How can Africa Benefit from Globalization?:

Global Governance of Technology and Africa's Global Exclusion

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List of Abbreviations and Acronyms

CI	Competitiveness Indicator
DFI	Direct Foreign Investment
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
ICTs	Information and Communication Technologies
ILO	International Labour Organization
IMF	International Monetary Fund
IPR	Intellectual Property Rights
ISP	Internet Service Provider
IUI	Internet User Index
LDCs	Least Developed Countries
NGOs	Non Governmental Organizations
ODA	Official Development Assistance
PC	Personal Computer
PSTNs	Public Switched Telecommunications Networks
PTOs	Private Telecommunications Operators
R&D	Research and Development
RDI	Research and Development Institutions
SAPs	Structural Adjustment Programmes
SMEs	Small and Medium Enterprises
SSA	Sub-Saharan Africa
TRIMs	Trade Related Investment Measures
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNIDO	United Nations Industrial Development Organization
UNU	United Nations University
WTO	World Trade Organizations

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1. Globlalization, Technology and Development

> Globalization itself is neither good nor bad. It has the power to do enormous good, and for countries of East Asia, who have embraced globalization *under their own terms*, at their own pace, it has been an enormous benefit, inspite of the setback of 1997 crisis. But in much of the world, it has not brought comparable benefits. For many, it seems closer to an unmitigated disaster.
>
> …the benefits of globalization have been less than its advocate claim, the price paid has been greater, as the environment has been destroyed, as political processes have been corrupted, and the rapid pace of change has not allowed countries time for cultural adaptation. The crises that have brought in their wake massive unemployment have, in turn, been followed by longer-term problems of social dissolution…. (Joseph Stiglitz, Winner of the Nobel Prize for Economics 2001.)[1]

Globalization refers to the deep on-going socio-economic changes that started largely in the 1980s. These changes have been associated with, and employed to explain the financial, market and technological competitiveness. It is also related to the increasing integration of national economies with that of the rest of the world. Internationalization, which refers to the trade relations of the 1950s has been revolutionized in part with the advent of information and communications technologies (ICTs). Nations of the world have always engaged in trade and other forms of exchanges. In the last 15 to 20 years there has been a major and qualitative change reflected in a high rise in capital mobility and shifts in the structure and forms of Direct Foreign Investment (DFI)[2]. What constitutes globalization is beginning to emerge but the precise ways in which they would affect individual countries, region and economic blocks are not clear. This paper focuses on the implications of the globalization process for Africa's industrial competitiveness, manifested in part in the region's inability to produce and export manufactured goods.

Much of the global changes leading to the intense internationalization of trade and production are partly driven by technological change particularly ICTs. The changes are highly interrelated and in some cases, causes and effects become difficult to separate. The key elements of globalization are summarized below:

[1] Joseph Stiglitz (2002), Globalisation and its Discontents, Allen Lane.
[2] OECD (1996), Globalisation and Competitiveness: relevant indicators, STI Working Papers 1996/5, Paris.

- Technological change has led to new and diverse range of products and services that in turn promote specialization and new forms of exchanges including inter-industry trade.
- Tremendous improvements in transportation and communications and sharp reductions in transactional costs have shortened economic distances for trade and manufacturing. Improvements in production technologies have given rise to economies of scale making it more attractive and efficient to produce far beyond the requirements of the domestic market; increased plant sizes is a tacit incentive to explore foreign markets.
- Growth of world exports output especially in manufactures, for instance between 1965 and 1990, share of exports to world Gross Domestic Product (GDP) increased from 11 to 20%.
- Rapid increases in Foreign Direct Investment (FDI). Economies in transition and some developing economies have recently benefited greatly from inflows of DFI. According to United Nations Development Organization (UNIDO) (1996), more than 30% of total world FDI compared to 20% in the mid-1980s goes to developing countries with most of it channeled into manufactured exports.
- Widespread adoption of deregulation and liberalization policies.

This last element and the ways in which economic parameters and "conditionalities" have been defined constitute the most contentious aspect of globalization. More controversial are the three main institutions that govern globalization: the International Monetary Fund (IMF), the World Bank and the World Trade Organization (WTO). Some United Nations (UN) sister institutions, such as the United Nations Conference on Trade and Development (UNCTAD), the International Labour Organization (ILO) and the United Nations University (UNU) provide countervailing views. However, the influence of the first three institutions in defining global agenda is so pervasive as to generate a strong exclusionary effect. For instance, efforts to tie all investments issues to Trade Related Investment Measures (TRIMS) has all but excluded substantive debates on the ways in which developing countries build up technological capabilities through technology investments. Yet, in its fixation with trade, and less so with technological development, TRIMS has removed an important plank upon which countries acquired technology by seeking to dilute or remove state intervention. Global governance is evidently imperative in an era of globalization, in as much as the role of the UN remains critical in fostering industrialization. However, global rules setting procedures and the same rules tend to set little store on the objective conditions and institutional capacity of poor countries.[3] There are other factors, but it is the dynamics of these elements, and not just their occurrence alone, that is giving rise to the new structures and patterns of global integration in trade, technology and markets.

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[3] An instructive example cited by Stiglitz (2001) captures the contradictions inherent in rules setting and the interest of the poor: "Those who seek to prohibit the use of nets that harvest shrimps but also catch and endanger turtles are told by the WTO that such regulation would be an unwarranted intrusion on free trade. They discover that trade considerations trump all others including the environment".

Several explanations have been advanced to explain Africa's dismal economic growth performance. These range from policy-related issues (World Bank 1981); structural and institutional factors (Easterly and Levine 1997, Sachs and Warner 1997); the shortage of technological and managerial capabilities that result in the failure to effectively transfer technology and the underutilization of human and physical resources (Enos 1992; Lall 1992, 1993); and the long-term effects of historical factors (Engerman and Sokoff 2000). While these factors explain parts of Africa's growth problems, a systemic explanation of the nature of institutions in long-term development is still lacking. Africa is far from having uniform conditions. There are wide regional variations in economic and political governance systems leading to differentiated trajectories in development. Thus, cross-country analysis tends to hide the considerable intra-regional variations, particularly, the significant influences of specific national innovation systems.

This paper explores the continuing exclusion of African countries from the benefits of global technology exchange. We propose that institutions and the persistent inappropriate pattern of human capital formation has conditioned the observed systems of innovation and effectively determined Africa's development trajectory. As Rodrik (1998: 5) observed, "the way to reverse the trend (poor economic growth) is not to target the region's trade volume per se, but to raise overall growth rate".

In this respect, the paper calls attention to the role of three broad factors supporting technological advance in long-term industrialization. These three important factors impact the national system of innovation in very important respects. They include institutions, human capital, and technological and physical infrastructure. The rest of the paper discusses some indicators of global exclusion, followed with a discussion of institutions and systems of innovation. Issues of human capital are reviewed, while section four focuses on physical and technical infrastructure. The fifth section addresses policy suggestions.

1.1 Indicators of Global Exclusion

African countries have not succeeded in acquiring technology effectively and subsequently have failed to achieve sustainable industrialization. Subsequently, the region has suffered the loss of competitiveness in traditional commodity exports. Loss of opportunities in global trade and technology exchange has meant that African countries have marginally benefited from globalization. Two proxy measures of globalization, FDI and export of traditional products and manufactures, are used to illustrate the point. For most sub-Saharan Africa (SSA) countries, manufactured exports, which remain a small proportion of global exports, had declined over the years (see Appendix Table A1 and Table 1). While SSA has realized some increase in manufactured exports, this has been due to, in part, the effects of reduction in the prices of commodities relative to manufactures in the last 20 years, UNCTAD (2001). Oil and non-oil commodities constitute more than 80% of Africa's exports. More disturbing is the decline in the exports of traditional exports. According to a recent study by Ng and Yeats (2002) for the World Bank, in 1962, Africa's exports of palm nuts and kernels accounted for 91% of $75 million world total. Exports fell to $3 million by 1999 while global market share was less than 10% of 1960s. Also, global market shares for groundnuts, palm kernel oil and palm oil was

between 51 to 83 % but have now fallen to only between 2 to 3 %, with the combined exports of these products now much lower than it was four decades ago. If Africa had maintained its 1960 global share of markets, current exports will be about $7.7 billion higher than current export value. According to the World Bank, "competitive share losses for palm oil are of major importance ($1.8 billion) and are about $1.1 billion for both alumina and unmilled maize", Table 2a.

Africa has not only lost market shares of products for what used to be "traditional exports", it has not gained the promised competitive share of manufactures for which much pain was endured in the process of Structural Adjustment Programmes (SAPs). The transition to processed exports of so-called traditional exports did not materialize. In the years after independence more that 40 years ago, Africa seemed destined to becoming a major exporter of various types of vegetable oils, tin, iron, bauxite and copper ore products. It was also easy to conjecture the export of sizeable global shares of meat products, fish oils, maize and rice products, fruit jams, and animal feeds. This scenario has not only failed to materialize, but the region has lost price competitiveness of traditional products. Table 2b shows that only tropical beverage group recorded an overall positive change over the last decade due to largely more than 20% increase in coffee prices. Country data is shown for selected countries in Table 2c.

Diversification into manufactured exports was an important objective of economic reforms with the aim of reducing dependence on commodity exports, however, the effort has not been successful. In an analysis of the international competitiveness of nine African countries over the 1980 and 1990 period, UNCTAD (2001) found that positive competitiveness indicator (CI) explained successful export performance. CI is explained in terms of the evolution of unit labour costs in dollars that is positively correlated with labour productivity, and real exchange rate but inversely related to real wages. Labour productivity is the most permanent and significant predictor of manufactured exports. Mauritius and Egypt that have displayed dynamic and stable export profiles for the last two decades exhibited the most sustained productivity growths.[4]

FDI constitutes an important source of external finance. It has assumed greater significance in the face of the decline of other sources of private and official capital, far more than for instance, commercial loans, portfolio investment, and official development assistance (ODA). The flow of FDI is a measure of technology transfer through such mechanisms as imports of capital goods, licensing and joint ventures. From low global flows in FDI of 15.2% between 1981 and 1985, developing countries share increased to 36.1% in the early 1990s. During this period, the SSA share dropped from 1.7 to 1.3%. By 2000, Africa's share in the flow of FDI to developing countries had been reduced to 5%, from 25% in the early 1970s. Regarding capital goods, East and South-East Asia, including

[4] Mauritius sustained an average manufacturing productivity growth of 4.5% for 18 years, and Egypt an average 3.5% productivity for 16 years inspite of real appreciation in real exchange rates, and without lowering wages. Most countries attempt to achieve competitiveness through wage suppression and sharp currency depreciation. However, wage suppression often lead to social problems as well as impact negatively on long-term productivity growth.

China, imported about 65% of total imports by developing countries in 1994. The share of SSA dropped disappointingly from 11.1% in 1970 to a low 1.9% in 1994. This reflects the technological dynamism that characterized the East Asian countries and the near stagnation that SSA economies continue to experience. However, significant intra-regional FDI particularly from South Africa and Mauritius has begun to take place while FDI from developing Asian countries has accelerated (ECA 2002).

Table 1: Composition of Exports from Sub-Saharan Africa

	1980	1990	1997
Crude Petroleum	75.6	61.3	54.7
Non-oilprimary commodities	19.7	22.8	26.6
Manufactures	4.0	15.5	18.4
Unclassified	0.7	0.4	0.3

Source:UNCTAD (2001)

Table 2a: Implications of the Demise of Some African "Historical" Exports

Share (%)	African Exports ($000)		Africa's World Trade	
Commodity (SITC)*	1962	1999	1962	1999
Palm Nuts & Kernels (2213)	75,061	2,861	91.1	9.9
Groundnuts Green (2211)	184,279	24,542	83.4	3.2
Palm Kernel Oil (4224)	8,941	15,816	53.4153.1	2.2
Palm Oil (4222)	36	11,634	50.9	1.0
Natural Abrasives (2752)	13,247	2,059	27.6	0.2
Fixed Vegetable Oils, nes (4229)	8,555	10,131	16.0	1.3
Alumina (5136)	25,608	60,330	13.8	0.7
Unmilled Maize (0440)	18,762	20,725	13.2	0.2
Fur Skins (2120)	37,855	757	12.3	0.1
Vegetable Oil Cake (0813)	47,401	49,264	10.9	0.8
Copper Ore & Concentrates (2831)	11,492	44,633	8.7	0.9
Fish Oil (4111)	7,825	1,453	7.6	0.4
Bovine & Equine Hides (2111)	18,155	24,627	8.0	0.9
Unwrought Tin (6871)	21,761	267	7.8	0.0
Meat Extracts (0133)	2,120	759	7.6	0.6
Tine Ores and Concentrates (2835)	5,851	9,139	6.0	0.5
Plywood (6312)	12,149	48,659	5.2	0.6
Glazed or Polished Rice (0422)	6,346	601	3.5	0.0
TOTAL OF ABOVE	505,444	328,257	13.9	1.0

* Since Revision 2 data were not available until mid-1970s, these statistics are based on the earlier Revision 1 classification which first became available in 1962.

Source: African Region Working Paper Series No. 26, worldbank.org

Table 2b: Recent Prices for Major Groups of Traditional Products

Change (%)	Average Annual Prices (1990=100)				Percentage Price	
Traditional Product Group*	**1980**	**1990**	**1998**	**1999**	**1980-99**	**1990-99**
Tropical Beverage Products	321.4	100.0	135.7	108.8	-66.1	8.8
Lumber and Products	102.9	100.0	85.4	100.8	-2.0	0.8
Fresh and Preserved Seafood	99.3	100.0	99.2	91.3	-8.1	-8.7
Fibers & Agricultural Materials	94.9	100.0	94.1	85.5	-9.9	-14.5
Ferrous Metals and Ores	120.3	100.0	91.4	81.5	-32.3	-18.5
Minerals and Products	144.9	100.0	80.9	78.9	-45.5	-21.1
All Traditional Products	**124.4**	**100.0**	**78.0**	**76.1**	**-38.8**	**-23.9**
Other Foodstuffs	152.6	100.0	87.0	74.1	-51.4	-25.9
Gold and Diamonds	220.3	100.0	73.6	70.2	-68.1	-29.8
Non-Ferrous Metals and Ores	118.6	100.0	69.4	69.3	-41.6	-30.7
Hides and Leather Products	101.1	100.0	56.9	48.9	-51.6	-51.1
Memo Items						
All Non-Oil Commodities	174.3	100.0	95.1	85.0	-51.2	15.0
All Foods	193.4	100.0	100.7	84.5	-56.3	-14.5
All Raw Materials	145.2	100.0	83.8	85.1	-41.1	-14.5
Metals and Minerals	130.8	100.0	72.4	71.2	-45.6	-28.8

Source: Ng and Yeats (2002)

Table 2c: Estimates of Real Price Changes for African Traditional Products (1990=100)

	Estimated Level of Real Prices (1990=100)				Percentage Change (%)	
Exporting Country	1980	1990	1998	1999	1980-1999	1990-1999
LARGER COUNTRIES						
Angola	255.0	100.0	118.0	101.3	-60.3	1.3
Kenya	156.3	100.0	194.5	92.5	-40.8	-7.5
Cameroon	128.9	100.0	88.7	92.1	-28.6	-7.9
Ghana	148.9	100.0	89.6	87.8	-41.0	-12.2
Zimbabwe	96.7	100.0	93.0	84.8	-12.3	-15.2
Nigeria	152.0	100.0	91.8	87.6	-42.4	-12.4
Gabon	101.9	100.0	80.3	77.3	-4.1	-22.7
Liberia	109.2	100.0	81.9	76.7	-29.7	-23.3
SACU	156.1	100.0	71.7	70.3	-55.0	-29.7
Cote d'Ivoire	257.3	100.0	111.7	84.4	-67.2	-15.6
Congo, Republic	123.1	100.0	69.2	67.5	-45.2	-32.5
Congo, Democratic Republic	138.8	100.0	69.6	66.8	-50.0	-33.2
Zambia	113.3	100.0	62.3	59.2	-47.7	-40.8
All Larger Countries	160.2	100.0	92.3	78.6	-50.9	-21.4
MID-SIZE COUNTRIES						
Ethiopia	369.7	100.0	144.4	118.7	-67.9	18.7
Madagascar	284.9	100.0	122.2	104.0	-63.5	4.0
Uganda	214.8	100.0	115.3	99.4	-53.7	-0.6
Guinea	186.1	100.0	98.1	87.3	-53.1	-12.7
Malawi	93.9	100.0	94.5	86.2	-8.2	-13.8
Tanzania	111.4	100.0	92.7	84.0	-24.6	-16.0
Mauritania	117.8	100.0	92.3	82.8	-29.7	-17.2
Senegal	125.1	100.0	90.6	79.2	-36.7	-20.8
Togo	194.5	100.0	92.8	77.6	-60.1	-22.4
Mozambique	113.8	100.0	79.3	73.5	-35.4	-26.5
Sudan	156.1	100.0	77.8	64.1	-58.9	-35.9
Mali	157.4	100.0	76.2	62.2	-60.5	-37.8
Benin	105.5	100.0	56.2	49.5	-53.0	-50.5
All Mid-Size Countries	171.6	100.0	94.8	77.1	-55.1	-22.9
All Above Countries	165.7	100.0	93.5	77.9	-53.0	-22.1

2. Institutions and Innovation Systems in Africa

Institutions are conceptualized narrowly or broadly[6] but in both contexts, they take on the functions of the management of uncertainty, the provision of information, the management of conflicts, and the promotion of trust among groups (Edquist et. al. 1997; North 1989).[7] For these reasons, institutions are necessary for innovation for two reasons. The first one is the uncertainty that characterize innovative activities. Institutions act to provide stability, regulate the actions of agents and enforce contractual obligations. Second, learning and knowledge creation, validation and distribution are prerequisites of modern economic change mediated by such institutions as organization (R&D laboratories, finance and investment institutions) and rules as intellectual property rights (IPRs) and patent laws. In this study, we employ the broader concept of institutions in addition to locating institutions within a historical context that admits the evolution of institutions themselves (David 1994; Zysman 1994). Coriat and Dosi (1998) called attention to another set of issues in understanding institutional evolution. First is the origin of the institutions, the need to explain institutions that preceded them and the mechanisms that led to the transition. Second is what is referred to as the degrees of intentionality of institutional constructions. It explains whether an institution arose out of a self-organizational process or derived from a collective constitutional process. Third is the concern for institutional efficiency. The point is whether institutions are merely "carriers of history" in the sense of David (1994) and simply "path-dependently reproducing themselves well beyond the time of their usefulness (if they ever had one)" (Coriat and Dosi 1998:7). Clark (2001) gave examples of Africa's higher institutions established for a purpose far different to what the current objectives of Africa's development presently demand. The founding initial objectives persist while the developmental requirements have radically changed and this constrains organizational effectiveness.

Three institutionally induced phenomena are said to explain the observed development of the SI in Africa. First is the pre-existing level and pattern of postcolonial education enrollment as a proxy of human capital, a strong determinant of national technological capacity. Second is the factor endowment that had been the starting point for wealth creation in other regions, may well be obstacles

[6] In a narrow sense, institutions correspond to such organizations as universities, technological service organizations, while in broad terms, it includes political context governed by constitutions and the rules regulating innovation activities.

[7] Coriat and Dosi (1998) refer to the broad meaning of institutions as having three components which are: (a) formal organizations (ranging from firms to technical societies, trade unions, universities, and state agencies); (b) patterns of behaviours that are collectively shared (from routines to social conventions to ethical codes); and (c) negative norms and constraints (from moral prescriptions to formal laws).

to development.[8] Factor endowments have strongly determined the course of investments and subsequently the path of endogenous technical change. Conceived as the "rules, enforcement, characteristics of rules, and norms of behavior that structure repeated human interaction" (North et al. 1988), we suggest that institutions strongly influence the pattern of endogenous technical development. In an increasingly interdependent global context, institutions may not necessarily be endogenous to regions and societies; they may be, and are often, imported.[9]

Financial markets are different because they are primarily concerned with information processing, a non-commodity factor that is bound to be more problematic for poor countries with poor intellectual institutions. Since price is unable to coordinate markets in the absence of non-existing institutions, "government may thus have to assume a more active role in performing this function", (Stiglitz 1996). The coordination role becomes doubly difficult when institutions are absent and state capacity for action is weak. Physical and human infrastructure including scientific and technological institutions, telecommunication and power are important prerequisites for transformation into modern economic systems.

Aron (1996) has applied the concept of path-dependency to explain the growth or lack thereof of African economies. Combining the notions of path-dependency and institutional evolution in Africa, Aron suggests that policies that presc ribe piecemeal reform that fail to take account of the historical context are unlikely to result in effective economic growth.

> With path-dependent institutions, empirical growth models without comprehensive proxies for initial institutional conditions, and shocks to institutions, may seriously underestimate the adjustment costs to new higher growth equilibria (Aron 1996: 111).

We take industrialization as the systematic acquisition of technological capabilities within the national systems of innovation. Our analysis is neither limited to technological artifacts nor to institutions as organizations only, but includes the norms, codes and conventions that guide the behavior of economic agents.

2.1 Constraints to Institutional Performance

A fundamental position of the evolutionary theory[10] is that institutions, unlike what neoclassical economics tell us, are not neutral, but are subject to x-efficiencies much in the same way as firms do not always perform at optimal levels (Niosi 2002). The inefficiency of institutions stems from their

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[8] The term "resource curse" has been used to describe the lack of growth-generating effect of natural resources in developing countries, see Mikesell (1997) and Aunty (1998).

[9] For instance, the system of organized R&D within labouratories is an invention of the West. See Rosenberg and Birdzell (1986).

[10] In broad terms, and in whatever discipline, evolutionary theories have properties by which they explain the processes of self-transformation, an issue central to our thesis. According to Witt (2002) an evolutionary theory is: (i) dynamic - such that the dynamics of the processes, or some of their parts, can be represented; (ii) historical - in that it deals with historical processes which are irrevocable and path-dependent; (iii) self-transformation explaining - in that it includes hypotheses relating to the source and driving force of the self-transformation of the system.

history and their connectedness to previous environment. Institutional evolution, therefore, is path-dependent and inefficiency could arise from any of the two sources. These are *inter alia*:

- *Rigidities in Organizations*: This may stem from the founding ideals of organizations that resist change in the face of new conditions and challenges. Clark (2001: 84) observed that, "in a world that is changing very rapidly (i.e. in one in whose systems parameters are shifting almost as fast as its variables) the pure scientific model inherited from the 19th Century is no longer viable in itself as a core methodology." Inertia may result from self-reinforcing institutional networking that is now obsolete, or at best, needing radical reforms. Institutional resistance may not be solely a result of poor judgment or lack of vision but of fear from the outcomes of change. Innovation brings uncertainty and as Niosi (2002: 294) points out, "Organizations tend to stick to their own obsolescence plans, particularly if they area uncertain about the gains to be realized by the abandonment of existing technologies or organizations, and the adoption of the new ones. Sunk costs, in form of machinery and training of staff are another reason why change becomes a difficult proposition."
- *Sub-optimal Knowledge Networks*: Information asymmetry may lead to poor flows of information and knowledge among critical economic agents within the system of innovation. For instance, highly centralized knowledge "producing" institutions that include universities and R&D laboratories, may be far removed from production systems. This has been observed particularly in developing countries (Forbes and Wield 2000).

There are different types of organizational ineffectiveness that may manifest as system inefficiency (Niosi 2002). They are as follows:

- Institutional inadequacy that manifest as lack of rules of the game, poor enforcement of contractual laws and inadequate intellectual property laws that may constitute disincentives to innovation and technological learning.
- A possible lack of threshold in the number of such organizations as research institutions, private or public agents that assure quality, universities and vocational education centers. In developing areas, it is not the number but the relevance of the institutions. Many have questioned the role of government Research and Development Institutions (RDIs) that have little linkages with the productive sectors, and the relevance of universities that do not relate with dominant actors in the economy, such as small and medium enterprises (SMEs).
- Poor coordination of knowledge and economic production functions as cited above. Examples include the demand and supply for skills at sectoral levels, the kinds and the quantity and quality mix required at different times.
- Poor resource commitment for meeting organizational commitments, such as poor funding and inadequate staffing may lead to x-ineffectiveness.

2.2: Systems of Innovation in Africa: The Roots of Exclusion from the Global System

In the 1960s, several African countries, in an attempt to achieve scientific and technological progress, engaged in the wholesale imitation of industrialized countries' model of institutionalization of science. This involved the establishment of specialized R&D institutes to generate scientific knowledge and from which industry and agriculture would then draw when needed.[11] Studies show that this great experiment achieved very limited success, (Oyelaran-Oyeyinka 1996; Adeboye 1997). We suggest that the two most important causes of this failure is the lack of an institutional base for innovation and secondly, the shortage of the right kinds of human capital to build and sustain a technical foundation for industry. Rather than aim to draw more on the underlying principles and processes that had generated the diversity of past and present institutions, African countries tend to focus on building organizations without much attention to institutions to sustain them. By this, we mean the evolutionary process of innovative design and development that had fitted institutions to differing and changing contexts, while usually embedding individual components within functionally coherent structures. By simply imitating structures that work for the present context in the industrialized countries, African countries ignored the fact that these institutions were products of an organic process, rather than mechanically given forms. The institutional forms were created, refined and adapted to given contexts over a long historical period. As a result, problems of functional incoherence were designed into the structure from the beginning. The present institutional structures observed in the industrialized countries were radically different from what they were half a century ago.

It took decades for basic science to become an increasingly powerful force in the productive sector. This was an evolutionary process following after the development of technological infrastructure and rising incomes. Gradually, through technological learning based on imitation, the skill of the artisan and the genius of the lone inventor became increasingly subsumed in what Galbraith referred to as the technostructure. Technostructure is the planning system that characterizes the modern industrial corporation. As Marx perceptively noted, "Invention then becomes a business, and the application of science to direct production itself becomes a prospect, which determines and solicits it" (Marx 1973:704). This leads to another important observation. The technical foundation of industry had to be laid, after which the post scientific era found a secure anchorage. Without the endogenous technical capability accumulated during the pre-scientific era, when metallurgy and machines tools industries developed, it would have been near impossible to erect the present complex industrial structures. This is a lesson easily missed by structural adjustment advocates and African policy makers. Systems of innovation support production, while production systems take a long time to build. "Getting the price right" cannot possibly be a panacea, neither could it be a substitute for the fundamental evolutionary assignment of getting the institutions right.

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[11] The establishment of R&D organizations seemed to have been taken to represent a system of innovation. This idea unfortunately persists in conception and practice. The so-called "linear model" of innovation has had a profound influence on the thinking of African policy makers for decades. See Vitta (1990).

But these developments seem more like consequences than causes of the West's unique institutional invention: a large, highly organized body of scientists seeking explanation of all natural phenomena by a common method based on observation, experiment and reason. This achievement can be credited to a large extent on the successful invention of an institutional form that suits the context of that particular environment. This unique characteristic of modern industry distinguishes it from the 19th Century Industrial Revolution. Indeed, it is doubtful if the scientific-technical revolution of the 20th Century could have been possible without it. Galbraith (1985) sums it up very succinctly:

> "The real accomplishment of modern science and technology is in taking ordinary men, informing them narrowly and deeply and then, through appropriate organization, arranging to have their knowledge combined with that of other specialized but ordinary men. This dispenses with the need of genius" (ibid: 64).

The lessons for African policy makers seem complex yet simple. The role of institutions is sharply illustrated by examples cited above but the context is as different as the past century is from the present one. What worked in the last 50 years may not be applicable now, and what worked for Europe may not be totally suitable for the present state in Africa. What seem important are the underlying principles: the role of institutions and their path-dependence, and the importance of investment in human capital at all levels from formal schooling to industry. In figure 1 we formalize the narrative into a simple model, while Table 3 provides a comparative picture of the nature of national systems in SSA and in other regions.

Table 3: Indicators of national efforts in S&T-Brazil, South Korean, Japan, the United States and sub-Saharan Africa.

Indicators	**Brazil**	**South Korea**	**Japan**	**United States**	**Sub-Saharan Africa***	
Scientists and Engineers engaged in R&D per million of population	168 (1995)	2193 (1996)	4909 (1996)	3676 (1993)	Senegal 3 (1996)	S. Africa 1,031 (1993)
Expenditure for R&D as a percentage of GNP	0.81 (1996)	2.8 (1996)	2.8 (1996)	2.64 (1996)	0.01 (1997)	0.70 (1993)
Expenditure in R&D by source of funds %					Uganda	S. Africa
Government	57.2 (1996)	15.9 (1994)	9.6 (1995)	35.5 (1995)	6.6 (1996)	42.7 (1993)
Productive enterprise	40.0 (1996)	84 (1994)	65.2 (1995)	59.4 (1995)	2.2 (1996)	54.4 (1993)
Other	2.8 (1996)	0.1 (1994)	25.2 (1995)	5.1 (1995)	90.3**	1.8 (1993)
Total patents field in the US as a percentage of total patents	0.07 (1998)	2.2 (1998)	18.6 (1998)	55.7 (1998)	0.004 (1998)	
Number of tertiary students per 10,000 inhabitants	-	5.0 (1996/7)	3.5 (1994/5)	14.0 (1995/6)	2.6 (1996/7)	7.7 (1994)

Source: Office for Patent and Trade Mark Information, USA; UNESCO *Statistical Yearbook*, various issues; OECD *Statistical Yearbook*, various issues.

Notes:
*Due to the difficulties in obtaining reliable aggregate statistics for the entire sub-Saharan region, the authors, in some cases, have chosen to use a range of values (from the lowest to the highest) to represent the statistics for the region.
** Funds from abroad.

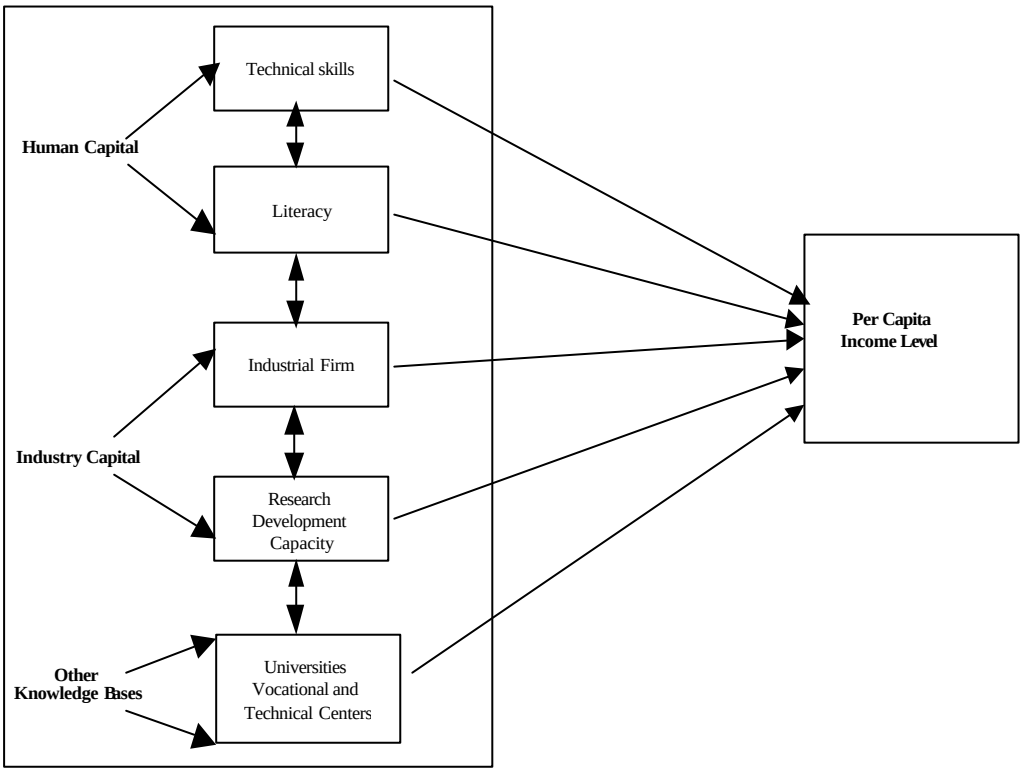


Figure 1: Performance Variables in the System of Innovation

3. Human Capital in African Development

One of the key factors behind the phenomenal economic success of industrial latecomers, such as the South-East Asian economies was their emphasis on forming human capital and a dynamic system of innovation. These countries, employing a mix of selective and functional policies, developed an education structure that effectively provided the requisite skills for their industrialization initiative. Public spending was concentrated on primary and secondary education while the demand for tertiary education was primarily financed by the private sector. Public spending at the tertiary level focused on science and technology education, while the humanities and social sciences were privately funded. The governments, to varying degrees, intervened in curriculum development to ensure that it was compatible with the needs of their evolving industrial policy. To this end, they *inter alia* encouraged private sector involvement in universities. Additionally, some countries, notably Singapore, imported expatriate skills where domestic capabilities were limited (Lall 1992; Page 1994).

By contrast, the current educational structure in Africa has been described as "unsuitable for industrialization" (Lall 1992: 119). Several reasons have been advanced to explain this description. First, some researchers argue that the present education system in Africa is a legacy of colonialism (Blakemore and Cooksey 1982). It seems that the missionaries, in concert with the metropolitan powers, implemented a highly academic, subject-centered curriculum in Africa. This curriculum, with its focus on producing an academic elite, was largely irrelevant to Africa's development needs.

African countries, partly influenced by the British and French colonial elite with their classical education and lack of technical knowledge, viewed academic education as the sole means of social and economic mobility. [12]

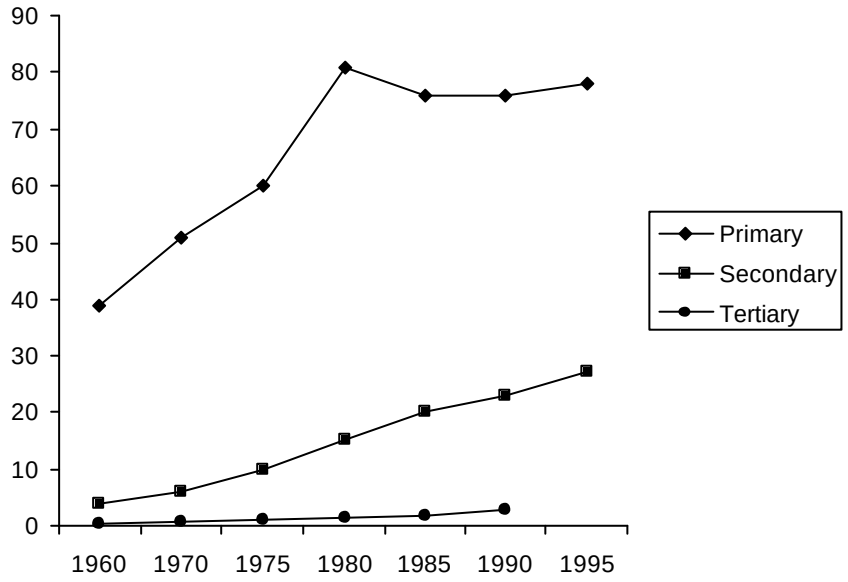
Only a privileged minority benefited from this elite education. In 1960, the gross primary enrolment in SSA was a mere 36%. This was roughly half the levels found in Latin America (73%) and Asia (67%) (World Bank 1988). It appears that the colonial governments, in an attempt at social control, deliberately

[12] Western education also disrupted power relations in Africa's traditional societies. In some cases, traditional leaders were more unwilling than their subjects to send their sons to school. However, over the course of colonialism, the status hierarchy in Africa changed from the traditional ascriptive one based on lineage to the Western achievement one of education. Indeed, the most educated increasingly replaced the chiefs as the elite. Their education and occupational achievement gave them status in the eyes of the local population according to the emerging hierarchy of values. See Blakemore and Cooksey (1982: 42-44).

limited access to education, particularly secondary education, among Africans. Lord Lugard, for example, postulated that the expansion of missionary schools in southern Nigeria, "seems to have produced discontent, impatience of any control and an unjust assumption of self-importance in the individual" (quoted in Blakemore and Cooksey 1982: 37). Indeed, academic education was conceived not as a means of industrializing the countries but rather creating an elite supply of white-collar African workers for the administration of the colonies.

African governments sought to remedy this situation in the post independence era. As Diagram 1 demonstrates, their performance has been impressive. Within two decades, the gross primary enrolment ratio[13] tripled from 39% in 1960 to an astounding 81% in 1980. This ratio subsequently declined by 8% in 1999. However, gross secondary and tertiary enrolment steadily increased during the period. Secondary enrolment ratios rose six-fold during 1960 to 1995, while tertiary enrolment ratios increased seven-fold during 1960 to 1990.

Diagram 1: Gross Enrollment Ratios in Africa, 1960 to 1995



Source: World Development Indicators (CD-ROM).

[13] Enrollment ratio is defined as the ratio of the number of persons enrolled in school to the population of the corresponding age group by educational level.

Enrollment levels vary considerably at the three levels, with the largest variation found at the tertiary level and smallest at the primary level. Diagrams 2a-c shows the mean, standard deviation and the coefficients of variation of the enrollment ratios at the primary, secondary and tertiary levels. The last variable, the coefficient of variation, is a relative measure of variation and can thus be expressed in percentages or ratios. The analysis of the data for primary education reveals that the standard deviation rose for the period 1960 to 1980, declined over the next 10 years before rising again, while the coefficient of variation declined over 1960 to 1990, showing a tendency of a rising mean enrollment. For both secondary and tertiary enrollment, standard deviation rose over the whole period, with the coefficient of variation for secondary enrollment first declining sharply in the first ten years, then rising and assuming a steady but slight decline between 1970 to 1990, again showing a steady rise in mean enrolment. Changes at the tertiary level were not as significant.

Diagram 2a: Primary Education: Mean, Standard Deviation and Coefficient of Variation

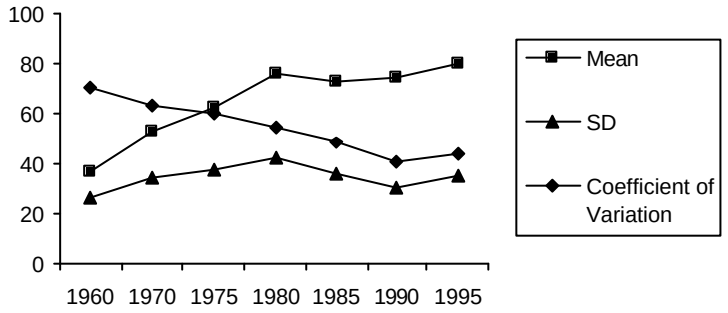


Diagram 2b: Secondary Education: Mean, Standard Deviation and Coefficient of Variation

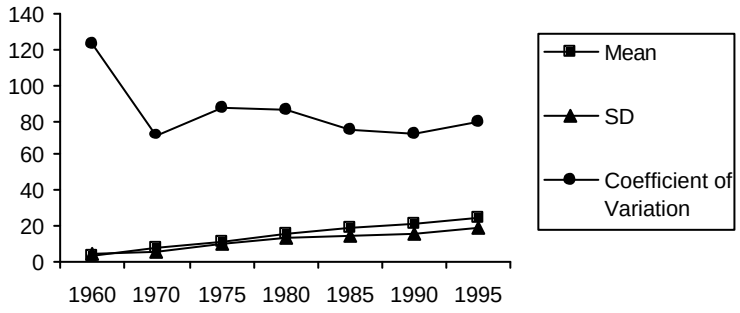


Diagram 2c: Tertiary Education: Mean, Standard Deviation and Coefficient of Variation

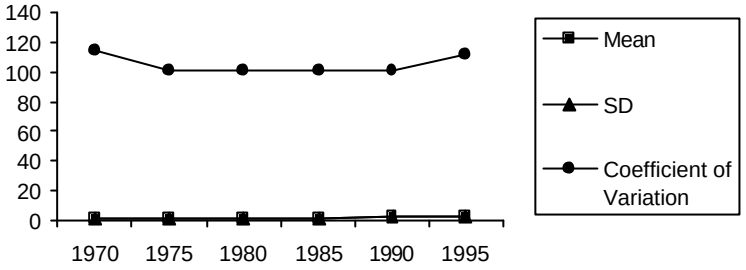
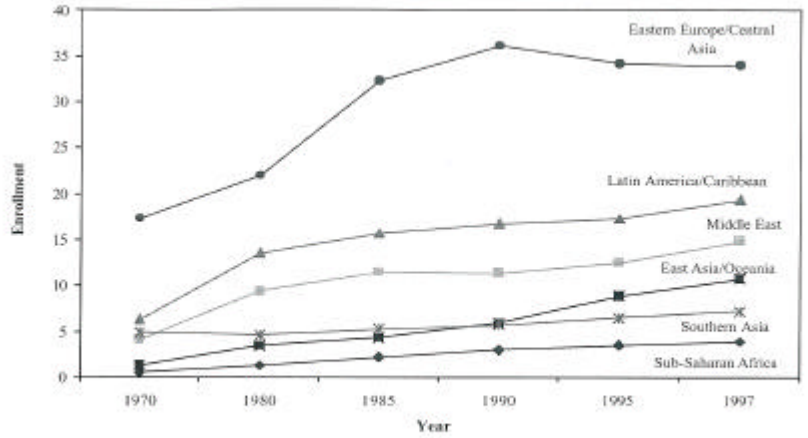


Diagram 2d : Tertiary Education: Comparative Picture Across Regions



Note: Least-developed countries are those so classified by the United Nations; in 2002 there were 49 countries in this category.
Source: UNESCO (1999, 2000b).

Further analysis reveals that the average annual growth rates in school enrollment vary widely among different groups of African countries. The average annual growth rate in primary education declined in the post 1990 period for only the middle-income, oil exporting countries as Angola and Cameroon, and the middle-income, oil importers including Botswana and Senegal. The former group saw average annual growth rates slip from 19% in 1985 to 1990, to 0.1% in 1990 to 1996 (See Diagram 3a). Moreover, it was only these two groups that experienced a decline in the average annual growth rates in secondary education. As Diagram 3b shows, the middle-income oil importers saw average annual growth rates in secondary education decline from 7.2% in 1985 to 1990, to 5.2% in 1990 to 1996. However, all of these countries experienced sharp falls in the average annual growth rates of tertiary education. For example, in the low-income, semi arid countries, such as Kenya and Burkina Faso, average annual growth rates in tertiary education were halved in the post 1990 period, from 6.5% in 1985 to 1990 to a mere 3.5% in 1990 to 1996 (See Diagram 3c). Diagram 2d shows a comparative picture across the regions and not surprisingly, SSA has the lowest tertiary enrolment.

Diagram 3a: Average Annual Growth Rates (%) in Primary Education

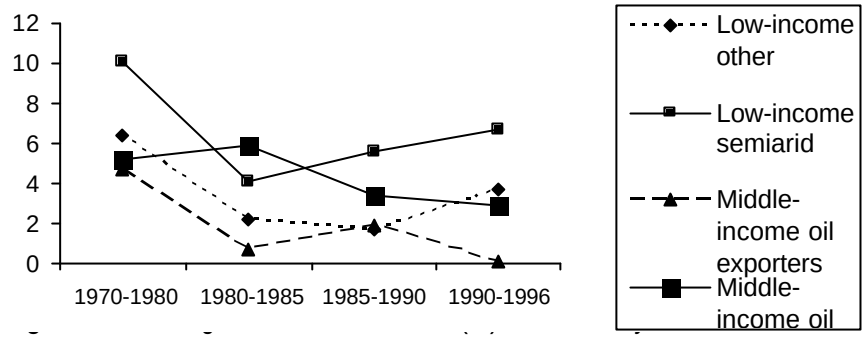


Diagram 3b: Average Annual Growth Rate (%) in Secondary Education

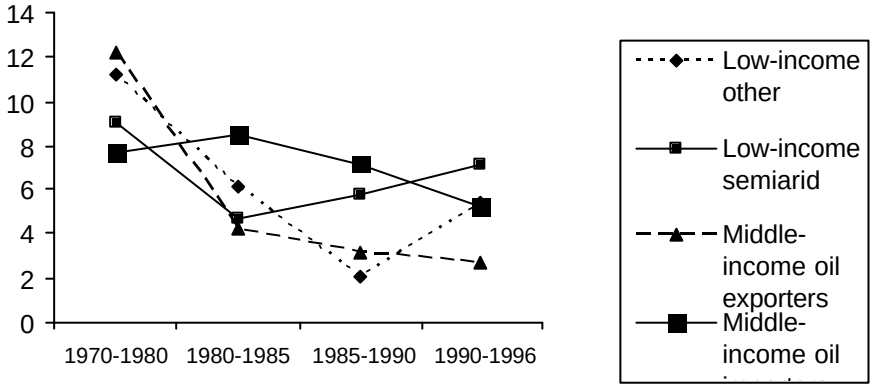
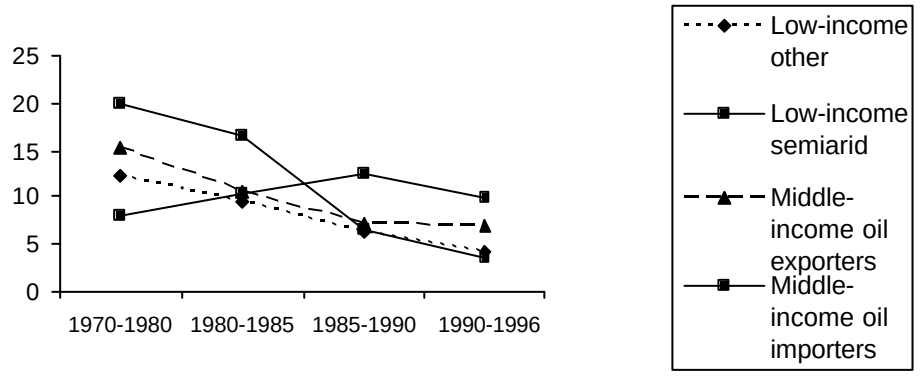


Diagram 3c: Average Annual Growth Rate (%) in Tertiary Education

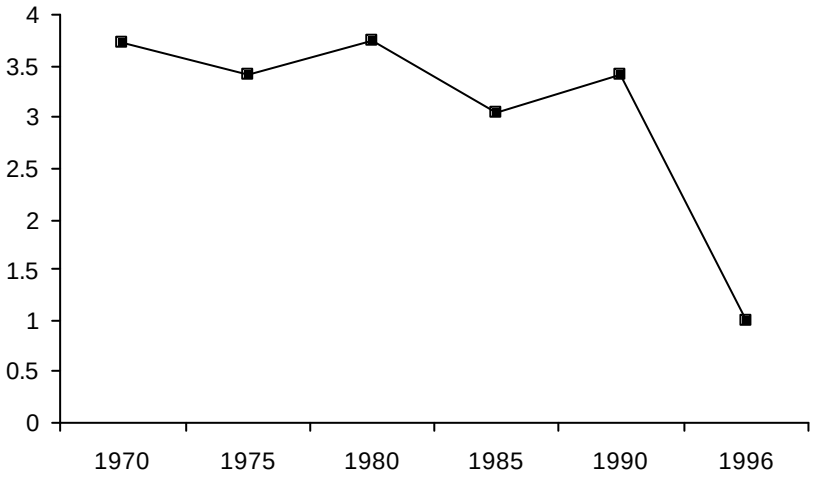


Source: ADEA, Statistical Profile of Education in Sub-Saharan African, 1999.

Notes:
Other Low-income include Benin, Burundi, Central African Republic, Comoros, the Democratic Republic of Congo, Equatorial Guinea, Eritrea, Ethiopia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Sao Tome, Sierra Leone, Sudan, Tanzania, Togo, Uganda, Zambia.
Low-income, semi-arid countries include Burkina Faso, Chad, Gambia, Mali, Mauritania, Niger, Somalia.
Middle-income oil exporters include: Angola, Cameroon, Congo, Gabon.
Middle-income oil importers include Botswana, Cape Verde, Cote d'Ivoire, Djibouti, Mauritius, Namibia, Senegal, Seychelles, South Africa, Swaziland, Zimbabwe.

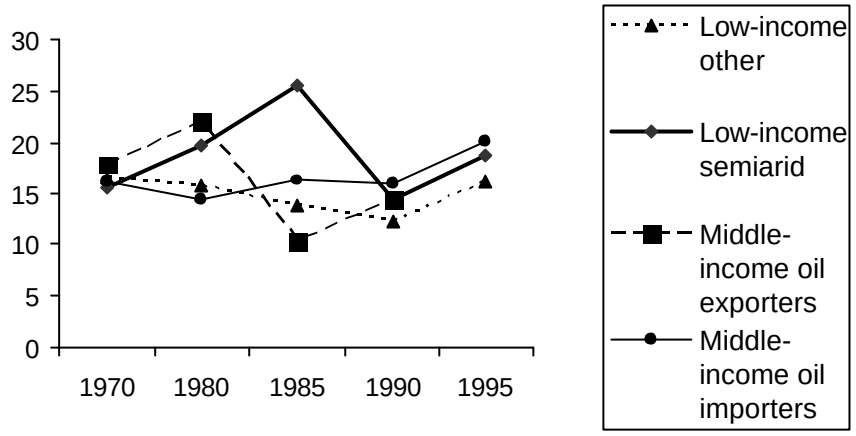
This period also saw fluctuations in public expenditure on education. This variable slightly declined during 1970 to 1975, recovered in 1980, but dropped dramatically to half of its 1970 value in 1996 (See Diagram 4a). Further analysis of the data on public education expenditure reveals wide variations among African countries. For example, low-income countries, such as Benin, Ghana and Kenya experienced the greatest decline in public expenditure on education: government expenditure on education as a proportion of total expenditure precipitously fell in two decades from 16% in 1970 to 12% in 1990. It was only in 1995 that government spending on education was restored to 1970 levels (See Diagram 4b). Other groups of African countries also experienced fluctuations in public expenditure on education. Most experienced steep declines in spending in 1985 with some recovery in 1995 (See Diagram 4b).

Diagram 4a: Public Expenditure on Education as a percentage of GDP, 1970 to 1996



Source: ADEA, Statistical Profile of Education in Sub-Saharan African, 1999.

Diagram 4b: Public Expenditure on Education (as a percentage of total government expenditure)



Source: ADEA, Statistical Profile of Education in Sub-Saharan African, 1999

Directly impacting industry is the product of higher education system, specifically engineering and science graduates. There is a suggestion that tertiary institutions produce an inappropriate mix of skills. For example, African institutions of higher education presently enroll 60% of students in the arts and humanities, and 40% in science and engineering. Enrollment in technical subjects presently lags behind that of other regions. While in 1995, only 0.04% persons as a percentage of the population were enrolled in technical subjects, such as engineering and mathematics, the figure for four Asian Tigers was 1.34% (Lall, 2001). In a set of technical enrolment index constructed by Harbison-Myers[14], while Norway ranked first with 73.52%, South Africa, the most industrialized country in SSA had a total of 23.61%, Nigeria, 5.85% (less than 9% of the Norwegian figure) with most SSA ranged from 1 to 5%. The colonial legacy of a limited emphasis on technical enrollment may have been appropriate during early independence period when most African countries were faced with a paucity of administrative staff. However, this skill mix has remained unchanged for the past four decades despite the declining demand for arts and humanities graduates, and the rising and unfulfilled demand for science and engineering graduates (World Bank 1988; Fabayo 1996; Delano et al. 2000).

The situation is compounded by the quality of education offered in Africa, which is said to be well below world standards. Education standards are increasingly becoming poor with the gap in achievement between African students and those in industrialized countries "widening to unbridgeable proportions" (Clarke 2000: 82). Indeed, the student/teacher ratios at the primary and secondary

[14]See Lall (2001). Technical enrolment index is tertiary enrolment (times 1000) plus tertiary enrolment in technical subjects (times 5000), both as percentage of population.

schools have steadily increased in the post 1990 period especially for low-income, semi arid countries, such as Gambia and Chad, and the middle-income oil importers like Botswana and Zimbabwe (See Diagram 5a-b). In addition, there has been a drastic decline in the quality of physical inputs (e.g., African staff, especially at the senior levels, and learning resources and facilities) that are essential for the successful operations of knowledge institutes. The declining quality of education is largely a result of constant budget cuts (since 1980) together with rapid increases in enrolment rates. This has made the financing of education recurrent costs more difficult (World Bank 1988). As diagrams 6a-c show, the expenditure per student at all levels has declined drastically since 1970. This decline is more serious for secondary and tertiary education, with most low-income countries experiencing the most severe declines. In Chad, Gambia and Niger, government expenditure per secondary student fell from US$ 536 in 1970 to a mere US$ 90 in 1995. Expenditure on tertiary education fared no better: spending per student dropped from US$ 5,054 in 1980 to US$ 1,185 in 1990.

Diagram 5a: Student/Teacher Ratios in Primary Schools in Africa, 1980-1996

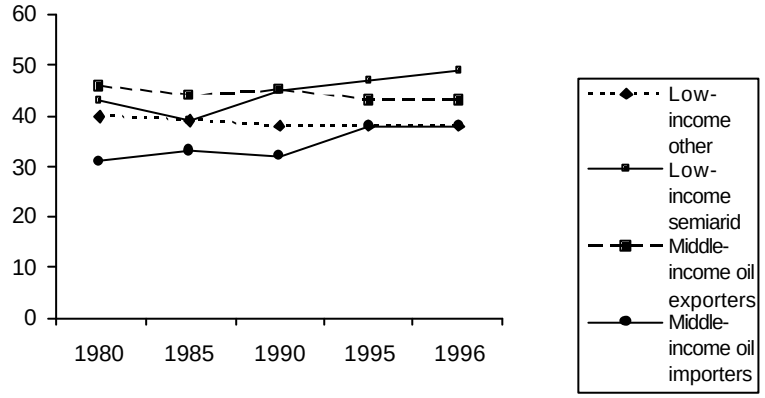
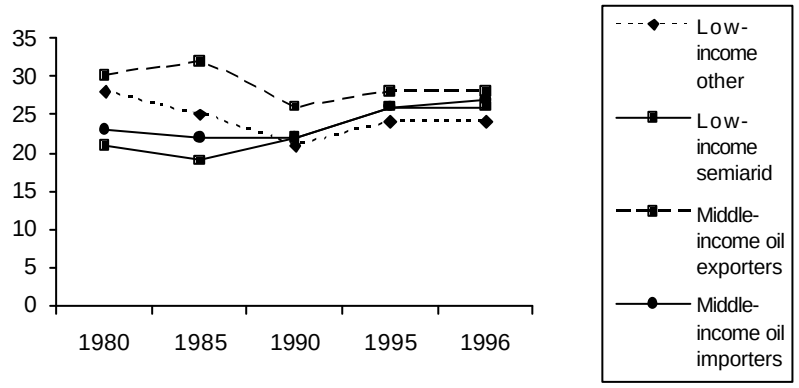


Diagram 5b: Student/Teacher Ratios in Secondary Education in Africa, 1980-1996



Source: ADEA, Statistical Profile of Education in Sub-Saharan African, 1999.

Diagram 6a: Government Expenditure on Primary Education per student (constant 1990 US$)

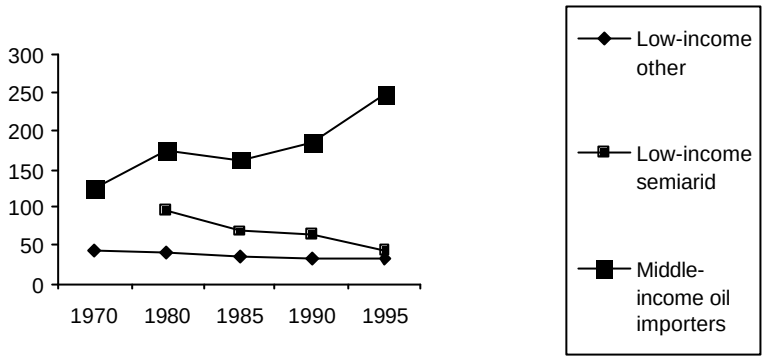


Diagram 6b: Government Expenditure on Secondary Education per student (cost in constant 1990 US$)

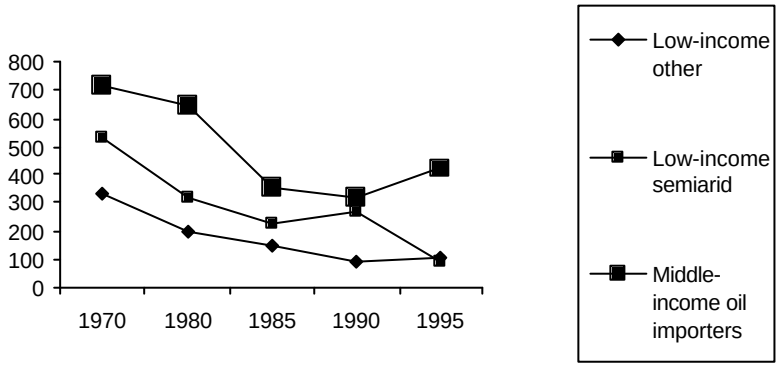
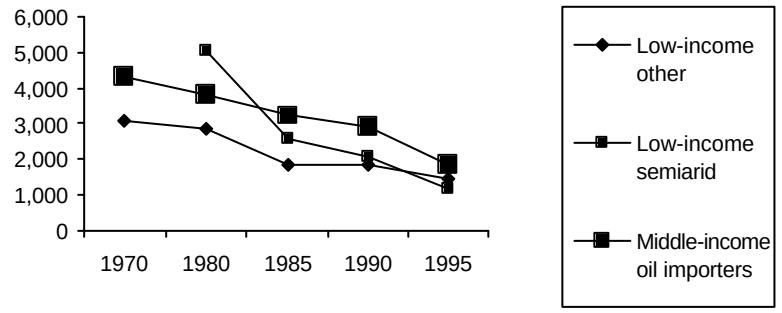


Diagram 6c: Government Expenditure on Tertiary Education per student (constant 1990US$)



Source: ADEA, Statistical Profile of Education in Sub-Saharan African, 1999.

Worsening the skills dilemma in Africa, firm-level training that complements the education system is weak. Enterprises, with the exception of the major multinationals, invest very little in training. Moreover, the apprenticeship system that exists in Africa is geared more to the development of traditional skills that are of a very low level of technological sophistication (Lall 1995). Several countries have attempted to bypass the formal education system by establishing non-formal training activities that are largely funded by non-governmental organizations (NGOs). They involve such activities as literacy, agricultural extension and vocational skills. However, it appears that the activities offered by the informal system are vulnerable to disincentives and are of poor quality (Clark 2000).

The economic conditions in most African countries and declining employment prospects in the public sector that historically, has been the largest employer, have resulted in growing levels of yment and underemployment of graduates. A recent study conducted in Nigeria places the level of unemployment among tertiary graduates at 22% (Delano et al. 2000). Further, studies point to the underutilization of graduate skills. Indeed, it is a paradox that in a region that suffers from a shortage of graduates with relevant skills, there seems to be unemployed engineers or technically qualified personnel operating in non-technical operations (Lall 1992; Fabayo 1996). Underemployment of skills within firms persists due to slow growth of capita income, caused by low and stagnating growth of key productive sectors.

Tables 4 and 5 show correlation and OLS regression output for human capital variables. The percentage of the population enrolled in technical subjects (including engineering and technical subjects) is a significant predictor of development, but the total R&D personnel was not significant. This means that development is positively associated with the growth of technical personnel while personnel in R&D make no contribution to income growth. This is intuitively correct as very little local R&D is carried out in Africa. However, technical personnel may be fully engaged in production and maintenance functions but not with R&D. Firms within the SI in Africa are engaged in imitative product innovation that requires marginal investment in formal research other than quality assurance. On industrial skills, we equally found statistical significance with industrial labour force but non-significance with agriculture labour force. The industrial labour variable is indicative of a country's level of development, but it is a surprising outcome given the low productivity of industry in Africa. However, one may not read too much into this finding as the variable might have been subsumed by other skills factors, such as technical enrolment. It may also find consistency with the continuing importance of agriculture that does not turn out significant in African economies. Read in conjunction with the contribution of technical personnel, our interpretation is that the economies of SSA do benefit from significant local but relatively low-level technological regime. Conversely, it may be argued that the lack of significance found for industrial R&D may be reflective of the immaturity of the region's industrialization initiatives that cannot yet fully use sophisticated technological products and processes. This is symptomatic of the dissonance between the education system and the stage of industrialization in the region.

Table 4: Correlation Matrix of Human Capital variables

		Log per capita	Agric labour	Indust. labour	Tech.	R&D Personell	Sec. enrol	Tertiary enrol
Pearson	Log per capita	1,000 36						
	Agricultural Labour	.717** (.000) 35	1.000 38					
	Industrial Labour	.728 (.000) 36	-.868 (.000) 38	1.000 41				
	Technical Enrolment	.643 (.000) 24	-.521* (.003) 27	.303 (.054) 29	1.00 29			
	R&D personnel	-.122 (.277) 30	.278 (.085) 32	-.209 (.152) 35	-.175 (.196) 24	 35		
	Secondary enrolment 75	.538 (.002) 29	-.720 (.000) 30	.697 (.000) 30	.229** (.131) 22	-.231 (.128) 25	1000 30	
	Tertiary enrol 80	.336** (.047) 36	348** (.000) 37	.108 (.300) 40	.543** (.002) 28	-.151 (.116) 25	.568 (.001) 30	1.000 (.000) 40

** .01 level of significance (2-tailed)
* .05 level of significance (2-tailed).
***enrol- enrolment

Table 5: Results of OLS Regression for Human Capital variables

	Model I	**Sig.**	**Model II**	**Sig.**	**Model III**	**Sig.**
constant	3.728 (2.785)	 .010	3.727 (2.864)	 .002	4.050 (3.434)	 .000
Agriculture labour	1.121E-02 (.791)	.426	1.122E-02 (.812)	 .531	8.111E-03 (.638)	
Industrial Labour	7.246E-02 (2.326)	.009	7.269E-02 (2.899)	 .006	7.489E-02 (3.060)	 .000
Technical enrolment	17.241 (2.809)	.001	17.190 (3.749)	 .001	16.639 (3.750)	 .000
R&D Personnel	.203 (.668)	.501	.203 (.685)	 .520	.190 (.655)	 .446
Secondary School	8.253E-03 (.396)	.534	8.040E-03 (.632)			
Tertiary enrolment	-2.048E-03 (-.013)					

4. Technological and Physical Infrastructure

An efficient infrastructure is important for two main reasons. First, lack of it compels optional provision placing added financial and material burden on firms. Firms regard the cost of alternative utilities a major impediment to new investments, as extra financial provision is required for major plant vintages as well as for minor plant additions. Second, inadequate national infrastructure makes networking among firms extremely difficult. For example, transaction costs are high where communication is hindered either by poor telecommunications or frequent power outages. In some cases linkage is not only made difficult, but impossible. In most African countries, agricultural and industrial production is constrained by inadequate backward linkage to exploit agricultural raw materials located within inaccessible but rich rural communities. This maybe due to poor road networks, lack of information and inadequate storage facilities[15].

Frequent power outage compels firms to acquire standby power generating sets. Firms that are unable to acquire private facilities either cut down production or in rare cases, share power with nearby firms with generating sets. There is the constant risk and realities of damages to sensitive machinery resulting from unplanned power cuts. The perennial poor state of infrastructure leaves manufacturers with little confidence in the ability of public enterprises to meet their supply requirements.

The effect of poor infrastructure on routine production activities could be very significant. To the extent that there is greater propensity for technical change in a regime of continuous production, the availability of infrastructure is critical to achieving competitive advantage. Planning becomes difficult and coordination among economic agents within the national economy and with international agents, very problematic. Spontaneous inter-organizational linkages made possible by all-purpose infrastructure are a prerequisite for 'networking' – that complex of backward and forward linkages - taken for granted in dynamic industrial environments. We find that the constraints seem to redirect the focus of firms in unprofitable direction. Rather than take a long-term perspective of 'internal' infrastructure as a component part of a firm's strategic growth process (e.g. skill development, re-training to match new technologies etc.), firms are forced to deal with issues largely of public policy.

[15]On a 1998 mission to some of Ethiopia 's agricultural research station by road, the journey which on a good road should be no more than one hour took three hours. The station had no functioning telephone.

Firms are being penalized for this public policy failure, through provision of alternative utilities. Where such options are beyond firms' capacity, the innovation investments tend to be the first casualty. In sum, issues relating to infrastructural capacity and capability within firms in a SSA country should be central to discussions on innovation as infrastructure significantly influences the path and process of inventive activities. It would be misleading to consider them as fixed factors of technical change.

4.1 Telecommunication and Information Infrastructure

ICT infrastructure may be divided broadly into three components: telecommunications, computing and connectivity infrastructure. Historically, the key telecommunications actor had been the Public Switched Telecommunications Networks (PSTNs). However, in the last two decades, privatization and market liberalization led to public divestments as well as the entry of new private telecommunications operators (PTOs) into the sector. Massive restructuring resulted but more remain to be done to create truly competitive markets in the telecommunication sector in Africa. While some progress has been made in improving connectivity infrastructure, there remains strong reliance on the US Internet backbones for connectivity infrastructure. Skills, innovations and major investments are concentrated in the triad of USA, Japan and Europe. While users have some form of control on the provision of private computing facilities, access to, and the quality, telecommunication and connectivity available to a user depend on geographic space. In effect, the economic environment is a determinant of the access, speed, and types of data and information and knowledge to which users have access.[16]

At the very basic level, countries have highly differentiated access to telephone and electricity services. The quality of these basic engineering and physical infrastructure is important because 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).[17] On the other hand, local and regional telecommunications infrastructure, such as server connectors, local loop telecommunication lines, inter-nodal connections and switching systems 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.

The combined effects of poor infrastructure result in high average cost of access to the Internet. Cost components include charges for local calls, line rentals and costs due to Internet Service Provider (ISP) services. Historically, there has been a strong correlation between basic domestic and industrial technological artefact adoptions, such as telephone, computers and levels of development.

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[16] Castell cites (Porat, 1972) and defines Information as simply : "data that have been organized and communicated"

[17] 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% as a result of the quality of telephone lines.

The correlation matrix in Table 7 shows the indivisibility of the various "wired" facilities particularly electrical power and telephone on the one hand, and networks variables comprising personal computers (PCs), modems, and other telecommunication facilities on the other. Internet use and Internet hosts display high correlations among themselves. The correlation derives from a group of 42 African countries but this propensity equally holds for other highly developed countries and regions (Hargittai 1999).

Table 8 shows further differentiation of SSA into *low* and *high*-income countries. Not surprisingly, most of Africa's Least Developed Countries (LDCs) fall into the low-income group as well as the low access, poor connectivity category. This confirms what we already know about the correlation of income with Internet access. For instance the 33 LDCs share of Africa's GDP was only 16.5%, about one-quarter of SSA 46 countries that was 59.5% of Africa's GDP. In Table 8, we have constructed an Internet User index (IUI) for all countries. The country with the highest per capita IUI, Mauritius, has the maximum value 1.0 and is one thousand times the value for the least, Ethiopia. Evidently there is higher correlation between IUI and the variables for the relatively higher income countries. South Africa has the next best while the African LDCs like Burundi and Eritrea with low per capita income also have low IUI. The general conclusion is that while low income is correlated with low access, some countries with the same economic structures may display different patterns Internet connectivity. Figures 2, 3, and 4 show the correlations in graphical forms. The main reasons for this may be well be historical, but may also result from policy and institutional building approaches.

Table 6: Information Infrastructure for selected African Countries (2000)

Country	Telephone mainlines per 1,000 people	Internet Hosts per 10,000 Inhabitants	Interband width outgoing (Kbps) 2001	Waiting time (years)	Mobile phones per 1,000 people	PC's per 1,000 people	Inter-net users
Algeria	57	0.01	2048	5.4	3	6.5	50
Tunisia	90	0.03	41500	0.9	6	22.9	100
South Africa	114	42.95	300,000	1.1	190	61.8	2,400
Namibia	63	18.51	3072	0.7	47	34.2	30
Mauritius	235	27.44	4096	1.0	151	100.5	87
Kenya	10	0.53	6144	8.1	4	4.9	200
Zimbabwe	18	2.16	5120	10.0	17	11.9	50
Egypt	86	0.35	112,500	1.9	21	22.1	450
Angola	5	0.01	14000	8.5	2	1.1	30
Guinea	8	0.25	128	0.1	5	3.7	8
Ethiopia	4	0.01	512	7.8	0	0.9	10
Lesotho	10	0.47	512	10.0	10		4
Mauritania	7	0.45	384	10.0	3	9.4	5
Niger	2	0.16	192	1.1	0	0.5	5
Nigeria	4	0.07	9216	1.4	0	6.6	200
Rwanda	2	0.47	128	4.0	5		5
Uganda	3	0.08	2048	3.6	8	2.7	40
Zambia	8	0.86	3072	6.7	9	6.7	20
Ghana	12	0.25	4096	1.5	6	3.0	30

Source: UNDP, Human Development Report, 2001

Table 7: Correlation between IT Infrastructure and Network Variables in SSA

Variable	Electrical power	Main telephone	Internet use	Internet Hosts	PC use
Electrical Power	1.000	0.641	0.599	0.838	0.329
	(.000)	(.002)	(.004)	(.000)	(.091)
Main Telephone	0.641	1.000	0.965	0.947	0.826
	(.002)	(.000)	(.000)	(.000)	(.000)
Internet use/capital	0.599	0.965	1.000	0.902	0.709
	(.000)	(.000)	(.000)	(.000)	(.000)
Internet	0.838	0.947	0.902	1.000	0.729
	(.000)	(.000)	(.000)	(.000)	(.000)
PC use/capita	.329	0.826	0.709	0.727	1.000
	(.091)	(.000)	(.073)	(.000)	(.000)

** .01 level of significance (2-tailed)
* .05 level of significance (2-tailed).

The results also show that investments in telecommunication infrastructure and existing telephone density are important determinant of Internet hosts that in turn influences use of the Internet. These finding are not surprising and support the findings of earlier studies (Hargittai 1999; Kelly and Petrazzini 1997).The study demonstrates the significant role played by economic wealth in stimulating the diffusion of the Internet. Similar results have been found by almost all the studies that have examined the predictive role of GDP per capita. The role of economic wealth becomes more relevant in the case of ICTs because governments need significant investment capital for a reliable and efficient communication network to experience a faster diffusion of these technologies. National and global communication network is not possible without sufficient economic wealth. In one of the chapters in his seminal book, Landes (1999) cited Gerschenkron (1962) proposal on the levels and sources of finance available for backward countries. The countries we explore are economically backward, for which Gerschenkron (1962) recommended three levels of investment capital. The three levels are:

- a country with lots of private wealth, well funded merchant banks which can finance small loans
- a poorer country with fewer and smaller private fortunes to finance industry through the creation of investment banks
- a poorer country still, where private wealth was not sufficient, and only the state could provide sufficient finance., (cited in Landes 1999, p.275)

Much of the African LDCs will be hard put to tap into any of these sources for capital. Yet, “You need money to make money”, as Landes aptly title the chapter.

Table 8: 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)	density (1,000
		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 Rcp.	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
		High 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	33.63
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

Internet User Index = $\{X_{j,i} - \text{Min}(X_{j,i})\} / \{\text{Max}(X_{j,i}) - \text{Min}(X_{j,i})\}$

Data Source: World Development Indicators, The World Bank (2002), and ITU (2002).

Data for GDP per capita in US Dollars at constant price (at 1995) have been taken from WDI (2002).

The paper also shows a strong causal relationship between the diffusion of the Internet and telephone density. In sum, high levels of GDP, strong presence of Internet hosts, an effective network of telephone are indispensable to the diffusion of the Internet and by extension to all innovations. However, network capacity without an educated citizenry may not lead to the required transformation into the network society. Our study has showed that education is a major factor in development. Internet diffusion is certainly more pervasive in the relatively high-income category of African countries even if comparatively these countries are poor relative to other developing countries.

What then should poor countries do to improve access to the Internet and in the end, bridge the digital inequality? There are two divides in broad terms, the global divide between Africa and the industrialized countries and the divide within the region. Evidently African countries need greater investment flows, since huge investments are a prerequisite to building effective communications networks. African countries have recorded improvements in literacy levels at the primary, secondary and tertiary levels since after independence. However, they are still far behind the rapidly industrializing developing countries. Even then, basic literacy is not enough, digital literacy is required and explicit investment will have to be made by African countries for individuals to become computer literate. There are other factors that have are significant predictors, such as institutions, telecommunications regulation, and forms of government. However, the major policy implication that has emerged from this paper is that the countries need to reorient their telecommunication and economic policies to promote public and private investments in ICTs that in turn might further boost economic growth (Roller and Waverman 2001). Future studies might consider the role of technological and other institutions that support effective use of the Internet. Further research is needed to examine the role of such institutions in the diffusion of ICTs in general and the Internet in particular.

Definition of income groups

GDP <= 360 USD	Low income
GDP >360 USD	High income

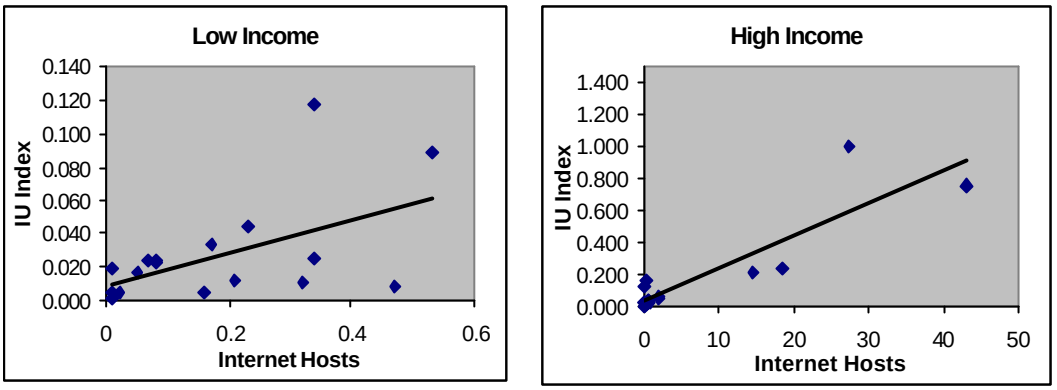

Figure 2: Internet users and hosts in SSA (2000

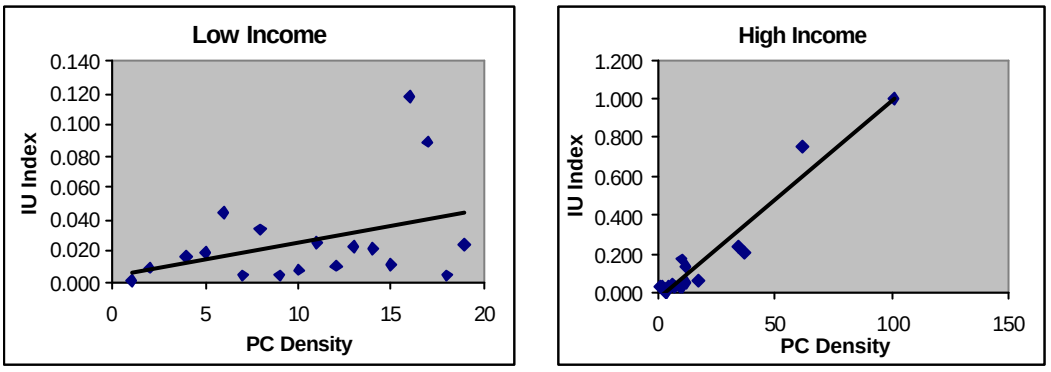

Figure 3: Internet users and PC density in SSA (2000)

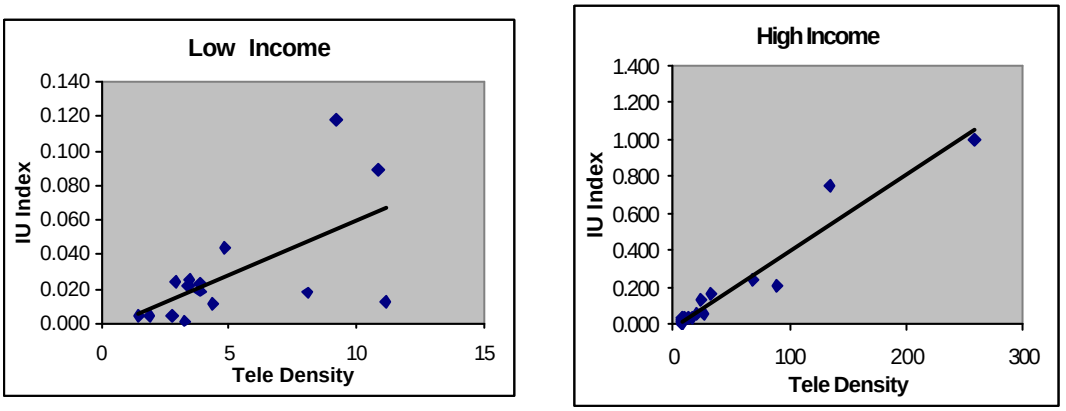

Figure 4: Internet users and telephone density in SSA (2000)

5. Conclusion

In this paper we advanced a set of propositions on the exclusion of African countries from the benefits of globalization. The first is that this development could be explained by the lack of dynamism of the region's SI, institutions that underlie the adoption, diffusion and adaptation of innovation. Second, institutions possess path-dependent characteristics influencing the growth rate of per capita incomes and the proxy for development. Third, we conjecture that these path-dependent variables, codified loosely into the concept of systems of innovation, have institutional origins that have persistently impact the evolution of African development. These variables include human capital, R&D system and industrial capacity. Fourth, we showed that human capital formation represented by schools enrolment and industrial skills capability acquisition has been inadequate in the new competitive global economy. Last, we showed that new kinds of infrastructure represented by ICT has revolutionized technology and trade exchanges. However, Africa lags far behind other regions in adopting ICTS and putting in place the necessary infrastructure, such as electrical power to support their optimal utilization. For these reasons, the nature of the state and its institutions (which are 'carriers of history') determine whether dynamic or non-dynamic learning systems of innovation emerge. We suggest that the combined impact of pattern of schools enrollment at the primary, secondary and tertiary levels combined with the commodity-based system of trade, rather than factory-based R&D supported system of industry, gave form to the current low technological base of African industry.

However, considerable work remains to be done in understanding the systemic origin of Africa's non-dynamic innovation systems and research may take several forms. First, we need to understand more specifically which are the key elements of the system of innovation that are the most influential and how much they contribute to building the SI. Second, we should understand the nature of interactions, not only within the narrow domain specified for firms and industry, but at a wider socio-economic level. For instance, how to intensify interactions of economic actors to make them more effective? Third, research should explore the specific ways in which the institutional origins of the SI influence development and what policies can mitigate the negative impacts that persist. Last, in a global economy, research and policies must understand the disruptive influences of global agreements while accommodating latecomer countries in SSA. Global governance institutions have made short shrift of the challenges facing the region, to paraphrase Stiglitz. African countries face the dilemma of the imperative integration into a world economy of the 21st Century with states and institutions that have changed little over time. Institutions developing human capital for industry and the bureaucracy need to be transformed to fulfill the needs of modernizing economies. The SI approach suggests

that the skills and knowledge bases of seemingly unrelated components can be fruitfully brought together to promote development. Capacities outside the productive firm, for instance, may well be as crucial for firm growth as the capacities within. As institutions and policies demonstrate persistent characteristics, African policy makers need to take a long-term view. Getting the institutions right is more crucial than getting the prices right.

Appendix

Table A1: SSA Manufacturing Export Performance and Foreign Direct Investment

Countries	Manufacturing Export % of total export			Manufacturing export % of GDP			Foreign direct % of GDP		
	1998	1999	2000	1998	1999	2000	1998	1999	2000
Angola				6.3	3.2	2.9	17.3	39.9	19.2
Benin	3.4			8.8	8.9	9.1	1.7	1.7	1.4
Botswana				4.8	5	5	1.9	0.7	0.6
Burkina Faso				15.9	13.1	12.2	0.4	0.5	0.5
Burundi	0.18	0.3	0.5	7.9	8.7		0.2	0	1.7
Cameroon	6.3	4.8		10.7	10.9	10.9	0.6	0.4	0.4
Cape Verde				8.9	8.9	9.1	1.7	2.6	1.8
C. African Rep.				9.4	9	9.3	0.5	1.2	0.5
Chad				12.7	12	11.2	0.9	1	1
Comoros	33.8	7.6	8.2	4.2	4.2	4.2	0.9	0.4	
DRC									
Congo, Rep.				7	5.5	3.4	0.2	0.2	0.4
Cote d'Ivoire	19.1	21.4	14.5	19.7	19.9	18.7	3.3	2.9	1.1
E. Guinea							5.3	13.8	8.9
Eritrea				14.1	14.9		4.7	5.6	5.8
Ethiopia	6.8	6.7	9.8	7	7	7	4	1.4	0.8
Gabon				4.9	5.2	4.2	3.1	-3.6	3
Gambia	5.2			5.7	5.6	5.3	3.1	3.2	3.3
Ghana	15.0	20.4	14.7	9	9	9	0.7	0.8	2.1
Guinea			30.2	4.4	4.2	4.2	0.5	1.8	2.1
Guinea-Bissau				9.3	10.2	9.9		1.3	
Kenya	23.6	22.2	20.8	11.1	12.3	13.1		0.13	1
Lesotho				17.5	16.4	16	29.8	17.9	13.1
Liberia									
Madagascar	36.2	49.8					0.5	1.6	2.1
Malawi				13.8	14	13.8	4	3.3	2.7
Mali				4.3	4.1	4	0.7	0.7	3.3
Mauritania				9.4	10	9		0.8	0.5
Mauritius	72.6	74.7	80.8	24.7	24.9	24.5	0.3	1.2	6
Mayotte									
Mozambique		10.1		12	12.2	12.6	5.5	9.6	3.7
Namibia				12.2	11.4				

Countries	Manufacturing Export % of total export			Manufacturing export % of GDP			Foreign direct % of GDP		
	1998	1999	2000	1998	1999	2000	1998	1999	2000
Niger	1.8			6.2	6.5	6.8	0.4		0.8
Nigeria	2.5	0.6	0.2	5.2	4.9	4.1	3.3	2.9	2.6
Rwanda				13	12.3	11.5	0.3	0.1	0.8
S T. & Principe				4.6	4.5	4.5			21.5
Senegal	52.8	56.6	30.4	16	16.7	17.8	1.5	3.3	2.4
Seycchelles				13.9	14.9	12.5	9.1	9.8	9.1
Sierra Leone				3.9	4.3	4.7	0.7	0.1	0.2
Somalia									
South Africa	53.7	55	54.3	19.3	18.8	18.8	0.4	1.2	0.8
Sudan	2.7			5.2	7.7	8.8	3.6	3.7	3.4
Swaziland				34.4	33.5	33.1	12.5	6.6	-3
Tanzania	21	15.5		7.4	7.4	7.5	2	2.2	2.1
Togo	12.2	17.7	30.8	9.4	8.6	9.7	2.1	3	2.5
Uganda	5.0	3.4	6	8.9	8.7	9	3.1	3.5	3.6
Zambia				13	12.2	12.7	6.1	5.3	6.9
Zimbabwe		27	28.1	16.6	16.6	15.8	7	1.1	1.1

Source: World development indicators 2002

Table A2: Data Sources of Descriptive Statistics

Variables	Source of Data
LOGPCAP	UNDP, *Human Development Report*, various issues
PRI60	UNESCO, *Statistical Yearbook*, various issues
PRI70	Ditto
PRI75	Ditto
SEC60	Ditto
SEC70	Ditto
TERT70	Ditto
TELCAP96	UNDP, *Human Development Report*, various issues and World Bank 2001, *African Development Indicators*
ELCETCAP	Ditto
ROADS96	Ditto
MVA99	Ditto
AGL90	Ditto
ILA90	Ditto
TECHSUB	UNESCO, *Statistical Yearbook 1999*, estimates
RD96	Gale Research Group (1998); UNESCO, *Statistical Yearbook 1999*; UNESCO, World Science Report 1998.

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