacy. Progressing to higher levels of usage - such as software design -demands a qualitative move to higher academic training. The limits set by lack of the most basic education are self-perpetuating. For instance, a country with poor investment at the primary education level opens up gaps at the secondary and tertiary levels a situation that tends to foster inequality. While wealth has been established as being linked to ICT access, the direction of causality is more complex to establish.

Causality may well flow both ways but other findings show that superior technical education is strongly associated with certain kinds of inequality, and among a certain community of users. First, individuals with superior education are the likely beneficiaries of the ICT-related opportunities that tend to command higher levels of wages. Second, the computer may well substitute work ordinarily carried by skilled craftsmen however, this is not a settled matter. The point of the ICT-inequality nexus is well put by Rodriguez and Wilson (2000), that "when a new technology is introduced into a social setting where the scarce resources and opportunities are distributed asymmetrically, the greater likelihood is that those with more resources will employ them to gain additional ones, including ICTs". Without clear action most appropriately by the state, it is not unlikely that patterns of skewed distribution of ICT

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[1] In 2000, Brazil (13.6 billion) half that of UK, India (20.0 billion) seventh in the world that year; China was fourth with $48.9 billion, and in 2002, it spent $72.0 billion to move to third largest behind USA and Japan. For details, see NSF (2006).

adoption and use will be reinforced in much the same way as patterns of educational inequality has persisted. In as much as diffusion of technologies are dynamic, it is the changes in the configuration of technologies and the social use to which they are put that over time that may well prove the most challenging for theory and policy. As DiMaggio et al put it, "Patterns of inequality are likely to reflect such changing factors as public connection availability, private subscription price, services available, and the technology necessary to access them effectively, as well as the diffusion of knowledge and the evolution of informal technical-support networks".

Access to the Internet and to other forms of ICTs is therefore mediated at complex multidimensional levels. Conceptualization of access as a binary divide of users and non-users is only one dimension, which cannot fully explain the nature of access. Inequality at the level of the individual and the artifact, the PC and modems, is equally not adequate. Beyond the device is the *network* of electrical power, the telephone and communication facilities without which the Internet does not exist. Hargittai (2001), suggests that digital inequality be considered at five different levels: differences in technical apparatus people use to access the Internet, location of access (i.e. autonomy of use), the extent of one's social support networks, the types of use to which one puts the medium, and one's level of skill. In effect Information and Communications Technologies posses the character of use and user differentiation that depend on the intensity of utilization and the qualitative user demand. Given that inequality of income and education is more pronounced in poorer countries and more poignantly between the poor and rich countries, this paper examines the impact of ICTs on the industrial development in the context of this equally asymmetric evolution of this technology.

For example much of the countries in Africa have a fraction of per capita income of East Asian countries. The low levels of per capita income reflect the underdeveloped structures of these economies compared to other developing countries, and their meager stock of capital. On average, more than two thirds of the population and labour force live in the countryside and work in the agricultural sector. The share of agriculture in GDP is more than double the average for other developing countries. The low level of industrialization is also reflected in the extremely low levels of modern sources of hydrocarbon based energy use, compared to other developing countries. The per capita consumption of combined coal, oil, gas, and electricity is one-tenth the prevailing levels in the developing countries. In contrast, fuel-wood sources of energy, still constitute the bulk of energy consumption in much of SSA.

African countries lag behind other developing countries in educational attainment and other aspects of human capital development required in an increasingly knowledge-based global economy. Unequal educational attainment translates to a significant industrial divide, see table 1.2. Available data indicate that adult literacy rate is on average 49 per cent compared to 81 per cent for other developing countries. Primary and secondary school enrollment rates are respectively on average about 30 and 50 percentage points below the other developing country averages, and tertiary enrolment rates are a tenth of that of other countries. The indicators suggest that African countries are fast falling behind other developing countries with respect to human capital formation in spite of the significant progress made since independence. The vast majority of the population is either rural based, or recent migrants to urban areas. The lag between these countries and other developing countries in terms of the stock of human capital, is likely to widen in the face of the rapid advances in science and technology in the more developed societies.

SSA lags far behind in terms of global industrial output and much has not changed in the last decade despite the somewhat considerable progress made by African countries in adopting ICTs. Impact takes time to manifest in real outputs and we might have to wait several years of consistent investment for a real transformation to take place. The superior performance of East and Southeast Asia is reflected the table 1.2 as it accounts for more than 60 per cent of the developing world's share in global industrial production.

Table 1.2 Industrial output, by region (1990 and 2002)

	Share in world output (percent)	
	1990	*2002*
Industrialized economies	78.17	73.25
Transition economies	6.10	3.18
Developing economies	15.73	23.58
Sub-Saharan Africa	0.79	0.74
excluding South Africa	0.24	0.25
Latin America and Caribbean	5.26	4.95
excluding Mexico	4.29	3.85
Middle East and North Africa	1.46	1.91
excluding Turkey	1.00	1.37
South Asia	1.01	1.51
East and South-East Asia	7.17	14.42
excluding China	4.99	7.84
Other countries	0.05	0.05
Least Developed Countries	0.18	0.24
World	100.0	100.0

Source: UNIDO Scoreboard database.
Note: Industrial output is measured by real value added (in 1995 US$) in the manufacturing sector (MVA)

Source: UNIDO Industrial Development Report, 2005

The vehicle of rapid ICT progress is a composite of infrastructure but African countries have comparably weak physical and knowledge infrastructure base, exemplified in the poor telecommunications and transport facilities. For example, the number of telephone lines per thousand people is about 5, one twentieth of the average for other developing countries although the introduction of the GSM has changed the picture significantly in many countries. We have constructed in Table 2 shows a composite of ICT infrastructure variables compared with levels of income (Oyelaran-Oyeyinka and Lal, 2005). The relationship between telephone density and IUI in two groups of countries is also presented in Figure 1. It is evident that the range of telephone density in relatively low-income SSA countries varies from 1.46 to 10.88 per thousand persons while in the relatively high-income African countries it is 7.17 to 257.85. It is clear that there is a substantial difference in the telephone density in two groups of countries and not surprisingly, IUI is significantly different in these countries. The impact of telephone as a key infrastructure is quite significant and suggests that African countries should focus on making it an investment priority.

Due to the poor supply of telephone services, the cost of local telephone calls is one hundred per cent higher than the average for telephone-rich countries.. The considerable lag in the development of telecommunication infrastructure within African countries and between SSA and other developing countries is likely to lead to their increasing exclusion from the global economy.

In sum, the foregoing highlights three broad aspects of the African economies, which have important implications for attenuating digital inequalities. First, majority of the Africa's population lives in countries with very low per capita incomes and underdeveloped production structures. Second, extremely low levels of knowledge and physical infrastructure constrain efficient use of productive resources and subsequently industrial progress in these countries. And third, largely as a consequence of the first two characteristics, SSA countries have not experienced the benefits associated with digitally-induced employment generation.

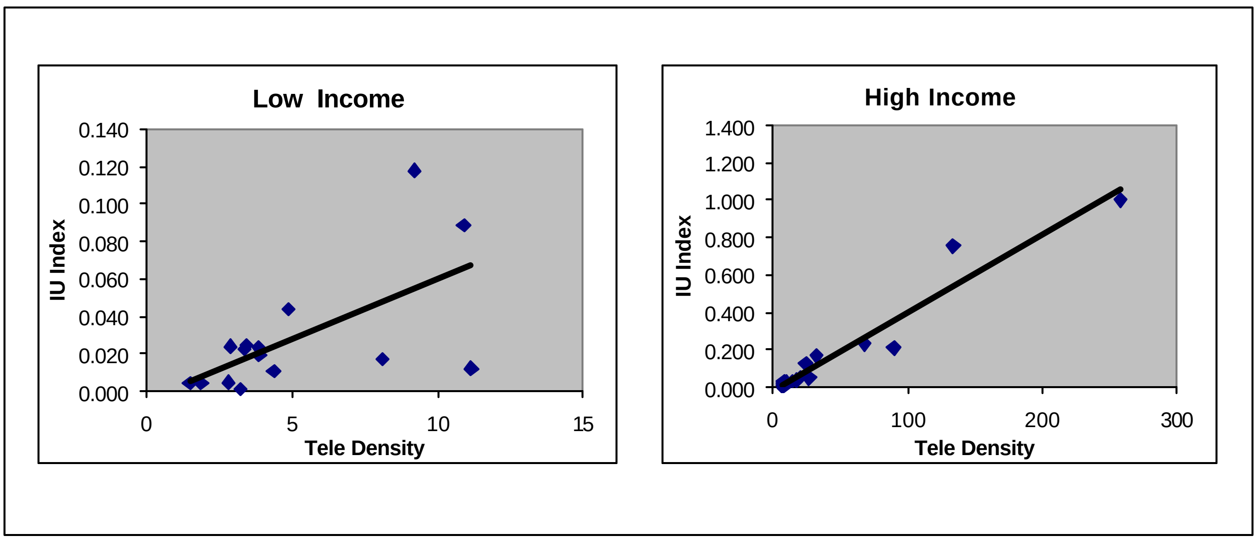
Table 2: Economic wealth and other determinants of the Internet use in SSA (2000)

Country	GDP (USD) at 1995	IU density (per 10,000)	IU INDEX	IH density (per 10,000)	PC density (per 1,000)	Tele density (per 1,000)
Relatively Low Income						
Ethiopia	115.88	1.58	0.001	0.01	0.945	3.23
Burundi	140.70	7.47	0.009		..	
Sierra Leone	147.39					
Eritrea	155.05	13.05	0.017	0.05	1.608	8.09
Malawi	168.63	14.51	0.019	0.01	1.161	3.86
Tanzania	190.49	32.75	0.044	0.23	2.847	4.87
Niger	202.80	3.73	0.004	0.16	0.466	1.86
Guinea-Bissau	209.76	24.97	0.033	0.17	..	
Chad	217.84	3.92	0.005	0.01	1.341	1.46
Rwanda	241.77	6.47	0.008	0.47	..	
Madagascar	245.80	18.82	0.025	0.34	2.195	3.43
Burkina Faso	252.05	8.38	0.011	0.32	1.257	4.35
Nigeria	253.60	17.57	0.023	0.07	6.587	3.84
Mali	287.74	16.74	0.022	0.08	1.157	3.36
Sudan	319.08	9.65	0.012	0.21	3.216	11.15
Togo	326.61	86.41	0.118	0.34	21.603	9.22
Kenya	328.20	65.21	0.089	0.53	4.891	10.88
Central African Republic	338.57	4.15	0.005	0.02	1.660	2.80
Uganda	347.95	18.01	0.024	0.08	2.701	2.87
Relatively Higher Income						
Gambia, The	370.48	92.11	0.126	0.12	11.514	24.42
Zambia	392.38	19.19	0.026	0.86	6.717	9.20
Ghana	413.25	14.84	0.020	0.01	2.969	9.93
Benin	414.17	24.6	0.033	0.415	1.640	8.05
Comoros	435.79	21.61	0.029	0.58	4.323	10.27
Mauritania	495.68	18.87	0.025	0.45	9.434	7.17
Angola	506.07	22.84	0.031	0.01	1.142	8.39
Guinea	603.40	10.12	0.013	0.25	3.669	8.16
Senegal	609.24	42	0.057	1.93	16.800	20.71
Zimbabwe	620.70	37.08	0.050	2.16	11.867	27.08

Cote d'Ivoire	742.52	27.05	0.036	0.41	6.087	17.01
Djibouti	783.07	21.94	0.029	0.064	10.188	14.09
Congo, Rep.	841.42	1.75	0.002	0.02	3.492	7.68
Equatorial Guinea	1598.60	15.45	0.020	0.13	2.264	
Namibia	2407.60	170.78	0.234	18.51	34.157	68.35
Botswana	3951.10	154.13	0.211	14.53	36.991	89.93
South Africa	3985.10	549.38	0.754	42.95	61.805	133.63
Gabon	4378.00	122.35	0.167	0.28	9.788	32.28
Mauritius	4429.00	728.91	1.000	27.44	100.539	257.85

IUI = Internet User Index = $\{X_{j,i} - Min(X_{j,i})\} / \{Max(X_{j,i}) - Min(X_{j,i})\}$, Xi refers to the Internet user per capita and I, and j refer to the number of countries reporting data.
Data Source: World Development Indicators, The World Bank (2002), and ITU (2002).

Figure 1: Internet users and telephone density in SSA (2000)



In the same manner, PC ownership correlates with income levels as shown in table 3. Ownership of PCs is as high as 74% in the OECD countries compared with 5.6% among the lowest-income, an evident impact of the nexus of income-digital inequality.

Table 3: PC ownership by income level, 2001, 2002 and 2004

Units per 100 households

	2001	**2002**	**2004**
Lowest-income households	3.2	2.8	5.6
Low-income households	6.3	5.5	10.0
Middle-income households	12.5	17.8	30.0
High-income households	22.1	37.2	55.1
Highest-income households	26.0	53.8	74.3

Source, China Statistical Yearbook 2002-2005 in OECD Information Technology Outlook 2006

1.3 The Pervasive Impacts of ICTs

ICTs have exerted a pervasive impact on all aspects of society, sectors and technologies. In this paper, we call attention to the variety of ways in which this technology impact on social and economic development, but we focus on industrial transformational effect and the ways this might influence economic growth and reduce poverty. In other words, the paper points attention to both the short term and the strategic dimension of ICTs. Analysts have pointed to both the opportunities as well as the challenges of ICTs but then all technological revolutions carry with them promises and dangers, as with the uncertain nature of all innovations. How and what trajectory ICT development follows in national development depend ass much as policy choices as it is on historical forces and institutional contexts. What we now know is that ICTs have emerged as a revolutionary technology (a technology comparable in impact to the invention of the dynamo and the birth of the age of electricity) that its impact has been felt across all societies, poor and rich alike. In fashioning policies and strategies for ICT therefore, it helps not to limit the possibilities of the technology but to see it as an embedding force of change that is changing all areas of life and work.
For this reason we examine the industrial and employment impact of ICTs at three different levels taking as contexts different levels of economic development, which are:

- The role of ICT in changing the ways and the speed of acquiring information and knowledge, and the impact on ***education and learning*** across societies and sectors. At this level of impact, ICTs in form of the Internet, PCs and different modes of communication (the GSMs) is relatively accessible to all people in society, although as we noted earlier this is differentiated across income groups.

- The ***manufacturing and production impact*** of ICTs which is the subject of this paper by which the technology change the organization of the work place much in the same way that electricity brought about different modes of production. The productivity impact has been a subject of much controversy but the visible impact of ICTs is undeniable. At this level of impact some countries particularly in East Asia, China notably the most recent, have used electronics as a basis of significant wealth creation. ICTs have not only been a significant *inclusion* in traditional sectors but a basis of new production regimes.

- The ***Network Impact*** relates to the role of ICTs in linking people, places and events all over the globe. In industry ICTs have revolutionalized the way enterprises relate to other enterprises as well as how firms reach customers, suppliers and buyers.

In what follows we will review selectively the industrial and employment impacts of ICTs

2.0 ICTs and the New Information Economy

ICTs are defined as technologies used to "store, receive, transmit, and algorithmically transform any type of information that can be digitised - numbers, text, video, music, speech, programs, and engineering drawings, to name but a few" (Brynjolfsson and Hitt, 2002: 2). The term "ICT" is used to describe electronic information processing technologies such as computers and the Internet. The emergence of information and communication technologies represents the most profound change to our mode of processing, information transmission and industrial production.

However, the “new” information revolution is not all about digital hardware and electrons and processors. The newness in the ICT is also relative because as (Arrow, 1999) points out, information processing has underlined the organization and coordination of economies for all time. What has changed fundamentally is the manner of exchange and production and the unprecedented change in the cost structure of obtaining vast amounts of information. For instance, one can download whole books, journal articles, and industrial manuals with the cost of no more than that for making a phone call or photocopying an article. Firms are able to reach long distance customers through electronic website advertisement formats.

However, we need to make a distinction between processing information and reproducing knowledge because the latter requires vastly more skills and resources. Essentially, greater cognitive capabilities are required to use information productively and to turn it into useful knowledge (David and Foray, 2001).

ICTs have facilitated the emergence of the “network society” (Castell, 1999) and has profoundly altered the ways business and research is done by fostering long distance exchanges and revolutionizing otherwise traditional modes of production. In addition to creating new processes, new service modes, ICTs have also created entirely new markets and products due largely to its high speed of delivery and low costs of transactions.

> "The real information revolution is not that information is suddenly becoming important. Information has always been important. The revolutionary aspect of the information age is the treatment of information in ways that would have been unimaginable only a few decades ago" (Perelman, 1998).

In the next section we present recent empirical evidence, much of which relate to developed countries that shows substantial and increasing rise of returns to IT investment, contrary to much earlier inconclusive findings. The stylized facts are as set out below (Oyelaran-Oyeyinka and Lal, 2006):

- At the level of the firm, there is “strong evidence of excess returns” to IT systems, equipment and labour investments (Lichtenberg, 1995).
- There is a strong relationship between IT and improvements in economic performance of the USA and that the impact of IT on aggregate economic performance has increased over time (Stiroh, 2001).
- However, externalities are equally important, that is the complementary effects of investments made in R&D, computers and human capital in other areas of the industry and sectors reinforce, and could in fact be indispensable to, the observed positive impact on productivity in a particular sector. In other words, ICTs should be seen in the category of what some economists conceptualize as a “general purpose technology” (GPT). A GPT exerts widespread and productivity-raising effects in all parts of the economy and sector.

- There is a time dimension to IT investment because of the learning effect of technological investment within which firms master techniques and by which "network effects" begin to be felt. Policy makers should therefore plan for lags in investment. For instance, adoption of advanced manufacturing practices may require significant changes in work organization that may sometime be disruptive while making positive impact on productivity (Siegel et. al., 1997).

While the rate of technological change has accelerated in the last three decades, the role of ICTs has been central to this phenomenal growth of information and three separate *network* laws have been formulated to explain the new economics of information[2] (Gilder, 1994).

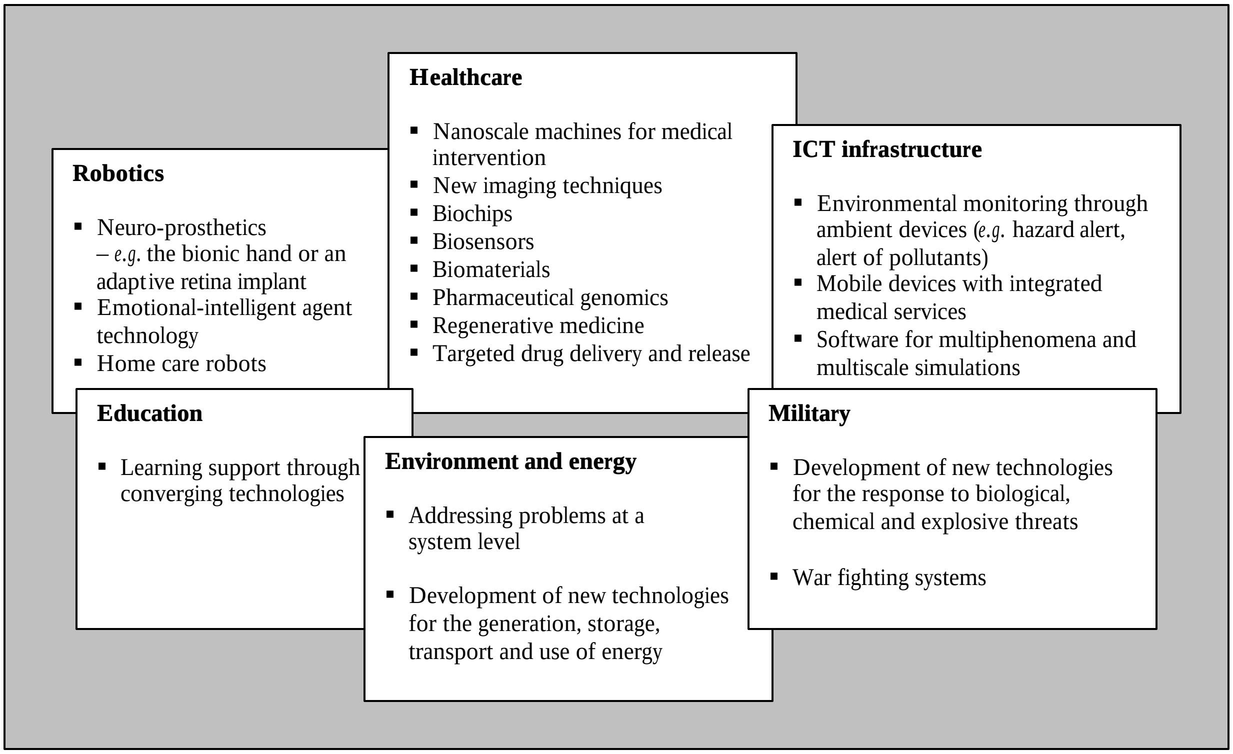
While Metcalfe's Law has been applied to the Internet, it is also true of telephone systems. Gordon Moore first formulated Moore's Law in the early 1970s. There can be no doubt that the cycle of technology development and implementation is accelerating and that we are moving inexorably onward, out of the Industrial Age and into the Information Age.

2.1 ICTs, Knowledge Convergence and Industrial Applications

The emergence of ICTs and other new technologies has led to the coming together of several technological techniques to provide wider applications in industry and society, Figure 2. The term "convergence technologies" (CT) has been used to describe this phenomenon defined as "the synergistic combination of nanotechnology, biotechnology, information technology and cognitive sciences" (Roco and Bainbridge, 2003). The benefits attending convergence include new organizational production structures and gains in communication.

[2] According to *Moore's Law* the maximum processing power of a microchip at a given price doubles roughly every 18 months. This means that while computers become faster, the price of a given level of computing power halves. *Gilder's Law* states that the total bandwidth of communication systems will triple every 12 months, again a description of declining unit cost of the net. *Metcalfe's Law* says that the value of a network is proportional to the square of the number of nodes. In other words, the growth of a network results in the exponential rise in the value of its connections, while the cost per user remains the same or even reduces.

Figure 2: Fields of Applications of Converging Technologies



Source: OECD based on Nordmann (2005), Roco and Bainbridge (2003) in OECD Information Technology Outlook 2006

In transforming codified generic digital knowledge to local use, only a portion can be transferred by formal technology transfer mechanisms, while the rest often require a long heuristic process of imitation, reverse engineering, learning-by-doing and apprenticeship. (Stiglitz, 1999) termed these processes of learning "horizontal methods of knowledge transfer," while the formal; codified storable mode is called "vertical transfer." These largely practical informal methods can take several forms.[3] Despite the increasing propensity to codify technical functions, tacit knowledge remains an important component not only in the context of traditional sectors and small firms, but also as a necessary cognitive basis for interpreting codified knowledge including digital and mathematical functions.

One such important development is in the pattern of knowledge change related to the increasing convergence of the different areas of science and technology. For instance if we take the biological sciences and biotechnologies knowledge base there is a convergence of techniques and practice that encompass genomics, molecular biotechnologies, agricultural and industrial biotechnology. Material sciences and technologies include advances in nanotechnology, smart materials, high-performance materials and advanced catalyst materials. The observed scientific and technological convergence has brought about fruitful

[3] Among these are: study tours to other countries, cross-training which is a form of "learning-by-observing" in other countries, an implicit knowledge acquisition process that is different from explicit training on how to do things, twinning or seconding which pair together institutions in a horizontal knowledge exchange process, (Stiglitz, 1999).

complimentarily to the different fields of science but more important for developing countries these technologies are being applied in traditional sectors in ways that could not be imagined a decade ago (Sagasti, 2004). Relatively technologically backward countries have gained foothold in regulated and competitive markets and are realizing significant export revenues from traditional sectors such as fish, cut flower and fruits. DNA techniques are being applied to convert oil palm, once known only as a consumption item to produce bio-diesel; molasses from sugarcane is used to produce ethanol and methanol all of which have great potential to reduce reliance to replace petroleum based fuels[4]. These new and emergent *distributed knowledge bases*[5] will translate new forms of industrial organization in developing countries as well as new institutional arrangements. The distributed knowledge base for aquaculture is shown in table 4 and illustrates the ways in which the above technological convergence is leading to completely new ways of organizing production. For instance, the fish farming sector, a notably low-tech[6] activity presently employs new materials, design concepts employed in satellite communications, and sonar technologies among others.

Another area of significant change is the inclusion of advanced digital techniques in what used to be purely mechanical instruments. While scientific instruments may have become costly in certain respects, they provide opportunities for transforming traditional sectors in which developing countries have comparative advantage[7].

Table 4: Activities, Technologies, and Scientific Knowledge Bases in Aquaculture.

Activity	***Technology***
Construction of Ponds, moorings, cranes, lifting-equipment boats	Materials technology, wave analysis, hydrodynamics , surface technology, construction- and welding technology, Information technology, CAD, CAM,
Monitoring	Sonars, information technology, computer imaging, electronics, advanced mathematical algorithms, acoustics, optics
Health, laboratory services, vaccines, chemicals	nutrition technology, bio technology, electromicroscopy, gas technology, thermodynamics, marine biology, chemistry hydrodynamics
Feed	process control, industrial processes, chemistry, marine biology, hydrodynamics, extrusion technology, monitoring technologies, information technology, nutrition technology
Feeding Machines	materials technology, information technology, telecommunication, electronics, cybernetics high pressured air technologies, robotics, welding technology
Measurements and manipulation of colour and fat	nutrition technologies, biotechnology, spectro photometer, bio physics, computer tomograghy, NIT, NIR, NMR spechtrography, 3D measurements, visions and camera technology, marine biology

[4] This study provides extensive case studies.
[5] A distributed knowledge base is “a systematically coherent set of knowledge, maintained across an economically and/or socially integrated set of agents and institutions” (Smith 2002: p.19).
[6] Other sectors considered low tech use scientific and technological knowledge extensively and in many respects including food processing, printing, and wood processing and so on.
[7] Mechatronics, the integration of mechanical devises with electronics components has for instance made major impact on the manufacture of precision machines, automobile, among others and has led to greater efficiency and pollution reduction in industry both in developed and developing countries.

Measurements and manipulation of stress before slaughtering	high pressured liquids, chromatography, magnetic resonance, biophysics, marine biology
Slaughtering, Filleting	mechanical industry, mechanics, information technology, acoustics, optics
Sorting, counting and weighing of fish	mechanical industry, information technology, electronics, laser technology, mathematical algorithms, optics
Fish processing, refinement	mechanical industry, freezing technology, information technology, programmable logical systems, robotics, optics, acoustics
Conservation, cold storage	materials technology, refrigeration technology, gas technology, NMR spectroscopy, thermodynamics, transport theory, biology, electronics
Trading of fish	information technology, telecommunication, signal processing, electronics
Transport and Transport equipment	material technology, mechanical industry, welding technology, refrigeration technology, gas technology, telecommunication, signal processing, thermodynamics

Source: Smith (2002)

2.2 Industrial Applications of ICTs

In the 1980s, main-stream firms began to use in-house ICTs such as Computer Aided Design/Computer Aided manufacturing (CAD/CAM), and CAE, but by the 1990s, firms began to adopt new advances in ICTs particularly the use of network technologies for intra-firm co-ordinating activities. Large corporations connect distant production facilities in order to create greater networks and reduce transaction costs. Traditional sectors such as garment adopted industry-specific ICT techniques[8]. By the beginning of the twenty-first century, the adoption of ICTs for inter-firm commercial and non-commercial transactions was widespread.

While many manufacturing technologies have been industry-specific, business organisations and other institutions have applied networking technologies, including the Internet on a general basis. Due to the unprecedented developments in communication and Internet technology, new trajectories of network technologies have emerged varying from the simplest forms, such as e-mail, to more complex forms such as portal-based technologies. Although these technologies are not activity-, firms- or industry- specific their adoption is influenced by firm- and industry-specific factors. Presently there is relatively widespread use of ICTs by firms in developing, as well as developed, countries in all business activities.

There is a difference between electronic commerce (e-commerce) and electronic business (e-business) technologies. According to an OECD (2002) study, examining the application of ICTs in commercial activities, defines e-commerce as "… the sale or purchase of goods or services, whether between business, households, individuals, governments, and other public or private organisations, conducted over computer mediated networks. The goods and

[8] In the garment-manufacturing sector, companies such as Gerber Garment Technology and Laser Lectra developed specific tools for marker making, fabric cutting, and computerized embroidery.

services are ordered over those networks, but the payment and the ultimate delivery of the good or service may be conducted on or off-line" (pp89). This differs from e-business, a term that encompasses the application of ICTs in all business processes from office automation, production processes, co-ordination with other plants, customer relation management, supply chain management, and to the management of distribution networks (Lal, 2004).

Broadly speaking, there are three modes of e-business transactions. These are off-line, on-line, and e-business using shared or individual portals. Off-line e-business is enabled by electronic messaging systems, which are comparatively less effective than other forms of e-business tools. Off-line e-business is normally done through e-mail systems while on-line e-business transactions take place with company web sites although having a web site does not necessarily mean that an enterprise is able to process on-line e-business transactions. Web sites must be dynamic and should have on-line transaction facilities such as Active Server Pages (ASPs) that allow online transactions. The most effective way of doing e-business is through portals. Portals are the essential additions in network technologies and fulfill an important role of aggregating contents, services, and information on the net. Broadly speaking, their function on the net is to mediate between users (buyers) and web contents. This unique position enables portals to leverage marketing and referrals, as they are intermediaries between web users and companies.

A number of empirical studies of ICT in industry show widespread impact and numerous benefits of ICT adoption. Industrial application of ICTs lead to reduction in co-ordination costs and promotes efficient electronic markets (Damaskopoulos & Evgeniou, 2003; Lee & Clark, 1997). A study of East European and Cyprus SMEs show that firms establish web sites to reduce cost, ease the search for new markets, and to augment competitiveness (Damaskopoulos and Evgeniou, 2003). The study concluded that "….e-business affects first the boundaries of the firm with the market in which it operates".
A number of studies have examined the impact of web-enabled technologies on the export market development (Hodgkinson & McPhee, 2002). A study by Teltscher (2002) deals with the fiscal implications of e-business, while Drew (2003) investigates the causes and consequences of the adoption of e-business by SMEs in East of England. Following an analysis of the total value of transactions conducted through electronic means and its implication on fiscal policies of developing and developed countries, Teltscher (2002) observed that "…an increasing number of e-commerce businesses are small entrepreneurs…" and "… the fiscal impact of international e-commerce is likely to be felt more strongly in the developing countries….". The findings of Drew (2003) suggest that SMEs are placing e-business at the centre of their technology strategy. The majority of the sample firms reported that the driving force behind e-business adoption has been opportunities for growth and the need to remain competitive. Hodgkinson & McPhee (2002) conclude that international networking by SMEs brought knowledge to the region that facilitates intra-firm learning. The study further suggests that adoption of the Internet by SMEs is higher, albeit marginally (68.8%) than large firms (66.7%).

In the context of developing countries, several studies (Moodley, 2002a; Moodley, 2002b; Goldstein & O'Connor, 2002; Goldstein, 2002) have examined the adoption of e-business by manufacturing firms. Moodley (2002a) did not find sufficient evidence to support the argument that export-oriented apparel firms in South Africa gain more in adopting e-business due to its promise of improved market penetration and its direct link to international competitiveness. Moodley's (2002b) findings on the South African automobile industry are similar.

Goldstein & O'Connor (2002) summarised the findings of several studies and concludes "…as multinational corporations integrate the Internet into their cross-border business operations, firms from developing countries run the risk of exclusion from global value chains if they cannot establish electronic ties with their major business partners." They also argued that, despite these general remarks, an evident need persists for detailed sectoral analysis of the adoption of e-business. A case study of one of the top automobile firms (Fiat) by Goldstein (2002) suggests that while the company has been very successful in optimising supply-chain management in Brazil, it has not been able to do so in India. The study further reveals that the use of the Internet by the company in India (Fiat India) has been limited to knowledge management, R&D, and marketing. In other words ICT are differentially adopted depending on context – specificity.

In Africa, a number of studies have been carried out in recent times that focus on industrial and sectoral determinants of ICTs adoption and applications in Africa (Oyelaran-Oyeyinka and Lal, 2005, 2006; Moodley, 2002; Oyelaran-Oyeyinka and Adeya, 2004; Oyelaran-Oyeyinka, Lal, and Adeya, 2006). According to these studies, the adoption of ICTs is likely to promote greater productivity within the enterprises. However, the effective use of e-business tools at the enterprise level is strongly conditioned not by a single factor, but the availability and interaction of a host of external elements such as access (broadly defined), diverse range of skills, telecommunication network, and good physical infrastructure.

3.0 Industry Structure and Sectoral Differences

Results of different country-level studies across sectors suggest there are industry-specific factors that influence the degree of the adoption of ICTs. The intensity of adoption in the skill- and knowledge-sectors, such as electrical and electronic goods sector, was found to be higher than in labour-intensive sectors such as garment, auto-component manufacturing, and food and beverages. Another factor derived from the skill-intensity of a sector, that is, the knowledge and academic qualifications of managing director/owner is another factor that appears to have played an important role in influencing the intensity of new technologies adoption.

According to Oyelaran-Oyeyinka and Lal, 2004, the intensity of ICT tools adoption was not affected by factors such as profitability, size of operation, age of firm, and per capital investment at the industry level. However, there are significant variations in the conduct and performance of firms that employed the lowest levels of e-business tools from the more advanced users of new technologies within an industry.

3.1 External and Internal E-business Technologies

Certain factors have been identified as major determinants of the intensity of internal e-business technology adoption. In this paper we make a distinction between external technologies: those that are needed for e-business but beyond control of individual firms and internal e-business technologies: tools that are acquired, implemented, and managed by firms.

Quantitative and qualitative analyses show that the considerable country differences in the variables that emerged significant in influencing the intensity of e-business technology. For instance in India with superior network and telecommunication facilities the key determinants of e-business adoption in Indian firms were size of operation, export performance, profitability, value addition, skill intensity, and academic qualifications of the managing directors. However skill intensity, size, profitability, learning processes, and technological collaboration with foreign firms influenced Ugandan Firms. Comparatively, the factors that emerged as significant for Nigerian firms are the knowledge base and academic qualifications of the managing directors, skill intensity, internal competition, and learning opportunities.

What these mean is that what tend to influence firms' propensity to adopt e-business at any historical period reflect the country's technological infrastructure, human skills and capabilities. One of the major implications of the comparative African study is the required emphasis on formal training in addition to on-the- job training. India recognized this need and over the last two decades, established a network of training institutions in the various Indian economic zones to provide the requisite skills to build a bridge between formal knowledge and informal factory level skills. In both Nigeria and Uganda, a vibrant private ICTs business services sector has emerged and although Nigeria seems to be far further ahead, it is less advanced and much less organized than the training culture in India. The role of the state has certainly proved beneficial and points the way to the potential for private-government partnerships. In this model, the governments provide logistic support to private institutions to establish training centres in industrial clusters. There is now considerable empirical evidence that close proximity of manufacturing firms to training institutions in such cluster settings has the advantage of facilitating practical training to trainees Piscitello and Sgobbi (2004).

Another recommendation of the study is that the provision of technological and marketing support to firms in developing countries would enhance their ability to compete in international markets. This can be achieved by setting up separate export promotion councils at the sectoral level. These councils performs functions such as assisting small firms in exhibiting their products, providing information on markets trend, and by tendering legal services in case of disputes. Export promotion councils can also play a major role in augmenting export performance by assisting in the acquisition and implementation of the latest manufacturing technologies. As well, measures need to be taken to encourage competition in domestic markets as strengthening competitiveness in the domestic market is expected to have positive impact on a firm's global competitiveness.

Much remains in our understanding of the network determinants of enterprise performance as a result of new technologies adoption. More importantly, there are bi-directional relationships among several factors that could emerge significant determinant of ICT adoption although no study will be able to identify all the causal relationships. The different studies cited identified the factors that influenced only one component of e-business technologies. For these reasons, further research is needed to identify and analyse the determinants of external e-business technologies in different contexts.

4.0 ICTs and Skills Impact

In a number of developed and developing countries, empirical literature shows evidence of continuous development of skilled workers, particularly those with tertiary education, over time. However, contrary to conventional wisdom, underpinned by the demand and supply argument that wage inequality will be attenuated by an increase of skilled workers, the wage inequality between skilled and unskilled workers seems to be growing (Piva, Santarelli and Vivarelli, 2003). This assumption draws on the historical evidence dating from the industrial revolution when machines and low-skilled labour replaced the artisan. Underlying this change is the emergence, diffusion and use of knowledge, particularly scientific and technological knowledge that has reached its full manifestation in the new technologies of ICTs and biotechnology.

The form (i.e. digitally coded information), content and the way we use different forms of technological knowledge has been transformed by rapid changes brought about by new technologies, while the mechanisms of skills transfer have been altered significantly by advances in microelectronics. The new competition Best (1990) as well as the changes in the economic contexts particularly the liberal regimes of trade and production, are equally significant factors (Lundvall and Johnson, 1994); (Johnson, Lorenz and Lundvall, 2002); (Ducatel, 1998). There is renewed debate on the most appropriate mix of skills and the most important sources of knowledge accumulation in a new knowledge-driven economic context. Discussions are likely to continue on how to assign relative weights to formal and non-formal knowledge in firms, and the underlying conceptual dichotomy of tacit and codified knowledge.

Despite the burgeoning empirical evidence from the highly advanced countries, we are far from a full understanding of the most important determinants of the "skill bias effect" often associated with both technological and organizational changes. According to the notion of "skill bias effect," the reason for the rising skill content of the labour force is due to the accelerating rate of technological change; wherein technological change induces the demand for better-educated and skilled workforce (Arrow, 1962); (Nelson and Phelps, 1966).[9] Sectors that experience rapid technological progress would be inclined to hire workers that are more educated because this group has far less need for training in basic skills and constitutes a ready innovation asset within firms. The corollary is that technological change will in turn stimulate the demand for more knowledge intensive and skilled labour. There is preponderance evidence of a positive association between the rate of technological progress and the demand for an educated workforce. (Berman, Bound and Griliches, 1994) working at the sectoral level, found positive correlation between R&D and skilled labour in the United States. (Bartel and Lichtenberg, 1987) also showed, using industry level data, that manufacturing industries in the 1960-80 period exhibited greater relative demand for educated workforce in sectors with newer vintages of capital.

In addition to technology induced skill effect, organizational change also seems to underlie the changing skill composition of firms. Introducing ICTs, for example, tend to change the ways decisions are made within organizations by "flattening" hierarchies and promoting

[9] According to these authors, experience gained in the process of operating a given technology or new technology results in increased efficiencies and as such an educated workforce will be more amenable to learning complex technologies.

greater involvement of the workers in management (Caroli, 2001). Facilitation of greater interaction as well as information exchange at the factory level would tend to promote worker productivity. However, while the evidence is mixed regarding the productivity-enhancing impact of ICTs, there is greater evidence of the nexus of new technologies and the emergence of new forms of organization[10] (Brynjolfsson and Hitt, 1998). What this implies is that firms have to manage technological and organizational changes simultaneously, putting a demand on the resources required for technical, skill and organizational upgrading. As (Guellec, 1996) observed, "human capital and technology are two faces of the same coin, two inseparable aspects of knowledge accumulation. To some extent, the same can be said for physical capital. Accumulation of these factors goes hand in hand with innovation: one does not accumulate billion dollars of wheelbarrows or train millions of people as stonecutters. Only the appearance of new devices makes it worthwhile to invest and train."

Developing countries are not insulated from, and indeed have much more to lose if, they do not engage in the debate to find ways to survive in the new environment of rapid technological and organizational changes. There are two reasons for this. The first is that all societies, regardless of their level of development, need to process and use knowledge. As (Metcalfe, 2003) observes, "every economy, always and everywhere, is a knowledge economy; for social systems and economies as social systems, could not be arranged otherwise". The second reason stems from the well-debated notion that the growth, validation and transfer of knowledge is a socially distributed process mediated by institutions (Lundvall and Johnson, 1994); (Metcalfe, 2003); (Ducatel, 1998). However, institutions of knowledge in poorer developing countries are weak and in most cases absent. Small firms often lack the resources for innovation and tend instead, to concentrate on achieving the nominal production capacity with which daily routine is ordinarily concerned.

The most significant lessons of the new economics of information in relation to formal as well as informal education are:

- Lack of investment in human capital, not a lack of investment in physical capital, prevents poor countries from catching up with rich ones. Educational attainment and public spending on education are correlated positively to economic growth (Barro and Sala-i-Martin, 1995; Benhabib and Spiegel, 1994).
- School quality measured, for example, by teacher pay, student-teacher ratio, and teacher education is positively correlated to future earnings of the students (Card and Krueger, 1992).
- Education is important in explaining the growth of national income. Life-long learning is an important part of this (Aghion et al., 1998).

On all these three, developing countries have to invest substantially to raise the level of formal human capital to match the wide ranging changes brought about by ICTs, see Box 1 for the emerging definition of ICT-related skills.

10 According to (Piva, Santarelli and Vivarelli, 2003)) new forms of organization include decentralization and delayering ("lean production") examples including just-in-time management; collective work such as "quality circles"; and multitasking which requires workers to master and perform a wider variety of tasks.

Box 1. Defining ICT specialists and ICT users

Box 1. **Defining ICT specialists and ICT users**

Three categories of ICT competencies are distinguished:

1. ICT *specialists*, who have the ability to develop, operate and maintain ICT systems. ICTs constitute the main part of their job.
2. *Advanced users*: competent users of advanced, and often sector-specific, software tools. ICTs are not the main job but a tool.
3. *Basic users*: competent users of generic tools (e.g. Microsoft Word™, Excel™, Outlook™, PowerPoint™) needed of the information society, e-government and working life. Here too, ICTs are a tool, not the main job.

Thus, the first category covers those who supply ICT tools (hardware and software), and the second and third categories those who use them. This paper uses the first category for the narrow measure of ICT-skilled employment, and the sum of all three categories for the broad measure of ICT-skilled employment.
It appears that, increasingly, ICT specialists are expected to have ICT specialist as well as other skills, including "business" skills. Similarly, non-ICT related professions increasingly require at least basic ICT user skills.

Source: OECD (2006)

One important conclusion that was systematically thrown up in the various studies is the differentiated effects of wider sets of firm level skill on the learning processes in SMEs in three developing countries, namely, India, Nigeria and Uganda. Studies by (Oyelaran-Oyeyinka and Lal, 2004, 2005) identified a pattern of adoption that shows clear relationships between internal firm variables and external infrastructure features that influence both the technological trajectories and firm-level performance. There is a certain gradation of adoption that displays skill-technology complementarity. There is net correlation between firms using advanced technologies and the education level of owners and a consistent correlation between learning modes and complexity of ICTs in use. New types of SMEs, called *networked enterprises*, have emerged during the last decade (Raymond, Blili and Thibault, 1999). These firms conduct their production and marketing businesses relying to considerable degrees on Internet-mediated technologies. However, the above set of studies suggest that this phenomenon is not automatic; there is a strong association between the complexity of firm-level e-technologies and the level of national technological capability. There is considerable scope for institutional learning support for SMEs suggesting new and additional challenges for developing countries that, for now, have relatively weak institutions.

Regression results show the relationship between the learning processes adopted by the sample firms and technological trajectories followed by them. Several modes of learning such as in-house training, learning-by-doing, Internet searching, learning-by-interaction, and overseas training were employed by firms depending on their level of development. The results of the study suggest that across countries and sectors, SMEs rely largely on learning-by-doing as the most effective first-order mode of knowledge and skills acquisition. However, the second choice of learning mode differs among sample countries. MDs of Indian firms employed Internet searching as the second best mode of learning, while in-house training is preferred in Nigeria and Uganda. This was traced to the fact that communication network facilities in Nigeria and Uganda are inadequate for effective use of the Internet and a reliable communication network significantly determines the adoption of new technologies. The study's findings also suggest that firms that adopted complex technologies had to employ relatively more skilled workers as well as use overseas training for effective use of such technologies.

Learning processes have also significantly influenced the technological trajectories of the firms, demonstrated in the ways firms in India adopted ICT-led technologies in production processes. For instance, several firms conducted transactions through web-enabled and portal-based technologies while there was not a single firm that adopted such advanced technologies in Nigeria and Uganda. Two factors tend to shape the adoption of advanced technologies by Indian SMEs: first, the accessibility of stable Internet connectivity and second, the availability of requisite technological infrastructure in clusters. Reliable access to the Internet might have encouraged Indian SMEs in the sample to use Internet searching as the second best mode of learning. In contrast, firms in Nigeria and Uganda adopted technologies that do not require on-line connectivity such as MIS, Email, CAD/CAM, CNC machines, and FMS in order to minimize their dependence external communication network. We therefore conclude that learning processes significantly influence the technological profile of firms. To this end, the choice of learning processes depends on other external factors that are beyond control of individual firms.

5.0 The Network Impact: Technological and Physical Infrastructure[11]

In this paper we conceptualize ICT infrastructure as being made up of three components: telecommunications, computing and connectivity infrastructure.
Connectivity infrastructure has four components: (a) the aggregate bandwidth of the domestic backbone(s), (b) the aggregate bandwidth of the international IP links, (c) the number and type of interconnection exchanges, and (d) the type and sophistication of local access methods in use. Internet penetration, defined as pervasiveness, represents the number of users per capita, which proxies either the Internet hosts counts or individual users. The pervasiveness of Internet use is a function among others of access to services, perceived value to users, acceptable costs to users, and ease of usage, which depend crucially on content language. Finally, the structure of the ISPs market is an important factor influencing access. The presence of, and the institutional regimes in which ISPs operate, is also important to market competitiveness and as such, it is also a cost to end-users. For instance, Internet diffusion may be slow where state policies restrict barriers to ISPs entry, or where cultural limitation leads to persistent disparity in girl-boy education, or where security concerns create a regime hostile to competition. Access at the individual level is achieved using modems at early stages of development, while more sophisticated infrastructure, such as leased lines, is used in later stages of development.

National, local, and regional telecommunications infrastructure include server connectors, local loop telecommunication lines, inter-nodal connections, and switching systems among others, and determine the cost and quality of access. Users in high-bandwidth telecommunications environment are likely to have access to lower cost connections. Most developing countries face capacity constraints, largely a result of thin-bandwidth and frequent power outages. At the very basic level, developing countries exhibit highly

[11] This section cites a study reported in a paper by Oyelaran-Oyeyinka and Lal (2005), 'Internet Diffusion in Sub-Saharan Africa: A Cross-Country Analysis', *Telecommunications Policy*, 29 (7), pp. 507-27.

differentiated access to telephone and electricity services, which in developed countries are taken as a given. The quality of physical and technological infrastructure is important for the simple reason that information, coded in files, travel through series of linked nodes within the ICT network. The slowest link in the network node becomes the rate-determining step and thereby defines the overall speed of data transmission, (Dholakia, 1997).[12]

Supply side factors significantly impact on the adoption of new technologies in SMEs. Evidently, availability of physical infrastructure has been a severe constraint in the adoption of e-business technologies in all the three countries. However, there are significant differences with regard to technological infrastructure as represented by availability of Internet connectivity and speed of communication. Human knowledge and skills represented by availability of computer literate workforce, abundant in India, emerged as an important impediment in the adoption of information and communication-led technologies in Nigeria and Uganda.

Six factors, namely: availability of Internet connection, speed of the Internet, availability of skilled workforce, utilities, communication cost, and Internet subscription cost were included in the analysis. Results of multivariate analysis applied to sample firms suggest that all the factors, except the availability of trained workforce, has significantly influenced the diffusion of e-business technologies in India. Country specific factors exert profound influences on the degrees of adoption of new technologies. For instance Nigerian firms using telephone and fax found Internet subscription a severe constraint while 30% of firms using similar communication technology in Uganda reported that it was not a constraint.

Results regarding communication cost and the diffusion of e-business technology in Nigeria and Uganda are very different. Many of the sample firms in Nigeria did not find cost of communication a major constraint while it has been an impediment in Uganda. In Nigeria, firms were so desperate for communication, that access rather than cost had become the primary concern for them. Again, there are substantial differences in the supply of high-level labour with Nigeria having considerably large numbers of scientists and engineers despite their being poorly organized for industrial purposes.

One of the major policy implications of the findings is that developing countries need to focus on institutions that support more efficient physical and technological infrastructure. In turn, efficient physical and technological infrastructure should reduce the cost of communication, which has been identified as a major bottleneck in the diffusion of e-business technologies. Privatisation and deregulation of the communication sector might be an option to achieve this objective.

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[12] For example, a 28.8kbps modem on a home computer may yield a transmission speed of no more than 24.6, a speed loss of 14.5% because of the quality of telephone lines.

6.0 Industrial Transformation and Employment Generation

Concern about the employment effects of ICTs[13] has been apparent since the early stage in the development of ICTs and its adoption in various economic activities. While many view ICTs as a major cause of mass unemployment, others believe that ICTs create many new jobs and give rise to new industries and services (Talero and Gaudette, 1995). In the early stages of ICT adoption, there was considerable apprehension that the adoption of these technologies might result in reduced levels of employment, particularly of semi- or un-skilled workers. This view underlined the programmability feature of ICTs and their capability in handling multiple tasks with a single ICT tool. Therefore, the perception emerged that the adoption of ICTs had a negative effect on employment. It is still believed that ICT tools replace certain categories of workers and lead to a significant rise in unemployment levels. The reasoning has some validity particularly at the enterprise level with respect to existing manufacturing processes.

The adoption of ICTs in labour-intensive activities is expected to result in the displacement of labour while creating a few jobs for the skilled workers needed to maintain the ICT tools. The adoption of ICTs may be labour neutral if there is a possibility of market expansion for existing products or the possibility of creation of markets for new products manufactured on the same assembly lines due to the extensive use of ICTs. This may apply at the enterprise level, but its application at higher levels of aggregation is even greater. In the presence of possible market expansion, the adoption of ICTs could lead to creation of employment for skilled workers; if the market expands fast enough, there may not be a loss of jobs for unskilled workers. However, in order to use ICT tools effectively, firms may need to effect organisational changes and workers may require training to upgrade their skills. The findings of several studies that deal with employment aspect of ICTs are presented below.

Rada (1982) and Kuwahara (1984) found that the adoption of information technology (IT) at the enterprise level from a static perspective leads to the creation of new jobs in some production processes and a loss of workplaces in other activities. The authors also found evidence of the emergence of firms with new activities, which usually fall within the sector, but outside the enterprises. For instance, several new consultancy firms have emerged in the garment sector to provide technical input and technological support to garment manufacturing firms. Although they provide consultancy services in other manufacturing technologies in the garments sector, their main activities are to provide training and consultancy services in the new ICT-based technologies.

Freeman and Soete (1985) found no evidence of an adverse relationship between employment and the adoption of IT. Their conclusions are based on several other studies (Leontief and Duchin, 1983; Kuwahara, 1984; Lawrence, 1984) carried out in developed countries (US, Canada, and Japan). The study by Leontief and Duchin (1983) is a very comprehensive one analysing 89 individual sectors, comprising almost the entire industrial spectrum of the US economy. They conclude that there will be no overall labour surplus due to the adoption of IT at the industry level, even though employment in some individual

[13] The term Information Technology (IT) has been used in studies carried out before the 1990s as the integration level of communication technologies with information technologies was not very high. After the 1990s, and particularly with the introduction of the Internet into the public domain, communication technologies are increasingly embedded with information technologies. Consequently, they are referred to as Information and Communication Technologies (ICTs).

enterprises may suffer. However, the study predicted that the structure of the labour force, in terms of skills and sectoral distribution, might have to undergo some fundamental changes. A study by Lawrence (1984) finds a positive correlation between the industrial adoption of IT and employment growth in Japan.

Peitchinis (1984) studied the employment effects of the introduction of computer equipment and office automation in a number of Canadian manufacturing sectors ranging from food to oil companies. The author rejected the prediction of mass unemployment as a result of IT adoption. On the contrary, his case studies, based on firm-level data, suggest that the employment effects of IT adoption have generally been positive. The results were found more relevant for firms where the demand for their products was not saturated and there was a possibility of production capacity expansion. Firms could generate employment by increasing production capacity and by the adoption of IT. The author, however, observed that in matured industries, there could be employment displacement because of IT adoption. Although the firms covered by Peitchinis were engaged in manufacturing of goods, the study concentrated mainly on the introduction of computer equipment in office automation. Therefore, the results cannot be interpreted as representative effects of IT adoption in manufacturing.

A study by Kuwahara (1984) emphasises the positive employment-generating effects of a range of new technologies in the Japanese economy. Although these new technologies include biotechnology and aerospace, the main emphasis is on IT. The study views microelectronics-based technologies (technologies used to manufacture hardware of information systems, communication equipment, audio/visual devices, and other electronic products) and IT as having creative multiplier effects in other industries and services. The study presents detailed estimates of job creation effects in high technology industries in Japan and presents the estimates categorised into various skills levels. The findings suggest that engineers are likely to be in greater demand than are non-technical workers in high technology industries. Several other studies (Rada, 1982; James, 1994; Rahim and Pennings, 1987) proposed the possibility of structural change in employment. Rada (1982) found evidence of a reduction of jobs at the supervisory level. At the same time, IT tools require a highly skilled workforce for the implementation and use of microelectronic-based systems (Ayres, 1991; James, 1994). Developing Countries (DCs) have experienced similar employment effects of IT. Acero (1995) reported changes in employment structure in a study of the Brazilian textile industry. Acero found that industrial automation and new organisational technologies are seen as contributing to higher employment levels in the technical and managerial category, while the number of occupational categories and labour-intensive tasks is decreasing with the introduction of IT. Sim and Yong (1995) found similar results in their study of the Malaysian telecommunication industry.

Doms et al. (1997) examined the correlation between the shares of non-production workers with the use of advanced technology. The authors found a positive correlation between two variables consistent with the complementarity of skill intensity of advanced technology use. A study of 402 plants in Britain by Kramarz (1998) suggests that the introduction of computers in plants is associated with an increase in the share of white-collar workers at the expense of unskilled workers. Card et al. (1997) investigated the effect of computer use on the employment rates of various age and education groups. Based on their knowledge of the institutional environment of the three countries (US, Canada, France), they expected the greatest negative impact of IT on employment in France. Their hypothesis was that if a similar negative demand shock affects less skilled workers in all three countries, then given the labour market flexibility in the US, the shock should result primarily in a decline in the relative wages of less skilled workers. In France, where labour markets are relatively inflexible, the shock should largely result in a decline in the relative employment of less skilled workers. However, the results do not seem to show this pattern. In the case of the US, results show that groups, categorised by age and education, that use computers most intensively record an increase in group-employment rates. In the case of France (female workers) and Canada, there is no significant relationship between computer use and employment. The US results are based on data extracted from Current Population Survey (CPS) of 1979 and 1989, while Labour Force Survey (conducted in 1982 and 1989) data was used for France. The data for the Canadian sample comes from the Survey of Work History, 1981 and Labour Market Activity Survey, 1988.

In the study by Oyelaran-Oyeyinka and Lal, the impact of ICTs on employment was analyzed using qualitative case study approach to examine the pattern of e-business technologies adoption in large Indian firms. The issues related to the use of e-business technologies in three sectors, namely: ICT producing firms; consumer electronics; and garment manufacturing industry. The firms that formed the basis of the case studies were considered the top firms in their respective sectors.

The study found that the pattern of adoption of e-business technologies is not uniform across industries but the adoption within sectors was fairly similar. The consumer electronics sector firms adopted these technologies in almost all business activities including production, marketing, coordination, supply chain management, and customer relation management; whereas garment manufacturing firms adopted e-mail and internet for interacting with buyers and CAD/CAM technologies in manufacturing process. Common in both the sectors is the adoption of Business-to-Business (B2B) e-business models. However, the Business-to Commerce (B2C) model has been neglected by all the sample firms, surprisingly even by those in the consumer electronics sector. The firms attributed socio-economic factors and lack of institutional infrastructure as the rationale for not adopting B2C model.

Their analyses of firms performance suggest that the adoption of these technologies has enabled the firms to survive in the both the domestic and international markets and has contributed to a better performance irrespective of the measure. The firms started adopting new technologies after the liberalization of Indian economy in 1991, possibly due to competitive pressures from the MNCs that were allowed to enter into the Indian market in the same period. In addition to achieving a high growth rate, employment opportunities increased significantly. The adoption of these technologies created varying levels of indirect employment corresponding to the firms' size and industry. The findings of this study suggest that concepts of resource-based theory and the role of competition can contribute in understanding the adoption of e-business technologies.

However, the study provides no evidence to suggest that the use of new technologies affects a firm adversely. Nevertheless, the adoption of ICTs could lead to changes in the employment structure as ICTs create skill-biased technological change. The impressive growth rate of sales turnover and employment of sample firms may not be solely attributed to the adoption of e-business technologies. Other measures taken since 1991, such as simplified procedures for the import of raw material and machinery, might have also contributed. Hence, the findings of the study need to be interpreted against the backdrop of other economic policies. Another limitation of the study, due to the small sample size, has been the lack of a statistical test of the significance of factors that influenced the adoption of e-business technologies. Further research is needed to examine the impact of e-business technologies on firm-specific factors such as, productivity, quality improvement, and conduct of firms.

6.2 ICTs and Industrial Export Performance

Manufactured export performance has been linked in the literature to strong domestic production capabilities. In this section we explain how ICT infrastructure influences industrial performance through export activities of firms. The review is limited to the Indian sample.
The data on e-business and export, like the one on employment is exclusively based on Indian data which analyzes factors that influence export performance of firms. The study concluded that the type of technology used for e-business and the profit margins were significant factors found to influence the export performance of firms. The scale of operations also emerged as a significant determinant of export performance. The study reveals that the labour productivity of export-oriented firms was higher than that of non-exporting units. These findings corroborate earlier studies.

The study captures the important role played by the type of technology used for e-business by the sample firms in influencing their export performance, although identification of the various factors that influence the adoption of e-business technologies is beyond scope of this paper. It also became evident that a good communication technology network is a driving force behind the diffusion of e-business and export success. This is confirmed by the study's finding that diffusion of e-business is strongly associated with available bandwidth. The study points to the imperative to create a strong network environment for greater diffusion of e-business technologies that in turn could augment the export performance of firms.

There are two implications of the focus on e-business and export performance. One, an appropriate environment for the effective adoption of e-business has to be in place. The limited use of e-business will have serious repercussions on the performance of firms in international markets. If firms that deal in international markets are unable to strengthen their e-business applications in areas such as on-line financial transactions and monitoring of status of consignments, they are likely to lose foreign partners. Although government in all the countries have taken some measures to encourage greater diffusion of ICTs, reliable access to high-speed communication networks at competitive price should be a major objective. This factor enhances the diffusion of e-business technologies, which is in turn promotes export performance. The formulation and enactment of communication technology convergence regulations can facilitate access to a broad range of communication networks. For instance, if last mile connectivity is allowed through the cable network, which is primarily meant for video communication, it could trigger an explosive adoption of e-business. Governments can also encourage the adoption of this new technology among export-oriented firms by continuing export incentives such as tax holidays on the value of goods and services traded electronically.

The second implication relates to policies on collective learning and training facilities aimed at SMEs. The study has shown that the incorporation of e-business practices, coupled with a highly skilled workforce enable firms to perform better in export markets. Hence, policy makers need to target learning and training facilities for SMEs. Providing logistical support to industry associations located in SME clusters is one means of achieving this objective. In turn, industry associations can take advantage of linkage programmes such as 'Industry-University link' program initiated by the Government of India to produce skilled labour for SMEs. It was concluded that it is imperative for governments to provide proper institutional support to export-oriented firms for the effective use of e-business, which would strengthen export performance. Based on the findings of this study, countries are advised to take proactive measures to speed up the adoption of e-business or risk losing its export share in the international markets.

7.0 National Policies in an ICT-driven Industrial Context

The various studies cited in this paper suggest several policy implications. First, industry and enterprises particularly SMEs need institutional support for their survival in the era of globalization. Second, human development policies aimed at firms need to emphasize both general and specific knowledge types and training; the adoption of advanced e-business technologies by Indian firms is a proof of this point. For instance, the Government of India (GOI) and the private sector shared the burden and the risk as the GOI encouraged private sector participation in the development of the industrial clusters' technological infrastructure. Consequently, SMEs in India have better access to web-enabled and portal based e-business technologies relative to the two African countries. In Africa, the study found that SMEs need much greater infrastructural support in order to reap the benefits of ICTs and develop the capabilities to contribute to economic development. Policies and programs aimed at providing required infrastructure need to be initiated in developing countries in order to make SMEs in developing countries more competitive in the domestic and international markets. One of such policies is the provision of *collective services.*

7.1 Collective Services and Competitiveness

Due to the well known resource constraints faced by small firms, the provision of collective service is an alternative way of promoting enterprise level growth and innovation. The role of collective services differs at different levels development and as such the roles of ICTs are to be differentiated. The Oyelaran-Oyeyinka and Lal (2004) study identify and analyse the factors that discriminate three groups of firms, namely: low level of ICT users, moderate ICT using firms, and users of advanced ICT tools. Firm specific factors included in the analysis fall into three broad categories: driving forces, collective actions, and sources of competitiveness. The variables in the analysis include management information systems benefit, reduction in production costs, abilities of ICTs in increasing sales turnover, potential to strengthen competitiveness of firms, efficiency in production process due to adoption of ICTs, learning opportunities within industrial clusters, size of operation, technological collaboration, innovativeness, low overhead costs and wages, flexibility in product design, and product quality.

The variables that discriminated different levels of ICT using firms were: the contribution of ICTs in reducing production costs, augmentation of sales turnover due to adoption of ICTs, and internal competitive pressures. Among the sources of competitiveness that emerged significant were size of operation, technological collaboration, and the contribution of ICTs in manufacturing modular and high quality products, innovativeness, and ability of ICTs in reducing overhead costs. For instance, wages emerged an important factor in the Ugandan sample firms. The significant variables for Nigerian firms were: reduction in production costs, availability of learning and upgrading opportunities within industrial cluster, size of operation and delivery schedule. The factors that emerged significant discriminants of the varying degrees of firms using ICT in India were similar to that of Uganda. An additional factor, the contribution of ICTs in inducing efficiency in production processes emerged as the most important discriminant of three types of firms. Among the sources of competitiveness, the ability of ICTs in strengthening the market network also discriminated firms using advanced ICTs from the others.

Ownership (shown in the opinion of MDs) is important to what kinds of e-business tools are adopted, so also is technical collaboration. This was poignantly illustrated in the way technological collaboration has been fostered with foreign firms in India sample firm since the liberalisation of Indian industrial policies in 1991. With liberalization, Indian firms no longer required any license for collaboration. Market network emerged a significant discriminant in Indian sample firms and not in firms in the other two countries due to the availability of relatively reliable communication network in India compared to the other two countries. The significance of low wages and low overhead costs as important discriminants in Ugandan firms suggest that, apart from quality competition, price remains a dominant mode of competition.

A number of policy measures to be taken by governments in developing countries to improve the competitiveness of MSMEs are evident. First, state policy should encourage greater private sector participation in setting up training and information service centers within industrial clusters. These institutions could provide need-based skills for better usage of new technologies. Second, owners of small firms should be given incentives to upgrade the skills levels of their workforce. This could be done by organizing orientation programs to raise awareness of MDs related to new technologies. As well, there is need to subsidize the cost of new technology equipment so that new technologies become economically affordable to small firms. New technologies can be put within reach of small firms by setting up technology service organizations to provide for instance, e-mail and Internet services. Setting up technological support institutions has many advantages in SME clusters. These institutions could be useful in searching function- and job-specific ICT tools that are expected to be efficient and cost effective. Such collective cluster initiatives should result in better cluster performance.

Finally, the findings in this study suggest a need to create proper local, national, and global information infrastructure in order for SMEs to derive the maximum benefit from the ICT revolution. Privatisation and deregulation of communications sector could improve local and national infrastructure, while allowing private and public sector organisations to own international gateways can significantly improve the global information infrastructure. However, in underdeveloped areas, governments will have to take the lead in stimulating service provision, see Boxes 2 and 3 for training and education programmes in advanced industrial countries.

Box 2: Promoting IT education

Box 2: Promoting IT education

Most responding countries have programmes for promoting IT education. The programmes mentioned all aim at improving quality and spreading skills more widely, but are diverse, and each country has its own specific focus. Initiatives include the following:

- Basic IT education for the population. The Czech National Programme for Computer Literacy consists of practical, two-hour courses to teach participants the fundamentals of computer work, Internet access, the basics of searching via the Internet and work with e-mail.
- IT education in schools and universities. The Spanish Avanza Plan covers education in the digital era, with a specific focus on integrating ICT technologies in the educational process. The initiative includes measures to increase use of the Internet by those engaged in the education fields and to improve trust in technology.
- Training for specific groups such as the unemployed, women or the elderly. Korea has IT training initiatives that target the disabled, the elderly, low-income earners, North Korean defectors and the illiterate.
- Training for government workers. The Italian CNIPA Programme for e-learning in the public administration includes a series of e-learning projects divided into three categories: top managers, middle managers and clerks. The ultimate goal is to create a virtual public administration school.
- Teacher training and the use of ICT for broader education. Hungary promotes the development of basic ICT skills, competencies and abilities in pre-school and school education by supporting in-service training of teachers and experts, thereby enabling the delivery of competency-based education and training.
- Distance learning. Belgium has an initiative for distance learning, focusing on just-in-time courses that are relevant for specific job requirements.
- Setting IT skill standards. Japan's METI published "IT Skill Standards" to indicate the abilities required to provide IT services. The Skill Framework summarises 11 careers and 38 job categories related to the information service industry. It classifies seven levels based on the abilities and experience of individuals in each career and job category.
- Promoting awareness for career development. In the ICT sector, Canada's Department of Human Resources and Skills Development (HRSDC) is financing a number of programmes with the Software Human Resource Council (SHRC). SHRC also addresses career awareness and skills development with the goal of providing lifelong career development and quality education and training for Canadians active in the IT sector.

Source: OECD Information Technology Outlook 2006

Box 3: General content initiatives

Box 2: **General content initiatives**

Austria: Austria provides financial aid to SMEs for preparation costs for participation in eContentPlus projects. The initiative Multimedia Business Austria also supports the Austrian content industry, with a goal of increased participation in international expert networks and the formation of a national cluster.
Denmark: Denmark has many initiatives for digital content for literature, music, research, museums and cultural heritage.
Netherlands: Content development is primarily market-driven (commercial), but in specific areas, such as

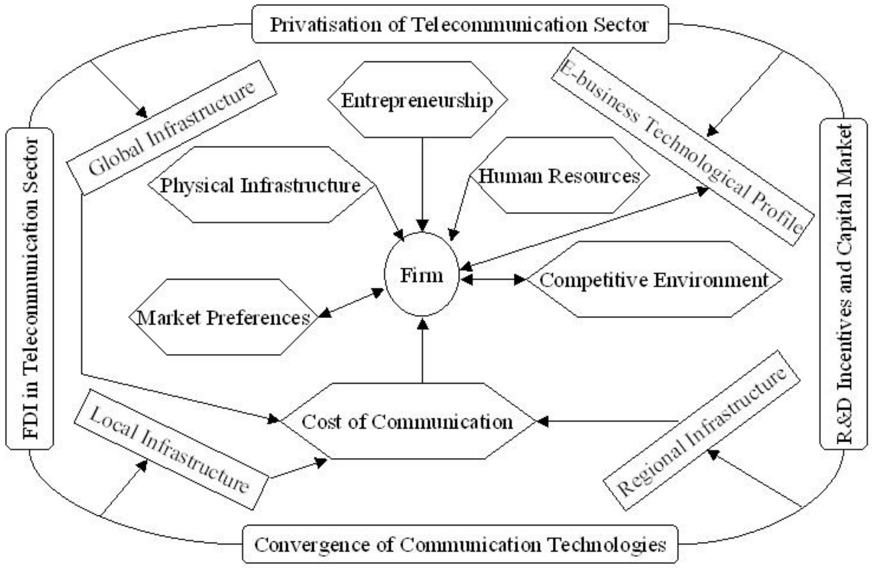
education, digital heritage and e-culture, the government supports production and distribution.
New Zealand: The One Digital Strategy initiative aims to achieve better online content by developing an online cultural portal.
Singapore: Under the iN2015 plan the interactive and digital media sector will receive special R&D support. Singapore will continue to support the Games Exchange Alliance to accelerate commercialisation, a digital media and entertainment hub for technology creation and commercialisation that provides storage, trade and distribution services for digital assets, and infrastructure for processing, management and delivery of content services.

Source: Responses to the OECD IT Policy Questionnaire, 2005 in OECD Information Technology Outlook 2006.

8.0 Proposed Methodology

In the recent past, the debate about the different factors that influence the innovation strategy of firms did not take much account of the role of ICTs. However, the need for faster integration of dynamic SMEs into the global economy and the concerns for the relatively slower process of globalization of small producers in poorer developing countries has broadened the debate on the possible roles of ICTs. Although they do so with different internal technological and other assets, both poor and rich countries, large and small firms face substantially similar technological and external economic conditions. In addition, local, regional, and global policies influence the conduct and performance of firms. A framework linking these factors and the performance of SMEs is depicted in Figure 3. Since the objective of the programme might be to understand industrial and employment transformation as well as the institutional infrastructure factors affecting the adoption of ICTs - importantly by telecommunication policies - the analytical framework provides a number of related variables that might be worth examining.

Figure 3: An Analytical Framework



Source: Author

As figure 3 shows, a number of factors should be considered in designing national and sectoral level research which include FDI I telecommunications, infrastructure, and human resources. For instance, the ability of a country to attract FDI in the telecommunications sector coupled with a liberalized economic regime might be expected to bring drastic changes in a country's communication network. Although several other issues, such as technology convergence and R&D incentive, are included in the framework, they are not discussed here in detail, and other national specific variables could be included.

Apart from communication technology policies, other factors also influence the adoption of new technologies which include:

- The competitive environment (Pratten, 1991),
- Skill composition of the workforce (Doms et al., 1997),
- Market preferences (Lal, 2004),
- Cost of communication (Mehta, 2000), and;
- Entrepreneurship (Drew, 2003).

The above point to the factors that are external to firms, namely, technological infrastructure, human resources, and physical infrastructure available to firms. These are the supply side factors that influence the adoption of e-business technologies, which differ from other innovations in many respects (Pohjola, 2001). For instance, its economy-wide pervasiveness means that it involves a wide array of actors and as such exerts profound systemic impact on national economies. These actors include communication technology providers, Internet service providers, and information providers. The costs associated with communication network, Internet services, and availability of information in public domain are some of the other factors that influence the diffusion of e-business technologies.

Another significant aspect of ICT is the network speed. This has two main components: first, the speed with which signals can travel along the communication network and second the speed of information processing systems (servers subsequently). Although, the capabilities of the information processing servers installed at local, regional, and national level, determine the network speed, the major factor is the processing speed of the immediate Internet service provider. For these reasons, the adoption of e-business technologies encompass several factors including a reliable high bandwidth communication network, competitive telecom services, and an available quantity of quality Internet service providers. As well, as the force of competition tends to shape the attitude of enterprises to the adoption of innovations, the level of competitiveness of firms operating in the same product market is another factor influencing the e-business technologies adoption. Although much has been written about the broad impact of physical infrastructure and human resources on innovation, they are likely to affect the adoption of e-business technologies in very specific ways. National and global data are relatively easy to obtain and should form an important set of variables.

In sum, there are a wide array of issues to choose from much of which have been highlighted in this paper. However, we still require considerable firm and industry level studies to understand the dynamic impact of ICTs on industry and employment in Africa.

A Research Framework for Sectoral Innovation System

Both the quantitative analysis and the case studies could be approached by specifying common building blocks of the sectoral system of innovation. A sectoral Innovation System (SIS) has its own **knowledge base** and **learning processes**, it has **specific technologies**, **systems boundaries, institutions** and **interactive activities**.

The basic elements of the SIS are:

- ***Actors or agents***: include individuals and organizations. Individuals include enterprise owners, and engineers/ scientists; while organizations include enterprises universities and firms, R&D departments, financial institutions such as development banks. Special attention should be paid to ownership structures (whether firms are owned by multinationals or local entrepreneurs). Ownership structures create different sorts of incentives with regard to innovation. The size of enterprise is equally important for its relationship to choices of products, techniques of production, ability to generate capital for investment and is usually also related to the level of education of owners and the opportunities available to them for learning on their own if a good extension system is not in place.

Knowledge and Learning Processes:

One of the reasons for the persistent differences in the innovative capacities of sectors and industries is the gap in the knowledge bases. Organizations and individual capabilities differ

in their scientific and technological skills and experiences. The habits and practices of the actors regarding how and what they learn for instance, diversification into new peripherals clones, services and so on.
The research should therefore carefully examine the different knowledge bases and he processes of learning.

Suggested Outline for the Background and Case Studies

The earlier section explained how the framework can help identify the types of actor and the types of interaction needed to bring about innovation; and that it can identify and design the types of habits, institutions, policies and other interventions that can create this pattern of interaction and linkage in dynamic environments. This section suggests an outline of the key elements to be explored in individual case studies. The approach combines the use of secondary sources of information and interviews to develop an understanding of historical patterns of development in order to provide context to an assessment of the current situation and the challenges being faced. The scope of this approach would include a systemic survey of actors in the sector, and the construction of detailed case studies.

The main section headings below could form the section in the case study report that complements the detailed systematic survey report.

1. Sector timeline and evolution.

What is the nature and dynamics of the sector? Who are the main players? What has been the performance of the sector to date? What challenges does the sector face? How effective have policies and support structures been in triggering innovation and developing a dynamic innovation capacity?

Rationale
One or a combination of things usually triggers new sectors or clusters of activity. This maybe policy or market changes or it may be the result of the intervention of a multinational corporation (MNC). There are many different types of **trigger**s and these present different contexts, which policies supporting innovation have to deal with. It is therefore important to understand these triggers. There may also have been a series of turning points in the lifecycle of the sector. It is important to understand this historical pattern of development as it is usually the case that current patterns of activities, roles and relationships have developed incrementally over time and cannot be fully understood without a historical perspective and an understanding of the local policy and institutional context that has shaped this. It is also important to highlight that these are evolving; dynamic sectors and that innovation capacities must be able to support that evolution. It is important to understand why sectoral changes occur where they do and why firms switch to different activities and what were the resources, linkages and capabilities that allowed then to do this and how this response related to local contextual conditions, particularly the institutional and policy setting.

Key questions for this section will include.

- When did the sector start to develop?
- What were the factors that triggered its emergence?
- Were these technical, policy or market or other triggers? For example changes in trade rule, the opening up of new markets.
- Who were the main players who initiated this and what were their characteristics – public, private, elite groups of farmers, local or foreign companies, international development agencies?
- How has the sector grown and evolved over time? Have there been any major market, technology or policy changes that have caused it to evolve in new ways? What were the turning points along the way? For example the switch from set of computer products to another, or the switch from domestic to international markets?
- What other dynamics took place in the sector? For instance declining world product prices, or the entry of new competing countries? Were there changing patterns of linkage or capability in the sector to cope with these dynamics? Or where there features of dynamics in the sector that set up distortion that organisations couldn't cope with leading to exit, decline or alternative paths.
- **Put Sector statistics**. Value, size, growth rate, employment potential, nature of domestic and international market.

2. Sector mapping

Central message and diagnosis from this section

- Who are the main actors and organisations in the sector, what role do they play and what are their skills and competencies?
- Which actors and competencies are missing are policy required to change the role of the public sector or to encourage others to play different roles or play existing roles more effectively?
- What is the extent of linkage between actors and organisations, what is the nature of these links and does it support interaction and learning?
- Which links are missing links are missing and what types of linkage need to be encouraged?

3. Innovation Policies

The role of policies in strengthening learning, investment and linkages that constitutes the bases for dynamic innovative change on a continuous basis. Research would map policies that directly or indirectly affect technological capacity building, learning, linkages and investment within the computer system of innovation. These might include:

(a) Policies affecting size and shape (demand characteristics) of the domestic market, e.g. taxation, wages;

(b) Policies that affect input costs or outputs for entrepreneurs for example land prices and use ;

(c) Policies that change the nature of competition, foreign investment, and those that promote local upgrading and linkages between foreign and local agents;

(d) Policies that change or make possible access to training for vendors and manufacturers.

(e) International rules that affect learning and innovation.

(f) Local capabilities and the ability to bargain in global markets and sustain competitiveness, for instance, how well each country is able to diversify into new markets; the development of substitutes. Innovation policy instruments are summarized in Box 1.

Box 1: Innovation Policy Instruments

Supply Side: (a) Support for knowledge infrastructure particularly R&D in public and private domains, promote research and professional associations, use of competitive research grants; (b) general and technical education, support university research, apprenticeship programmes. (c) Information networks, library and database services.
Macroeconomic Conditions: (i) Loans, subsidies to private provision of innovation, financial services, export credits; (ii) taxation: company, personal, indirect and payroll taxation and tax allowances; (iii) Legal regulatory: patents, health and environmental regulations and monopoly regulations and competition policy.
Demand Conditions: (i) Procurement policy**:** central and municipal government purchases and contracts, R&D contracts, purchases; (ii) Commercial instruments: trade agreements, tariffs, currency regulation.

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