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Ethiopia: Innovation and Growth in international comparison

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INTERNATIONAL ORGANISATION FOR KNOWLEDGE ECONOMY AND ENTERPRISE DEVELOPMENT

1 INTRODUCTION AND BACKGROUND[1]

1. With technical progress and, notably, the advance in information and communications technology (ICT), which allows for the diffusion and access to information at increasingly low costs, there are rapidly improved conditions for societies around the world to strengthen their development prospects. At the same time, it is becoming more difficult for any society to compete and lay the foundation for an acceptable level of living based on simply standardized production, low wages, and low costs. Increasingly, *innovation* is recognized as key to economic transformation, growth and poverty reduction. A country's ability to tap into the creativity of its population and support new, commercially relevant, ideas and products is therefore becoming critical. The poorest of countries therefore find it both worthwhile and urgent to upgrade their institutions and economic activities so as to make better use of the new tools. Yet, progress with respect to new technology and knowledge cannot be commanded from the top. The key formula for success must critically include the adoption of instruments that allows each society to advance from within.

2. The *innovation systems approach* (Freeman, 1987; Lundwall 1992) views innovation as resulting from a constructive interplay between different key spheres of expertise, and between key players. More specifically, innovation and better knowledge use is dependent on the interface between three key spheres of society: academia, the private sector, and the government. All represent key actors whose interactions are influenced by the quality of each entity as well as by the incentives and means that drive their behaviors, as laid out by the theory of *triple helix*. Increasingly, the success of innovation systems depends on the degree of integration and collaborative interaction between the entities. The different spheres can enhance their contributions to the economy by interacting in a complementary, mutually reinforcing manner. Among other things, the *triple helix model* illustrates how the connectivity between policy makers, scientists and business is becoming more important in linking research and technological and commercial opportunities (Etzkowitz et al., 1998).

3. The ongoing globalization process implies that reduced costs for diffusing and accessing information, reduced transport costs, ongoing liberalization and enhanced competition has made product and factor markets more accessible for all players. At the same time, countries encounter different strengths and weaknesses. Most developing countries have not yet paid sufficient attention to the importance of innovation and ideas for generating growth. Developed countries, on the other hand, have so far not sufficiently considered the role of international cooperation in fostering technical and non-technical innovation (Juma et al., 2001). Numerous rules and regulations tend to account for lock-in of knowledge flows and innovative efforts, due to fragmentation of labor markets, risk capital markets, playing rules for universities and research institutes, etc.

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[1] The substantive work on the report has primarily been undertaken by Dr. Sara Johansson de Silva with inputs from other colleagues at IKED. Thomas Andersson is particularly thanked for providing extensive comments and additions to the paper. The author is also grateful to Boyan Kostadinov for assistance with graphical material and to Karin Helene for editing and formatting the document.
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4. The problems of turning knowledge creation and use into a driving force for local, economic development are particularly stark in Africa. Whereas each country needs to learn how to master and upgrade its own specific assets, it is important to study and draw lessons from the experience of others. So far, there have been relatively few in-depth considerations of the African contest. Against this background, the present paper provides an overview of the growth and innovation performance of one individual country, namely Ethiopia, while adopting an international perspective and drawing on multiple comparisons with other relevant countries, including in Africa.

5. As Ethiopia is one of the poorest countries in the world, an impetus to equitable income growth is badly needed. An analysis of the potential and problems inherent in its national innovation system could help identify opportunities for growth-friendly reforms. An application of the triple helix concept can further contribute to essential understanding what roles can be played by the various key societal actors to enable effective implementation of such reforms. This benchmarking exercise takes its main thrust and structure from two important points. First, drawing on the entities outlined in the triple-helix model – government, university and industry - it focuses on the basic ingredients needed for a successful innovation system. Second, it recognizes that fostering science and technology and innovation more broadly is more challenging in low income countries. To this end, the paper is organized as follows. The next section suggests some specific issues related to innovation systems in low income countries. The third section looks at the challenges facing Ethiopia specifically, while the fourth section focuses on its international competitiveness. The fifth section looks at the national innovation system, especially aspects of relevance to the triple helix, and indicators that measure its outputs, inputs and, to some extent, its linkages. The sixth and final section concludes.

2 INNOVATION IN LOW INCOME COUNTRIES: OPPORTUNITIES AND CHALLENGES

6. The World Bank defines low income countries as countries in which (2002) GNI per capita was $735 or less – i.e., an average income of less than two percent of that of the United States. This groups together many geographically, culturally and structurally very diverse countries. In spite of vast differences, many of these countries are likely to face similar opportunities and challenges with respect to innovation. What hopes does innovation hold for the poorer countries, and what challenges need to be addressed for these promises to be realized?

   - The promise of income growth. The literature on endogenous growth has developed a strong case for the role of innovation and ideas more broadly in spurring higher income growth. Innovation is a process that can raise productivity; higher productivity is, over the longer run, essential to higher income per capita. Clearly, poorer countries have most to win, if innovation can spur a growth process that can bring the majority of the population above minimum standards of living. High growth dynamics in small firms,

which dominate the private sector in low income countries, can result in better spread of wealth.

- The promise of better health and more food. The role of innovation in raising growth can be seen as an "indirect" - albeit extremely important - effect of innovation on wellbeing. There are also many areas where science and technology advancements could be applied directly to improve the lives of millions of peoples, with potentially dramatic effects especially in low income countries. There is a dire need for drugs against pandemic diseases like malaria and HIV/AIDS. New fertilizing techniques to raise crop productivity would help small farmers feed their families and raise incomes. Technology can help provide clean and safe water (see Box 1). Indirectly, improved health and higher farm productivity would increase both the quality and quantity of labor supply, which in turn could feed back positively into growth.

Box 1. The role of science and technology in improving access to water and sanitation in developing countries

Sound water management is one of the key pillars to sustainable development. It's essential for agriculture and food, energy, biodiversity, health, and poverty reduction. One of the Millennium Development Goals, agreed on by the international development community in 2000, focuses on halving by 2015 the proportion of people without sustainable access to safe drinking water and sanitation.

Investments in science and technology and their application can directly help improve sustainable water management in developing. One the one hand, it is a matter of applying current knowledge to the field. This needs to be coupled with intensified research efforts, however, to meet existing challenges in safe water use and distribution.

Existing knowledge in water science includes the technological hardware for providing drinking water and sanitation in poor countries (boreholes, hand pumps, improved latrines) and improving irrigation service delivery for small-holders (the bamboo tube well, on-demand canal regulation systems). There is also a body of experience on the institutional "software" for implementation and scaling up, such as decentralized community systems for operational management, health and hygiene education, and participatory management systems for small-holder irrigation. With a concerted effort from the international community, the knowledge base can be successfully applied to help promote equitable access and adequate supplies of water. But inefficient water use in agriculture together with climate threats (both variability and long-term changes) means that water availability will remain limited.

Research avenues to pursue include the development of technology and institutional set-up for increasing access to sanitation, especially through eco-sanitation approaches, develop further new institutional approaches to water management (legal reform, partnerships), increase water productivity in agriculture, e.g. through innovations in molecular biology, and increase climate information and improve forecasting. Such advances would help develop consistent water management strategies at all levels, and ultimately, would help the world reach the millennium goal.

Source: Lenton (2002).

- The promise of indigenous knowledge. Developing countries and development agencies are increasingly recognizing the knowledge base in developing countries, including traditional medicines, farming methods, etc., and the need to focus not only on appropriate technology transfer, but on integrating and adapting indigenous knowledge in the innovation system (Finger and Schuler, 2002).

7. But the challenges of adopting and adapting science and technology to local systems are also daunting. The foundations that need to be in place to build a strong national innovation system tend to be much weaker in low income countries (Table 1). Similarly, the linkages between the different entities in the system itself are often more fragile and ineffective than in more developed countries.

- The challenge of low demand. Low income levels mean less demand for new products and services, meaning that entrepreneurs may operate in a low profit-high risk environment, which is creating a vicious circle.

- The challenge of human capital. Overall levels of education tend to be low and education systems tend to foster few researchers and scientists. Health problems are also much more pervasive, all of which considerably reduces the productivity of labor and the ability to create or absorb technological change. Brain drain – the flight of educated people to more developed countries where returns to education are higher – can also constitute a risk, although migrants abroad can also increase the international connectivity of local business men and research elite (World Bank, 2005a).

- The challenge of physical infrastructure and communications means. Lower income countries are often geographically challenged – indeed, difficult geographical conditions, lack of access to sea transportation, etc., is in itself an important obstacle to economic growth, and more of the population lives in remote, rural areas. Physical isolation is exacerbated by lack of physical infrastructure, for lack of resources, for lack of technology, or for lack of policy priority. Information and communications technology is much less spread and has fewer potential users.

- The challenge of institutional capacity and set-up. Low income countries tend to be characterized by worse governance systems and more corruption, and often lack institutions and regulatory frameworks to support an effective innovation system.

- The challenge of the economic structure. Triple helix relations have a special character in many low income countries. Perhaps precisely because they tend to have less innovation taking place, these countries are also less diversified in terms of economic sectors and ownership. More often than in the case of richer countries, larger state-owned companies have an important role in production and exports, but the private sector tends to undertake very little research activity. Government bureaucracies are typically heavy and themselves less well adapted to a flexible innovation system, and FDI operations may be confined to isolated islands with little spill-over effects. Universities may be the only natural forum for research in the early stages, but are often bureaucratic and striving to primarily fulfill traditional criteria for academic excellence which may leave little incentive for triple helix inter-phase.

Table 1. Low Income Countries have weaker foundations for building an innovation system.

Average by country group	Paved roads 1/	Fixed line and mobile phone subscribers 2/	Secondary school enrollment 3/	Government effectiveness 4/
LIC countries	16	40	46	-0.90
OECD high income	88	1240	106	1.59

1. % of total roads, 1999. 2. per 1,000 people, 2002. 3. % gross, 2000. 4. -2.5 =completely ineffective, 2.5= fully effective, 2004.

Source: World Development Indicators and World Bank Governance Data

8. Again, the above characterization is not well fitted to such a diverse group of countries. While the challenges are real, progress is being made in areas like increasing education enrolment rates and investment climate reforms. And some countries, including among others Vietnam and India, have worked to address some of these challenges head-on and have seen high growth rates. This suggests that there is much to be learned from different countries experiences, also in a low income setting.

9. Finally, a caveat: innovation bridges all new ways of doing things. This includes not only technological change but just as often innovation related to management and organization, or with respect to entrepreneurial efforts to carve out new ways to reach markets with low-cost products. This applies to more or less all sectors, although the specific opportunities and hurdles vary. The non-technical types of innovation tend to be harder to capture than technological advances, but are just as important.

3 ETHIOPIA – CHALLENGES. GROWTH AND COMPETITIVENESS

Ethiopia faces a monumental challenge to raise income levels and pull its population out of extreme poverty. With a GNI per capita of only 100 USD in 2002, Ethiopia is one of the absolutely poorest countries in the world (Table 2). Growth levels have been moderate in the 1990s, especially in relation to the continued high population pressures. Reflecting these low income levels, about four fifths of the population presently live on less than two dollars per day.[2] Hunger and health risks are pervasive, also in an international perspective: almost half of all children under age five are undernourished; child mortality rates are forbiddingly high, and only half of all two-year olds have been immunized against diphtheria, whooping cough and tetanus. An overwhelming share of the population is located in rural areas, and agriculture – mostly small-scale farming – accounts for some 40 percent of output and 80 percent of employment.

[2] In a regression of $2 poverty rates on average income levels for 74 developing countries, Ethiopia is right on the regression line, neither over nor underperforming relative to its income levels. [Percentage of population living on less than USD 2 per day = 266 – 28 ln(per capita GNI in international USD) + ε].

Table 2. Ethiopia's challenges are huge, also in an international perspective.

	GNI per capita	Real GDP growth	Population growth	2$ poverty 1/
	US$, 2002	% p.a., 1995-2002	% p.a., 1995-2002	Latest 1998-2002
Low income countries average	430	3.2	1.6	
Ethiopia	*100*	*3.8*	*2.1*	*81*
Uganda	240	5	2.4	
Tanzania	290	4.1	2.1	
Kenya	360	1	2	
Vietnam	430	7	1.4	64
India	470	4.4	1.4	80
Indonesia	710	0.4	1.1	52
China	960	6.7	0.7	47

1. Population living on less than two PPP dollars per day, as share of total population.

	Child Malnutrition 2/	Under five mortality rate	DPT Immunization 3/	Rural population	Agriculture
	Latest 1998-2002	Per 1,000 2002	2002	% of total 2002	% of GDP 2002
Low income countries average	42	121	65	69	24
Ethiopia	*47*	*171*	*56*	*84*	*40*
Uganda	23	141	72	85	32
Tanzania	29	165	89	66	44
Kenya	22	122	84	65	16
Vietnam	34	26	75	75	23
India	10	90	79	72	23
Indonesia	47	43	70	57	17
China	25	38	75	62	15

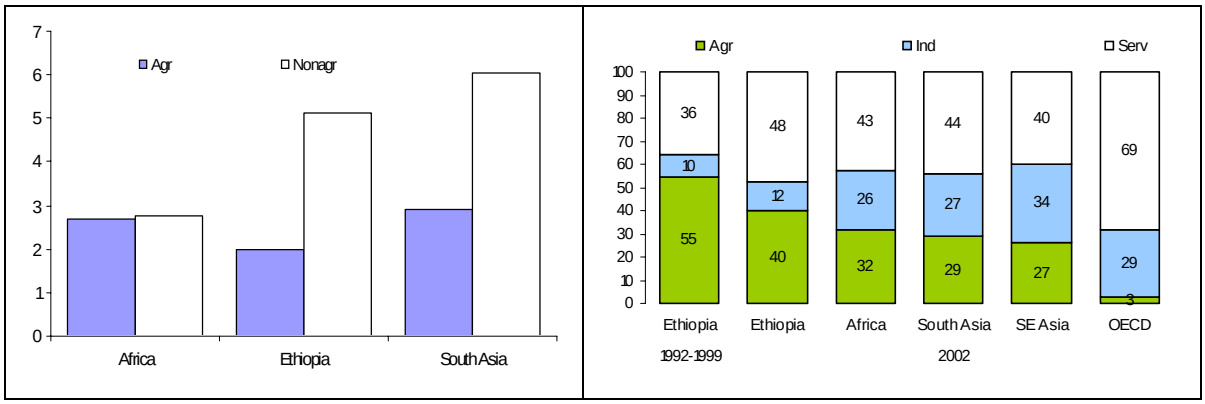
2. Percentage of children under 5 who are malnourished (weight for age). 3. Percentage of children under age 2 who had received adequate vaccination for diphtheria, whopping cough and tetanus in their first year of life.

10. As a land-locked country exposed to extreme weather conditions Ethiopia faces severe environmental challenges as witnessed in serious droughts. There are also important regional differences in economic structure and actual and potential income growth. The geographical, climate and economic conditions vary greatly between highlands and lowlands, east and west.

11. This said, the last decade saw some important market oriented reforms in Ethiopia. Among other things, trade and foreign exchange controls were overhauled, the agricultural sector was liberalized, and a privatization process was initiated, including the financial sector, and foreign debt was reduced. From 1993 onwards, growth was above Africa average in spite of the armed conflict with Eritrea. The services and industry sector have increased their share of the economy at the expense of agriculture (**Figure 1**), and the private sector has increased its share of output.

Figure 1. Growth has been higher than the African average and the economic structure has changed - but remains very focused on agriculture.

Agricultural and non-agricultural growth 1990-2002 (left), economic structure (right), Ethiopia and comparison countries.

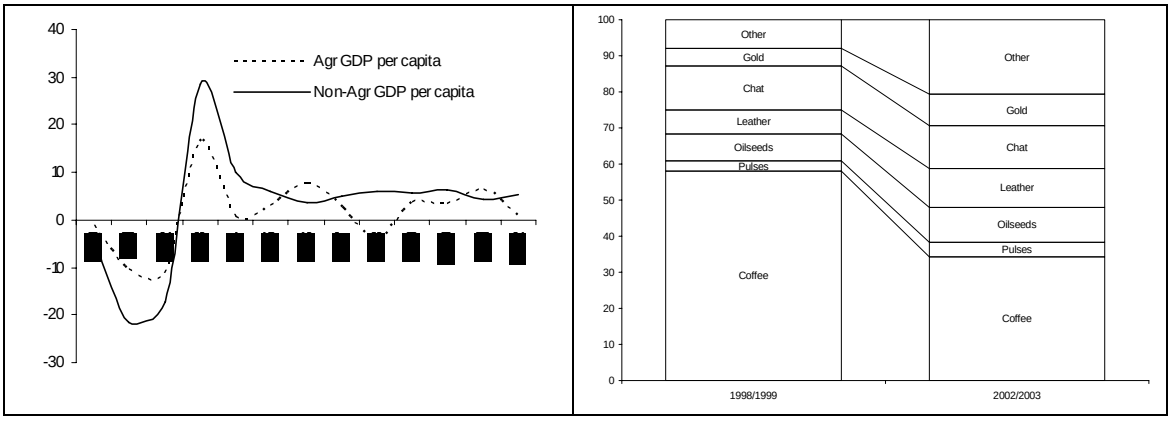


Source: WDI (2004)

12. But in spite of some structural transformation, the economy remains focused on agriculture and traditional exports. Ethiopia is largely a agricultural economy, and exposed to volatility through agricultural output and international coffee prices. The public sector retains an important role in economic production and the economy is dependent on foreign aid. Coffee continues to dominate exports although its share of total exports has given way to leather, gold, textiles, spices, and oils. (Figure 2).

Figure 2. The swings in agricultural output remain very large. The exports structure has become more diversified, but partly due to a dramatic fall in coffee prices.

Non-agricultural and agricultural GDP per capita growth (left), exports structure, % total (right).



Source: WDI (2004) and IMF (2005)

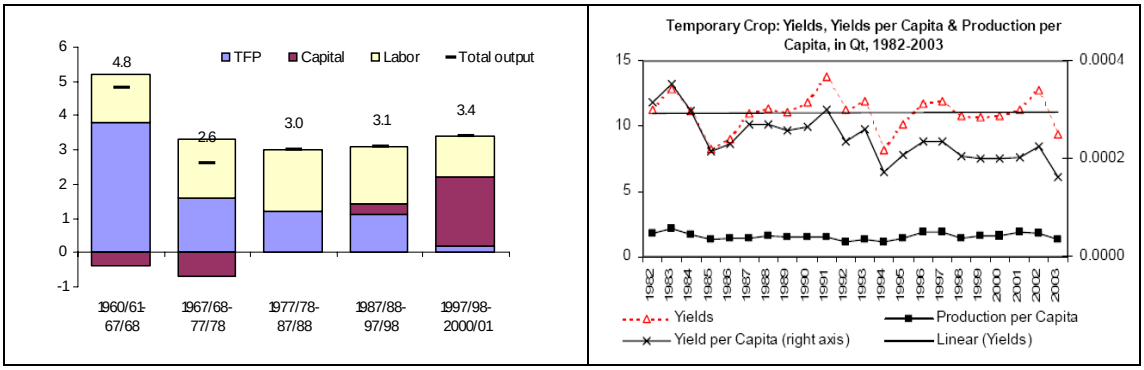
4 How internationally competitive is Ethiopia?

13. How internationally competitive is Ethiopia? The low income levels, high rates of poverty, and traditional economic structure of the Ethiopian economy, are themselves basic indicators of lack of competitiveness, low productivity and little dynamism in the economy from a longer term perspective. Ultimately, low income per capita reflects low labor productivity. But conversely, higher productivity is needed to raise income levels.

14. Ethiopia has several factors speaking in favor of its growth potential (UNCTAD, 2002): Ethiopia's assets include a large domestic market – with a population of 67 million, Ethiopia is the second largest country in Africa – a location with proximity to both East and North Africa and the Middle East, a well educated and English proficient elite, a growing and respectable private sector, and at least until recently, a comparatively safe business and social environment, among other things.

15. But productivity has fallen over time. There is relatively little information available on productivity developments, especially labor productivity, but what is available does not speak favorably of productivity developments. A growth accounting exercise for 1960-2000 suggests that total factor productivity has been contributing a smaller share to total growth over time. The World Bank's estimates of crop productivity suggest that it has fallen over the past 20 years: a result of soil erosion, increasing incidence of droughts, and continued high population pressures. (World Bank, 2005b).

Figure 3. Total factor productivity has been contributing less and less to economic growth and crop productivity has fallen.



Source: World Bank, 2005.

16. Other measures of competitiveness confirm and partly explain Ethiopia's low productivity and income levels. The World Economic Forum's (WEF) competitiveness benchmarking exercises approach the issue of competitiveness from a different perspective using industry surveys and hard data to compare country standings. As expected, Ethiopia performs poorly also in these rankings. According to WEF's *2004 African Competitiveness Report*, Ethiopia ranks number 19 out of 25 sub-Saharan economies. In a global ranking of 117 countries, Ethiopia is the twelfth least competitive country in the world, and its rank has fallen over time. (Appendix 1).

17. Relative to its low income levels, Ethiopia has a fairly stable macroeconomic environment and acceptable public institutions according to WEF's international comparison. The growth competitiveness index is composed of three sub-indices related to the quality of public institutions, the macroeconomic environment, and the capacity to produce and adapt technology. Importantly, it is in the area of technology that Ethiopia performs worst. In particular, in this ranking, the quality of Ethiopia's public institutions appears to be high relative to the country's average income level. Ethiopia's public institutions rank above Mozambique, Mali, Uganda, Zimbabwe, and Chad, countries that are all richer than Ethiopia.[3] The macroeconomic environment is also more favorable than in Mali, Mozambique, Chad, Zambia and Zimbabwe.

18. But shortcomings in terms of technology production and absorption leave Ethiopia at the bottom in WEF rankings. Only Chad ranks lower with respect to its technological capacity. Given the way the technology ranking is calculated this low standing reflects three problems in Ethiopia: a very weak ICT infrastructure, a low capacity to absorb foreign technology, and an unfavorable perception in the private sector of the national innovation system. [4] This suggests that a specific focus of Ethiopia's national innovation system is warranted.

5 BENCHMARKING ETHIOPIA'S INNOVATION SYSTEM

19. The WEF rankings suggest that Ethiopia's low competitiveness is due not only to unfavorable broader framework conditions - at least in consideration of its very low income levels, Ethiopia appears to have made important strides in improving its investment climate. Rather, limitations in the broad investment climate appear to be compounded by specific weaknesses related to the innovation and technology system. This section therefore concentrates on some aspects of Ethiopia's innovation system and how they compare to other countries. It starts off by looking at some more standard measures of *innovation output*. Weaknesses in these may be due to the lack of appropriate *innovation inputs*, the quantity and quality of the entities that make up the innovation system, and finally and perhaps most importantly, the strength of the *linkages* within this system. The distinction between these different indicators is blurred –e.g. information and communications technology is a measure of both innovation input and system linkages. The division below is therefore not an absolute classification but a way of organizing the information.

20. Lack of data for benchmarking the innovation system is a serious problem in the case of Ethiopia. This is reflecting the limited collection of data in poor countries on the one hand and the low level of development of the innovation system in Ethiopia on the other. A great deal of the information below is based on "soft" and not necessarily representative data, i.e.

[3] Using GNI per capita in international PPP dollars.

[4] The technology index is calculated from three sub-indices: an innovation index, a technology transfer index, and an ICT index. Each of these sub-indices is in turn calculated from both quantitative data on e.g. ICT use together with qualitative data from private sector surveys.

the impression that (parts) of the local business community has of the innovation climate, as revealed in surveys.

21. To make a useful benchmarking exercise of Ethiopia against what could be considered as its potential, we use as reference point three sub-Saharan African low income countries – Kenya, Tanzania and Uganda, and two Asian low-income countries – India and Indonesia, which have been experiencing relatively high growth in recent years.

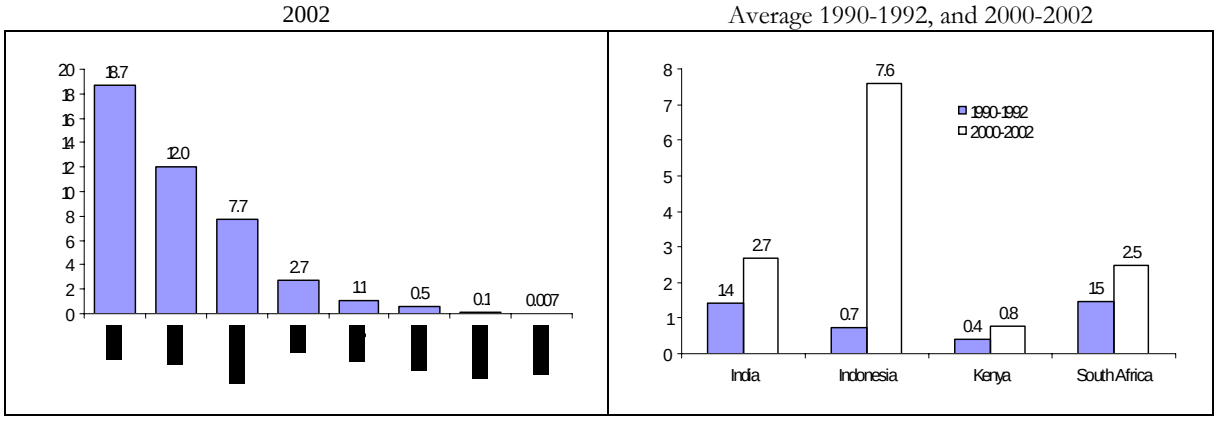
Traditional innovation output indicators – not very relevant

22. A wide set of indicators can be applied to measure the competitiveness of the national innovation system in terms of what it produces. Some of the more common (see OECD, 2003) include (i) the share of high-technology products in exports, as a measure of the ability to compete internationally in technology; (ii) registered patents, as a measure of the output of possible marketable new innovations; and (iii) scientific publications, as a measure of how competitive the academic community is. A common problem with these indicators is that they are more appropriate for more developed countries with modern economic structures and institutions.

23. Unsurprisingly, Ethiopia's exports have no high-technology content. In this regard, Ethiopia is not different from other African low income countries, but behind India and Indonesia. It is perhaps noteworthy that some of these countries have increased their share over time, showing some evidence of dynamism (Figure 4). The case of Indonesia is particularly impressive, but also Kenya has doubled its share of high-technology exports, albeit from a very low level.

Figure 4. Ethiopia is not competitive in high-technology products, and is falling behind other low-income countries.

High technology exports as share of total exports



Source: WDI (2004)

24. Other more traditional indicators like patents and scientific articles similarly indicate very little effectiveness of Ethiopia's innovation system. Resident and non-resident applications to the national patent office are scarce, and in the past 10 years there have been no applications from Ethiopian nationals to the US patent office, compared to almost 200 from Kenya and nearly

1300 from India (Table 3). While resident applications are scant in other African (and non-African) low-income countries, the lack of non-resident patent applications is noteworthy compared to other countries. This could, of course, reflect several problems, including insufficient property right protection, lack of foreign investors, the use of 'strategic' patenting in other countries and so on.

Table 3. Other standard innovation indicators confirm Ethiopia's low ranking

	Patent applications, per million people, 1999		Patent applications to the US PTO 1993-2003	Scientific and technical journal articles, per million people, 1999 1/
	Residents	Nonresidents		
Ethiopia	0.05	0.10	0	1.5
Kenya	0.07	4895	192	8.4
Tanzania	0.06	4318	2	2.7
Uganda	0.08	6287	5	2.5
Indonesia	0.0	370	57	0.7
India	0.23	76	1271	9.1
OECD	586	47396	--	499

1/ Scientific and engineering articles published in the following fields: Physics, biology, chemistry, mathematics, clinical medicine, biomedical research, engineering and technology, and earth and space sciences.

Source: WDI (2004), USPTO (2005).

25. The above indicators, while conventionally used, are not a complete or perhaps even good illustration of the strength and weaknesses of the innovation system and especially not so for a low income country. Patents are losing their relevance as a "true" indicator of innovation or economic development, often representing instead strategic protection against unwanted competition and/or lacking "real" economic value (Griliches, 1990; Desrocher, 2001).[5] Conversely, many innovations are not patented because they are of an intangible sort, or because patents are not valuable – in many developing countries, insufficient protection of intellectual property rights makes it less meaningful to seek patents, because they cannot be enforced. Patents are also best suited to protect technology and less so "softer" innovations in management, organizational structures, etc., which may be at least as important as technical innovations in raising productivity. Finger and Schuler (2002), for instance, argue that patenting may in fact be damaging in rural societies for the cultivation of traditional values, and must take second seat to long-term capacity-building in early stages. Publications, further, may have a different significance for the innovation system as a whole depending on whether the researchers live in their home country and the extent to which articles are co-authored with foreign scientists (Andersson et al., 2006). The fact that Indonesia has seen high growth and an increase in high-technology exports while displaying the weakest academic output of all the comparator countries in table 3, also shows that this indicator can be irrelevant (though there seems to be a positive relationship between patents to the USPTO and academic achievements).

26. A complementary approach in order to gauge the potential of the innovation system is therefore to examine its inputs and linkages.

[5] Corporations are increasingly patenting the results of "thought experiments", before the innovation has been realized.

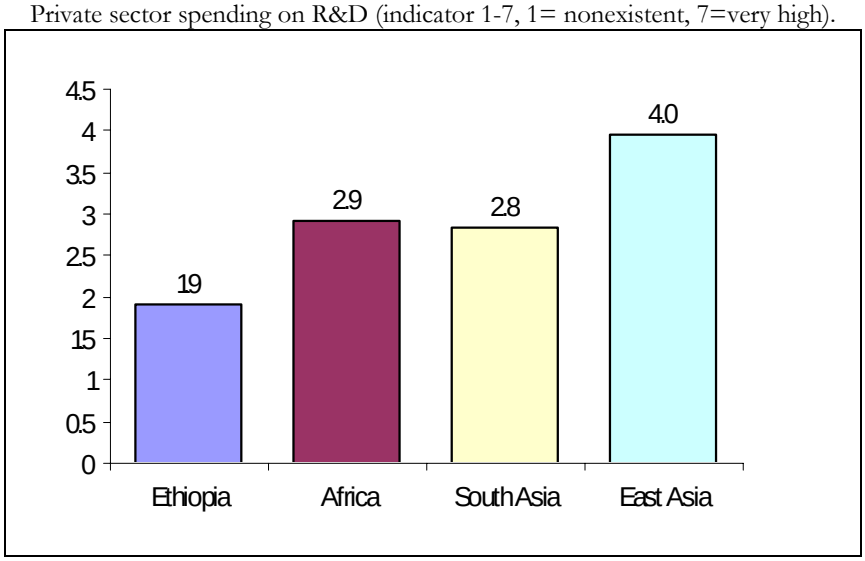
Inputs – the entities for an effective innovation system

27. What ingredients are important for innovations to happen? A potential indicator can be the amount of financial resources that companies and the government allocate to research and development activities, although again, this is more related to formal and technology oriented innovation in larger enterprises, rather than smaller incremental innovations which may be just as important. From a more general perspective, a key factor is the human capital available in the country. Another area concerns the physical and financial infrastructures which serve as a basis for entrepreneurial activity. And governance framework conditions – corruption, government effectiveness, rule of law, and others – are another important aspect of the innovation system.

28. There is no "hard' data available on the level of expenditures on research and development in Ethiopia. Surveys of the private sector indicate that *the perception* in the Ethiopian business community is that there is very little spending on research and development taking place. This perception is lower than in Africa as a whole and in South Asia, and much lower than in East Asia where, on average, the local private sector considers that there is quite a lot of spending on research and development taking place.

Figure 4. The Ethiopian private sector's perception is that there is little research and development spending taking place.

Private sector spending on R&D (indicator 1-7, 1= nonexistent, 7=very high).



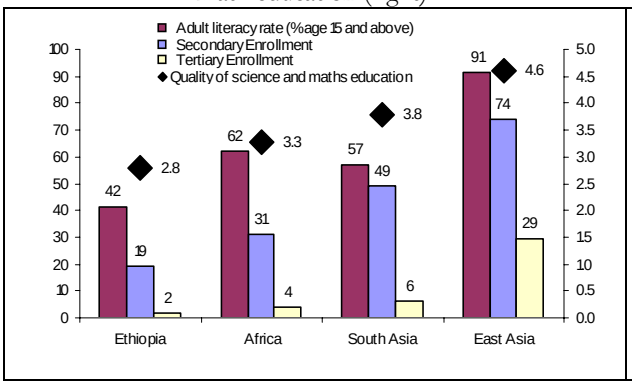
Source: WBI KAM (2005)

29. Human capital provides the perhaps most important pillar for a dynamic innovation system. Without people who are able to invent or adapt new ways of doing things, be they technology or non-technology related, innovation cannot happen. And this ability is honed through literacy, education, and exposure to new ideas, but also through good health and overall well-being. In Ethiopia, education outcomes are low, however. Less than half of the adult population is literate, compared to over 90 percent in East Asian low and middle income countries, on average. Enrolment rates are far behind competitor countries and regions – in particular, secondary enrolment rates are much lower than the African average. The quality of

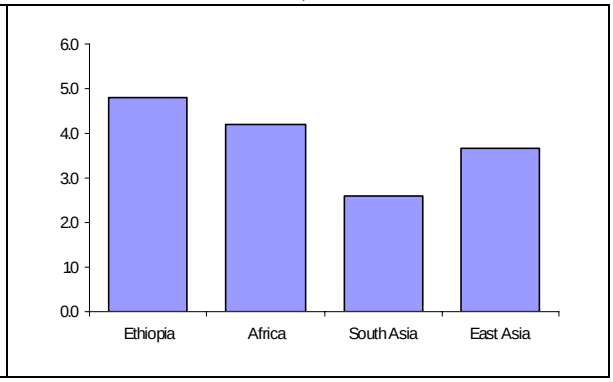
science and math education, as measured by scores in international tests, is inferior. Relatively speaking, science and engineering enrolment at the university level is not lower than elsewhere (some 26 percent of total tertiary enrolment, compared to 28 percent in East Asia). Given the low overall university enrolment rates, at 2 percent compared to 29 percent in East Asia, the resulting supply of scientists and engineers inevitable becomes very low, however. Yet, the problem appears not to be spending *per se*, but the efficiency in its use, as public spending on education is higher in Ethiopia compared to comparator regions (Figure 6).

Figure 5. Relatively high spending on education is not delivering:

Literacy and enrolment (left) and quality of science and math education (right).



Public spending on education as percentage of GDP, 2001/2004



Source: WDI (2004) and WBI KAM (2005).

30. But the availability of human capital is also dictated by health. Ill health, apart from the obvious direct negative effects on well-being, also means a smaller and less productive work force. In Ethiopia as in many other Sub-Saharan countries, life expectancy has fallen over time, from 45 years in 1990 to 42 years in 2002 (WDI 2004), with the onset of HIV/AIDS – which hits young persons at their prime working age – armed conflict, and several famines as important causes. One in twenty adults aged 15-49 has HIV, and almost half a percent have contracted tuberculosis. From these perspectives, Ethiopia is not far from the – highly alarming – health situation in other African countries. Instead, Ethiopia stands out for the remarkably low access of its population to clean water and sanitation, which can be part of the explanation for the high child mortality rates shown in Table 1 earlier. With the exception of TBC, the low outcomes in health in Africa stand in stark contrast to those of India and Indonesia, where life expectancies were already higher in 1992 and have increased over time (Table 4).

Table 4. In Ethiopia, as in other African countries, ill health affects a majority of the population, and the situation has worsened over time

	Life expectancy at birth 1992	Life expectancy at birth 2002	Tuberculosis prevalence 1/	HIV prevalence, % 2/	Population with access to -an improved water source		-improved sanitation	
					Urban %	Rural %	Urban %	Rural %
Ethiopia	*45*	*42*	*440*	*5.0*	*81*	*12*	*33*	*7*
India	60	63	431	0.8	95	79	61	15
Indonesia	63	67	742	<0.1	90	69	69	46
Kenya	57	46	462	12.3	88	42	96	82
Uganda	46	43	544	5.8	80	47	93	77
Tanzania	49	43	439	7.1	90	57	99	86

1. Per 100,000. 2. Among 15-49-year-olds.

Source: World Health Report 2004.

31. Access and reliability of physical infrastructure is another key feature of the innovation system. How can entrepreneurs access new ideas, if they are not exposed to them, and how can they implement and produce them, if there is no electricity to run machines and computers, roads to transport products and perform services, or phone lines to talk to customers and suppliers? Infrastructure access and effectiveness appears to be one critical deficiency in Ethiopia (as evidenced in the low access to water and sanitation services shown above). The country has less developed physical infrastructure, higher costs, and more service delivery efficiency problems than other countries, also compared to low income countries within Africa. The low road density and long delays in service delivery through phone and electricity connection are particularly remarkable. Ethiopia is clearly disadvantaged by its geographical conditions. Yet, in a country with large distances, low urbanization rates and rough terrain, the conditions of physical infrastructure, including telephone connections, become all the more critical for improving the interconnectedness of the population.

Table 5. Physical infrastructure

	Ethiopia	Kenya	Tanzania	Uganda	Africa	Indonesia	India	OECD
Electric power transmission and distribution losses (% of output)	10	21	25	n/a	23	13	27	8
Television sets (per 1,000 people)	6	26	45	12	45	153	83	657
Aircraft departures (thsds)	28	26	5	0	7	152	242	618
Road density (km/km^2)	3	11	10	14	13	19	112	131
Fixed line and mobile phone subscribers (per 1,000 people)	5	30	17	14	22	66	44	1303
Telephone average cost of call to US (US$ per three minutes)	7	6	5	4	4	..	3	1
Telephone average cost of local call (US$ per three minutes)	0.02	0.07	0.12	0.21	0.11	0.03	0.02	0.11
Delay in obtaining an electrical connection (days)	116	39	82	15	57	55	49	n/a
Value lost to electrical outages (% of sales)	5	6	9	4	6	..	9	n/a
Delay in obtaining a telephone connection (days)	155	33	87	27	74	23	99	n/a

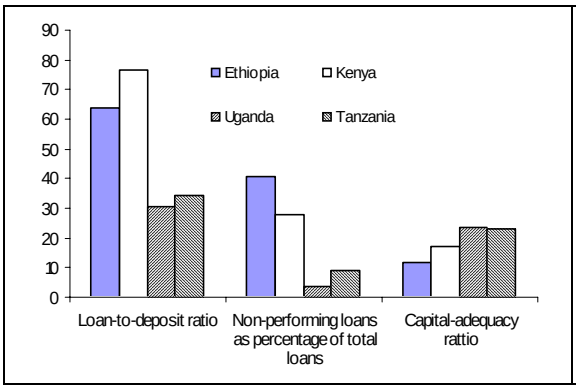
Source: WDI (2004) and World Bank Investment Surveys (2005)

32. The financial system is a key feature of the general investment climate, and is particularly important for the creation of new firms. The availability of microfinance, and for financing of more risky, but potentially innovative enterprises, is key. As an immature financial system, the Ethiopian financial structure is dominated by banking. The banking sector has seen some improvements in recent years, as the government has opened up the sector for private banking. Public banks still account for 75 percent of the assets and deposits, and it remains closed to foreign investors, however. Ethiopia has a relatively deep financial market compared to other low-income countries in Africa, but financial deepening has largely been driven by an extension of credit to the public sector (IMF, 2005). The loans to deposit rate is higher than in Tanzania or Uganda, suggesting some success at financial intermediation. But slower progress on financial reform is reflected in a much higher share of non-performing loans and lower capital adequacy ratio (Figure 7). Moreover, survey based information indicates that firms distrust the national banking system relatively more than do firms in Africa on average or in other regions, although the differences are not remarkable.

33. A recognized problem is that banks generally lack experience in implementing methods for risk analysis. As a result small firms, in particular in rural areas, are locked out of the formal finance sector. The formal banking system is also focused on short-term credit based on collateral only which needs to reach over 100 percent of a typical loans value. The demands on collateral are a problem for small innovative firms who may have the potential to grow but whose main assets may be intangible.

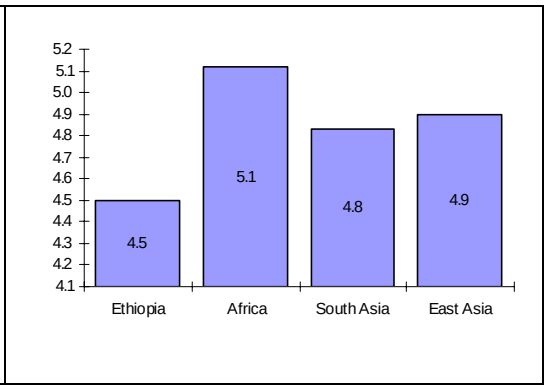
Figure 6. Financial soundness indicators show some weaknesses in the banking system which are also reflected in private entrepreneurs' views

Finance indicators



Source: IMF, 2005

Soundness of Banks.1



Source: World Bank Investment surveys

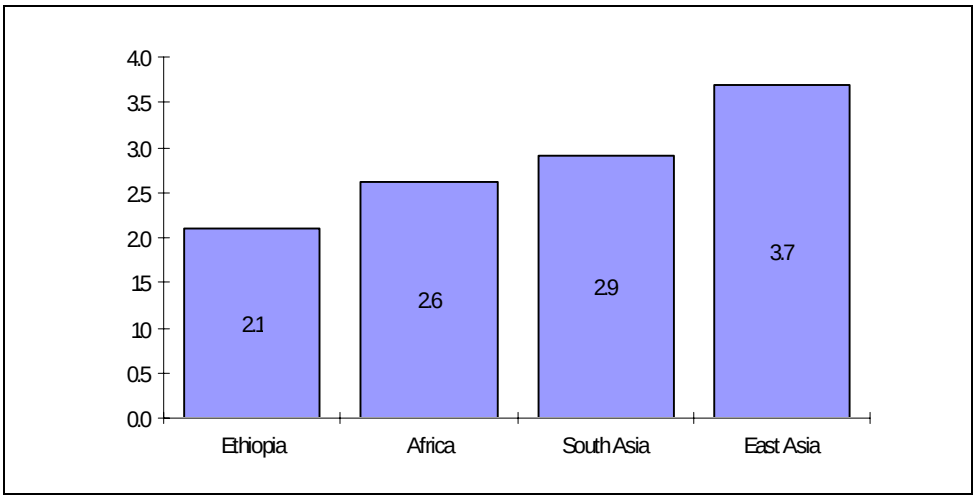
1. Answers the question: are banks generally sound in your country (1=insolvent, 7=generally healthy)

34. There are currently some 22 microfinance institutions active in Ethiopia. These institutions are largely rural and a majority (57 percent) of clients is women. Although the sector has expanded and counts two of the largest MFIs in Africa, estimates suggest that the rural poor's demand remains largely unmet (IMF, 2005).[6] Given the relatively limited outreach of small-scale lending, it is perhaps not surprising that venture capital appears to be virtually unavailable in

[6] MFIs and commercial banks cover only some 30 percent of total demand for credit (IMF, 2005).

Ethiopia (Figure 8). Informal sources of capital remain crucially important for supporting new business activities, including remittances from diasporas consisting of Ethiopians living abroad. Some of these funds could become more productive, and informal ventures to a higher extent enter the formal economy, given less red tape in the bureaucracy and regulatory framework.

Figure 7. Little venture capital available for innovative projects.1/



1. Survey-based. Answers the question: Can entrepreneurs with innovative but risky projects generally find venture capital in your country (1= not true, 7=true).

Source: WBI KAM (2005)

35. The government has an uncontestable role in building and supporting the innovation system. At the same time, the government has limited access to experts and skilled officials that can service strategic functions in development projects. Rather than evaluating the specific public innovation policies in place in Ethiopia[7] this paper provides an overview of the more general capacity and quality of Ethiopia's public institutions, as revealed in the governance system. These general conditions are important: for example, where legal frameworks are weak, corruption tends to reduce the incentives to invest in innovation. In WEF rankings discussed earlier the quality of Ethiopia's public institutions was rated low, but higher than other countries at a similar income level. Other governance indicators give a mixed picture. Figure 9 below presents data for three different aspects of the quality of governance (Kaufmann, 2005):

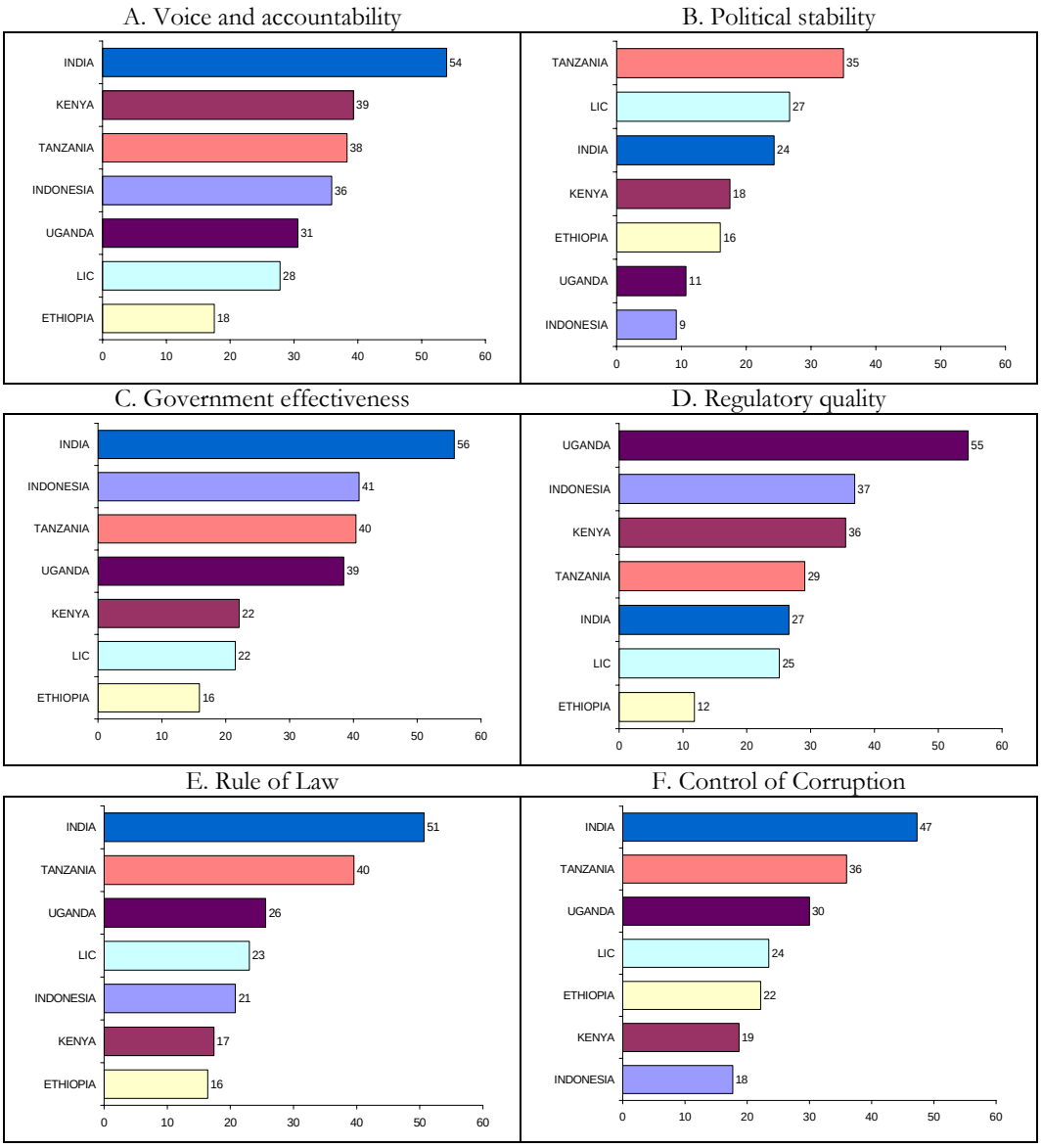
- The process by which those in authority are selected and replaced, as illustrated in voice and accountability, and political stability.
- The capacity of the government to formulate and implement policies, in government effectiveness and regulatory quality.
- The respect of citizens and state for institutions that govern interactions among them, measured by the degree of rule of law and control of corruption.

[7] An overview of the government of Ethiopia's National Science and Technology Policy (dating from 1993) can be found on: http://www.telecom.net.et/~estc/policy/national1.htm

36. Ethiopia is among the lowest twenty percent of all low and middle income countries in terms of governance. At first sight, this could perhaps be attributed to the country's low income levels, but there is, to date, little evidence that low income levels cause bad governance; instead, bad governance structures are an important cause for low income levels.[8] Ethiopia scores consistently lower than most comparator countries and always lower than average for the whole group of low income countries. The comparative situation for Ethiopia is worst regarding government policy capacity, and low regulatory quality appears to be a particular concern. Ethiopia appears to have made relatively good progress on the control of corruption, however.

[8] See, e.g., Kaufmann and Kraay (2003).

Figure 8. Ethiopia's governance system is not competitive
Governance indicators (country percentile rankings).



Source: WB governance indicators (2005)

Linkages

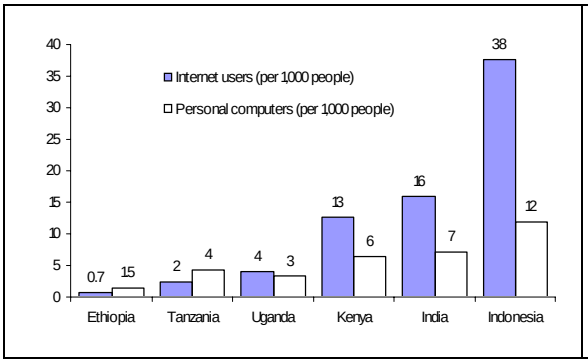
37. An effective government, good climate for private investment, and strong academic performance will not necessarily result in a good innovation climate. The way in which these entities are linked and interact is crucial to building relationships and identifying opportunities for collaboration, so that scientific research can be put to practical use and commercialized in the private sector, so that ideas flow from the private sector to academia, so that government provides the framework and institutions that can help bridge the gap between the two and so that all can be linked to the global system. Unfortunately, the strength of such innovation

system linkages is notoriously difficult to measure, especially informal interactions which may be most important. A few aspects of system linkages are outlined below.

38. The spread of information and communications technology provides a means of measuring potential interconnectedness between national and international innovation stakeholders. Ethiopia's ICT infrastructure is clearly underdeveloped and its use very limited, also compared to other African low income countries. There is less than one internet user in one thousand, the regional distribution is very unequal, and there are very few personal computers. There is little commercial use of ICT (Figure 10).

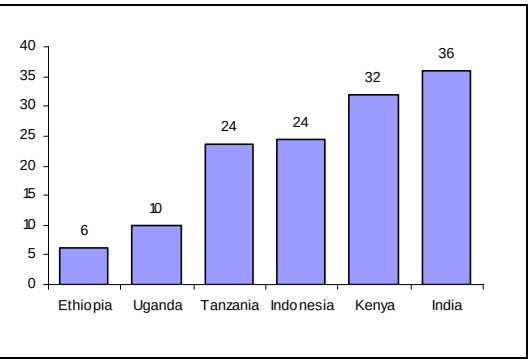
Figure 9. ICT infrastructure and use remain at low level.

ICT infrastructure



WDI (2004). Latest available 2001-2002.

% of firms that interact with customers via web

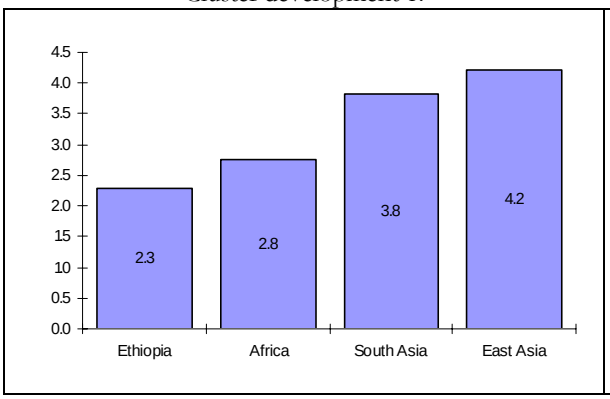


World Bank Investment Surveys (2005)

39. Collaboration between firms, and between firms and universities, appears also to be weak. A number of studies have underlined the potential importance for local development of establishing local exchanges of information and joint efforts in knowledge upgrading. The so-called cluster literature points to various ways forward, but also points to the presence of pitfalls and what tends to be required for supporting success, including that various local players are able to specialize and combine incentives for co-operation and competition (Andersson et al., 2004). Survey-data indicate that there is very little cluster development in Ethiopia, compared to the average for the African, South Asian, and East Asian regions. And, importantly, local universities and private companies do not collaborate in research and development to any great extent. In this respect, the difference between Ethiopia and the East Asian region is particularly stark.

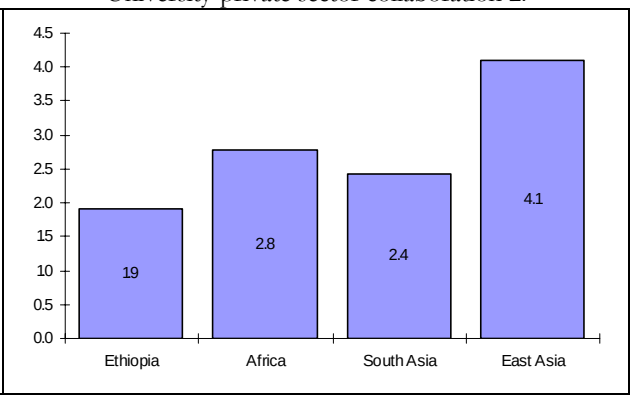
Figure 10. Weak linkages in the innovation system – within private sector, and between university and private sector.

Cluster development 1.



1. Survey based, answers the question: How common are clusters in your country: 1=limited and shallow, 7=common and deep.

University-private sector collaboration 2.



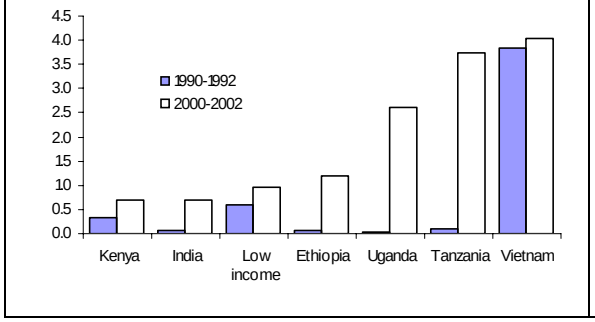
2. Survey based, answers the question: Do companies collaborate closely with local universities in R&D activities? 1=non-existent, 7=intensive and on-going

Source: WBI KAM (2005)

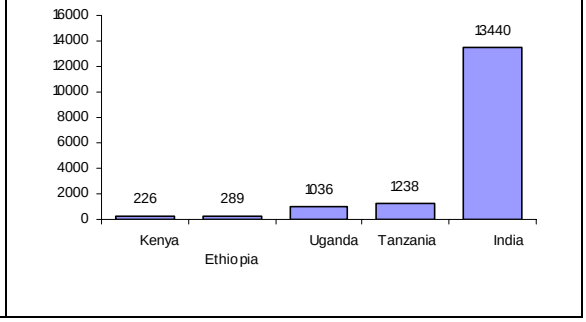
40. Foreign direct investment is one potential source of technical and non-technical know-how, depending on the nature of linkages established between foreign companies and local actors and on the type of foreign investment taking place. FDI has increased from nil in the beginning of the 1990s to one percent of GDP in 2000-2002 (Figure 12). In absolute numbers (US$), Ethiopia's inflows in 2000-2003 represented less than 25 percent of the resources going to Uganda or Tanzania, and only two percent of the resources going to India, however. FDI tends to be concentrated to Addis Ababa; most is directed to the primary sector, although one single project in the hotel sector accounted for about one third of all accumulated FDI in Ethiopia between 1992 and 2000 (UNCTAD, 2002).

Figure 11. Foreign direct investment has increased but remains low relative to comparators.

FDI inflows as percentage of GDP



Total FDI inflows (US millions), 2000-2003.



Source: UNCTAD (2005) and WDI (2004)

Firm size and innovation

41. The strong presence of small firms in Ethiopia can under the right circumstances work to its advantage. Small firms are potentially more flexible and able to introduce innovations,

especially those requiring genuine experimentation and that fall outside the domains of established core business in big firms. Innovation in small firms is nevertheless tilted towards gradual, or incremental, changes. Small firms are unlikely to undertake any significant investments in R&D and, while their innovations may draw on and use technology in new ways, they are often of a non-technological kind. As a result, R&D investments, patent statistics and other more conventional innovation indicators are unlikely to illustrate the extent of innovation taking place in small firms in the services sector. There is indeed some evidence that small firms do innovate in Ethiopia. A special survey of 71 manufacturing enterprises in chemicals, food processing, leather, metal working, and textiles, predominantly (88 percent) in the private sector, suggested that small and medium sized enterprises were more likely to innovate than larger firms (Table 6).

Table 6. Small and medium sized firms innovate more?

	Percent of firms that introduced minor technological changes	Percent of firms that introduced new products or production processes
Small	44	18
Medium	51	20
Large	22	0

Source: UNCTAD, 2002. Based on a survey of 71 manufacturing firms.

42. In most countries, small firms face more problems in undertaking their business than larger firms do. These difficulties appear to be pronounced in Ethiopia, however. According to the World Bank investment climate surveys, SMEs in Ethiopia have less access to infrastructure and land and believe themselves to be worse affected by corruption than larger firms (Table 7). It is also very costly to register a new firm, and there are long delays in other typical start-up activities including electricity and telephone connections, which are likely to hamper the birth, growth and flexibility of innovative firms

Table 7. SME's face disproportionate challenges in running their businesses.

	Ethiopia	Small (1-49 employees)	Medium (50-249 employees)	Large (250+ employees)
Percentage of surveyed firms citing indicator as a major obstacle to business				
Corruption	39	42	33	22
Access to land	57	62	36	24
Tax administration	60	64	42	51
Percentage firms that				
Share/own a generator	17	10	41	40
Offer formal training	22	10	57	64
New investment from internal funds or retained earnings (%)	70	72	53	73
New investment from banks (%)	21	18	41	23
Delay in days for obtaining an electrical connection	116	118	77	63

Source: World Bank Investment Surveys, 2005

6 CONCLUSIONS AND RECOMMENDATIONS

43. This paper has provided an overview of relevant data sets and ongoing trends for the purpose of estimating Ethiopia's competitiveness relative other comparable countries, and to identify and examine key issues that need to be addressed in order to strengthen Ethiopia's competitiveness and national innovation system. It elaborates only on some of the main issues, however, and does not address key aspects such as the role of human networks and social capital in innovation. Nonetheless, the available data suggests that Ethiopia faces important challenges: in raising literacy, educational enrolment and quality and improving health, in providing better infrastructure, in increasing the use of technology, including ICT, in improving the investment climate, especially for smaller firms, and in addressing critical weaknesses in the governance system.

44. Some of these adjustments may take a relatively long time to resolve. Higher enrolment rates may result in a better educated work force, but only in the future, as these children enter the labor market. Better vaccines and less hunger for children have an immediate positive impact on children's well-being; its effects on labor productivity may take longer to realize. Physical infrastructure can take time to develop, even if the resources are forthcoming. The fact that these are long-term adjustments does not imply that they do not need immediate attention, only that they are not a silver bullet for success in the short term.

45. Action in other areas might bear fruit in the shorter run, however. Some governance issues can be addressed and improved if the political will is there, and there is domestic and international support for needed measures.

46. Moreover, apart from the fact that investments in education and health pay mostly in the longer run, they will not necessarily result in more innovation, productivity or growth. A strategic and more immediate challenge for Ethiopia will be to enhance the network and mobility linking different capabilities and actors in the innovation system through mechanisms and institutions that allow them to interact in a mutually rewarding manner. This implies working towards a system where academic researchers can become entrepreneurs or at least get a better understanding of entrepreneurship, where entrepreneurs can work with universities, where there are fora for academic and industrial researchers to meet, and where government institutions can take on a variety of roles in providing a fruitful interface between policymakers, private sector and academia. Agricultural productivity represents one such area where research and business links can make significant advances through joint, interrelated efforts. For these advances to be useful to, and for them to reach, small-scale farmers in remote areas, strong partnerships and supporting institutions are needed.

47. What role is there for Ethiopia's universities – one of the Triple Helix pillars – in the institutional build-up? The national strategy recognizes the important role that universities can have in fostering science and technology, in adapting advanced technologies to solve local problems, and in supporting economic development more broadly. But in the right circumstances, the universities could take a stronger lead in encouraging innovation in ways that are conducive to economic development. Their role could potentially extend from providing educated workers and entrepreneurs and undertaking research, to enhancing

integration, cross-fertilization and collaborative action between academia, private sector and government. The undergoing expansion of the number of universities could inject such impulses in different regions, industries, and social spheres.

48. In order to fulfill such roles, universities need to adapt and adjust to specific structures and circumstances. They need to specialize and prioritize their roles, and be able to build local connections as part of a strive to excel in their special areas of expertise. They need to use scarce human and financial resources strategically, and develop specific competences instead of spreading their efforts thin across multiple areas. Regional features do, in fact, already constitute more of a focus in university expansion in Ethiopia. In order to advancer further, however, universities need to meet with stronger driving forces that promote appreciation among their constituents for social alliances and impacts, along with the perfection of traditional academic merits. In order to achieve this, there is a need of adjustments to the mechanisms for funding universities, so to become more performance-based and responsive to the whole range of relevant performances.

49. Whereas universities matter, the triple helix model clarifies the interactive role and the significance of all the relevant parties. Government and public authorities matter crucially through their rule-setting and financial roles. On top of that, government officials act as human beings, to a considerable extent led by their knowledge, perceptions, and values. The business sector, supposedly the research partner and actor in commercialization processes, is likewise bonded by traditions, available skills, and vested interests along with financial constraints. If universities are to become more dynamic, governments and businesses must be induced to play a role in the interface, and assist in the formation of linkages in the triple helix from their end..

50. In terms of realms for action, a "laundry list' of functions to consider include:

- Developing and maintaining alumni- and other networks;
- Strengthening links with academic institution abroad, and extending migrant networks abroad for this purpose;
- Participating actively in the build-up of science parks and incubators, and ensure that they are able to accumulate competences, and meet with objectives, that orient their efforts to fulfilling a bridging role;
- Reviewing the direction and selection criteria for research funding, so as to promote pluralism, specialization and the range of relevant performances;
- Including migrant networks and putting in place mechanisms that ensure safe remittances, so as to provide an interface that can exploit complementary pools of skills and help increase market access and funding;
- Collaborating with public/private innovation institutions abroad, so as to enhance the accumulation of complementary competencies in the triple helix;

- Providing a knowledge-base (perhaps through intermediation with other actors abroad) for science and technology challenges specific to Ethiopia – water, disease control, etc.

- Eliminating excessive bureaucracy, reducing red tape and putting in place tax incentives and better mechanisms for the diffusion of venture and seed capital, so as to remove impediments to the establishment of new firms, and strengthen the incentive for informal business to enter the formal economy;

- Using ICT, notably cellular technology, for demanded and currently under-supplied services to be better articulated and mobilized, to spur and commercialise innovations in for Ethiopia instrumental areas, such as the provision of informal capital and micro-credit, health, sanitation, ecological sustainability, education, and so on..

51. Expanding synergies between the actors of the triple helix with respect to these tasks, institutional upgrading is also required, including a strengthening of management and governance mechanisms, and a streamlining of priorities for research focus in parallel with decentralization of decision making on how to shape the linkages between the actors.

52. What role, then, for the international community? Ethiopia has a strong presence of foreign aid, in terms of institutional presence as well as in terms of financial contributions (foreign aid amounted to some 20 percent of GNI in 2001 and 2002). These resources, both in the form of technical assistance and financial inflows, could support the strengthening of an innovation system in Ethiopia, by:

- Recognizing the role of science and technology in international cooperation;

- Institutional capacity building and twinning with institutions in developed or other developing countries;

- Putting in place, or upgrading, regulations and institutions that support technology transfers as well as healthy and competent approaches to intellectual property rights protection;

- Where applicable, help identify, adapt and transfer best practice experiences from abroad in those areas where Ethiopia is in the greatest need of improvement.

53. One area for action, in relation to this particular study, is for Ethiopia as well as other low income countries to strive to develop indicators of relevant tangible and intangible assets, of interaction and of linkages between the different entities, in order to heighten awareness of key issues in an international and/or regional perspective, and provide benchmarks for improvement. Where appropriately, the methods and types of indicators used by the OECD and the European Community can be emulated, but there is also clearly a need for introducing other indicators better suited to capture the specifics of the low-income economic structure and its medium term potentials. The information needs to be adapted to reflecting the tangible and intangible assets that are specific to the environment in poor countries, to the predominance of agriculture and the rural settings, to the kinds of health and education gaps prevalent in the country and that may time to close, and the way the ICT can fill basic gaps and articulate basic needs.

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APPENDIX 1. ETHIOPIA'S RANKING IN WEF GCR AND ACR

		African Competitiveness Report 2003 25 countries				Global Competitiveness Report 2005-2006
	GNI per capita 1/	Growth Competitiveness	Public Institutions	Macroeconomy	**Technology**	117 countries
South Africa	9810	Botswana (1)	Botswana (1)	Botswana (1)	South Africa (1)	Tunisia (40)
Botswana	7740	Tunisia (2)	Tunisia (2)	Tunisia (2)	Tunisia (3)	South Africa (42)
Tunisia	6440	South Africa (3)	Malawi (3)	South Africa (3)	Botswana (4)	Botswana (48)
China	4520	Gambia (6)	Gambia (4)	Gambia (5)	Zimbabwe (9)	*China (49)*
Indonesia	3070	Tanzania (9)	South Africa (5)	Ghana (11)	Uganda (10)	*India (50)*
India	2650	Ghana (10)	Tanzania (9)	Uganda (12)	Gambia (11)	Ghana (59)
Zimbabwe	2180	Malawi (12)	Ghana (10)	Tanzania (14)	Tanzania (12)	Tanzania (71)
Ghana	2080	Uganda (14)	Zambia (13)	**Ethiopia (18)**	Ghana (14)	*Indonesia (74)*=
Gambia	1660	Zambia (17)	**Ethiopia (14)**	Mali (19)	Zambia (16)	Uganda (87)
Uganda	1360	**Ethiopia (19)**	Mozambique (16)	Mozambique (20)	Mozambique (17)	Mali (90)
Chad	1010	Mozambique (20)	Mali (17)	Chad (21)	Malawi (19)	Mozambique (91)
Mozambique	990	Zimbabwe (22)	Uganda (18)	Malawi (22)	Mali (23)	Gambia (94)
Mali	860	Mali (23)	Zimbabwe (19)	Zambia 23)	**Ethiopia (24)**	Malawi (105)
Zambia	800	Chad (25)	Chad (25)	Zimbabwe (25)	Chad (25)	**Ethiopia (106)**
Ethiopia	780					Zimbabwe (109)
Tanzania	580					Chad (117)
Malawi	570					

1. PPP (current international $)