



African Higher Education and Industry: What Linkages?

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GENERAL INTRODUCTION

Massive transformations in global communication, production and management over the last half century have placed knowledge and its application at the centre of economic and social development in all parts of the world, by integrating the generation and application of advanced knowledge into material and cultural production to an extent unknown in history. This has given added significance to the systems and institutions of knowledge production. There is evidence that spectacular economic and social developments in recent decades, especially in the newly industrialising countries of South East Asia, have gone hand in hand with rapid and substantial expansion in higher education and skills training. Though the exact character of the nexus between knowledge production and economic and social development remains unclear, there is little doubt about its existence or its reciprocal

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nature, with knowledge production and the conditions and operation of the productive sectors of economy and society influencing each other.

To start our consideration of one aspect of this problem, we offer a brief review of the key features of higher education-industry linkages and the conditions for their success. This should set the background for the examination and assessment of the African specificities.

Forms and channels of interaction

While there is no reason to expect all kinds of industry to interact with the knowledge production process in exactly the same way, even in the same country, the general pathways for the interaction are clear. From the side of knowledge production institutions², the contribution to industry takes a variety of forms and moves through a variety of channels, mainly:

- Provision of well-educated technical graduates, assuring a cadre of skilled and trainable personnel for industry, especially in the fields of science, engineering and management;
- Conduct of fundamental as well as applications oriented research that leads to industrially relevant new knowledge;
- Direct generalised transmission of the outcome of such research through publications, patents and prototypes;

² This term goes beyond “higher education” and “university”, in order to emphasise that relevant knowledge production occurs outside the formal university system, though the latter remains the principal locus for research and knowledge generation.

- Direct targeted transmission through conferences, workshops, meetings, networks and other formal and informal interactions;
- Indirect transmission in the course of collaborative ventures and exchange of personnel; and
- Transmission under commercial arrangements – research contracts, licences, consultancies, etc.

With regard to the provision of skilled cadres, the outcome turns, in the first instance, on the number, variety and quality of technical graduates produced by the education system and available for absorption into industry as managers, skilled and semi-skilled technical workers, as well as researchers. Equally significant, though often ignored, is the ability of industry to absorb and put to productive use the products of the universities and training institutions.

For interaction around the production and injection of knowledge into industry, there needs to be both a basis for interaction – relevant knowledge, on the one hand and, on the other, the need for it – as well as a disposition for productive engagement.

Clearly, in the absence of knowledge institutions with both capability to produce useable knowledge and the orientation and ability to transfer it to industry, the supply side will be absent or weak.

Thus, the higher education and training system must have the capability and flexibility to produce and supply technical graduates on the scale and in fields relevant to industry and its evolving needs. These will staff the managerial and

technical levels of industry and, in the case of medium and small scale industry, even provide entrepreneurial leadership. To meet the special needs of high-tech industry, the graduates must include a substantial portion of PhDs in mathematics and engineering to ensure high-level appreciation of emerging technologies and innovation possibilities.

Even more than the supply and engagement of graduates, the higher education-industry linkage is often perceived in terms of the production and injection of knowledge into production and management as a basis for technological and managerial innovation. A key condition for this is the capacity of the knowledge production centres, through cutting-edge as well as applications-oriented research, to produce useable new knowledge and new applications. Thus, institutions that lack high quality research capabilities have no part in such interactions. Yet the capacity to produce such knowledge is not sufficient. It must be combined with the appropriate orientation and an ability to transmit knowledge to potential users. Academic institutions, through the publication of research findings and the taking out of patents, do much of this in the normal course of their work. The critical factor is to go beyond this, and engage in more deliberate and targeted transmission to industry and other users of the research product, or indeed to engage in co-production of knowledge with such users. Modes of such targeted transmission include conferences, workshops, meetings, networks and other formal and informal interactions; collaborative ventures and exchange of personnel; and commercial arrangements, such as research contracts, licences, consultancies, etc.

For the effective discharge of this extension function, institutions frequently provide appropriate incentives for their staff and set up specific structures, such as consultancy or commercialisation units.

For there to be successful interaction, there has to be, on the part of industry, a posture of active receptiveness. Where industry feels no need for new knowledge or technology, or is unwilling or unable to invest time or resources in its acquisition, there will be no effective demand for locally-produced knowledge and technology. As the account of the situation in Africa will make clear, the receptiveness of industry to the offerings of the knowledge centres cannot be taken for granted. There must be a perception of need, recognition that the proffered knowledge products will meet the need, and preparedness to invest in the acquisition of such products. In the case of skilled technical and managerial cadres, this is usually not a problem, certainly not for high-tech and medium-scale enterprises, which need such cadres to be minimally effective. In relation to the acquisition of knowledge, however, a distinction is usually drawn in the literature between high-tech industries and enterprises engaged in the export of manufactures, which need such knowledge in order to raise their productivity and international competitiveness, on the one hand, and on the other, small-scale, low-tech enterprises, which do not perceive such need. In the latter instance, the absence of a true technology culture, which develop out of the pressure for constant updating and deepening of technology in order to survive, means that there is little disposition to invest in the acquisition of new knowledge for upgrading or adapting current technology beyond what is embodied in new machinery and other equipment.

Even in the case of high-tech producers and export-oriented manufacturers, however, whether and under what conditions they will engage with local knowledge producers for needed knowledge turns on a wide range of factors. For branches of transnational enterprises the primary source of research and new technology is the parent company and its branches and affiliates, rendering marginal any local knowledge production capacity - as often happens in Africa. In other cases, a good deal turns on the existence or otherwise of a technology culture, as well as the degree to which local knowledge producers are perceived as credible partners from whom to procure knowledge or with whom to collaborate in the co-production of knowledge. As will be seen from the consideration of the African case material, this can be a major barrier to higher education-industry linkages.

An element that runs through all discussion of higher education-industry linkage is the importance of a large measure of pro-activity from both sides. The universities and research centres must have incentives and structures aimed at promoting and facilitating linkage with industry, even as industry must be actively receptive. However, there is evidence that, necessary as university interest may be to engage, successful linkages have come into being and survived principally through the commitment of industry and its investment of time and resources in specific linkage arrangements – whether through seeking collaboration, commissioning contract research, setting up an incubator or citing a research laboratory, receiving student interns, or releasing staff as adjuncts to institutions. Indeed, it may be stated with some force that, without vibrant industry driven by the pressure to raise productivity and lower costs in order to thrive on a fiercely competitive, usually export market, the demand for new knowledge and new technology remains weak, and recourse to

knowledge institutions for support or collaboration is highly unlikely. In such conditions, therefore, the response to overtures from the knowledge institutions is bound to be lukewarm. This must explain a large part of the lack of long-term success of the many university initiated measures aimed at promoting and facilitating linkages with industry.

Policy Framework and Intervention

A third general condition for the success of higher education-industry linkages is a supportive public policy framework. Experience shows that appropriate public policy interventions are often necessary to strengthen both the supply and demand sides, and bridge the gap between knowledge producers and industry. This takes a variety of forms, from creating the necessary competences on the supply side, mainly through support for graduate training and research selected priority areas in universities and research centres, to the establishment of official structures to facilitate collaboration and information flow, to direct incentives to stimulate industry demand and receptivity to local knowledge workers and products. In some instances the state has collaborated directly, in a variety of ways, with universities and industry.

THE AFRICAN SCENE

To frame the review of the African situation, a set of clarifications are necessary. First is the limitation of the discussion essentially to Sub-Saharan Africa. The histories of the Maghreb and South Africa, as well as their levels of development are sufficiently different from the rest of Africa to make meaningful generalisations difficult for purposes of our topic. On the other hand, even though Sub-Saharan Africa is by no

means homogenous, there is enough in common to allow reasonable for generalisations.

Secondly, an undertaking such as this is faced with the usual difficulties of lack of adequate and consistent national and inter-country data. This is compounded, in this instance, by the virtual absence of literature dealing with the actual forms and structures of interaction, in contrast to the burgeoning literature elsewhere. We have been fortunate to come across a number of country case studies, which provide us with useful, if limited, material on which to proceed.

A third factor relates to the near-absence of high-technology industry properly so-called, as will be clear from the discussion in section “INDUSTRY”, below. Given the prevalence of small- and middle-scale industry and its critical role in Africa’s development, our presentation will deal with industry generally, including high-tech industry where it is found, concentrating on pathways between industry and knowledge production centres, and the extent and potential of such linkages.

HIGHER EDUCATION

As indicated above, the key conditions for effective higher education-industry linkage include (a) the capability of higher education to produce skilled technical and managerial graduates and useable knowledge, and (b) the capacity and disposition of higher education institutions to transmit such knowledge to end users. To assess this, it is necessary to review briefly the state of African higher education and its relationship with industry.

Capability

The starting point has to be the liberal arts and basic science orientation acquired by most higher education institutions from their inception as colonial or immediate post-colonial creations. This orientation, which suited the immediate post-colonial agenda of providing a cadre of leaders and workers to run the public and private sectors of newly the independent states, was, by and large, effective within the first decade or so of independence. Before the end of that period, however, there began a clamour to alter the mission of the almost exclusively public universities and training colleges to make them more development-oriented. This culminated in the call by Africa's higher education leaders for the transformation of the leading African institutions into "developmental universities", at two major events, a UNESCO/Economic Commission for Africa Conference held in Tananarive, Madagascar in 1962 and the Association of African Universities' workshop on, "*Creating the African University: Emerging issues in the 1970s*", held in Accra in 1972.

In recognition of the changing global environment and the increasing centrality of knowledge to production and social development, the call for developmentalism became more insistent and steps were taken to give it meaning. Universities of science and technology and of agriculture were established; new emphasis was placed on polytechnics and technical training; and, in the early 1990s, technology parks began to be set up around universities and other higher education institutions. However, these attempts to re-orient higher education in Africa have to date had very limited success, partly because of the persistence of the ingrained orientation and practices of the leading universities, but also for lack of complementary transformations in economy and policy.

What had changed by the end of the 1980s was the profile of the typical higher education *system*, with an explosion of enrolment and ageing faculty, and reduced research and graduate study. The situation was exacerbated by a combination of neglect and underfunding, as well as policy errors at both system and institution levels. The result of all this was that, by the late 1990s most African universities were in dire straights, not excluding its premier institutions, which had, in their prime, vied with the best in the world.

The situation is, perhaps, best captured in the following set of paradoxes:

- Dramatic increases in the number of universities following the wave of political independence, bringing the number from 52 in 1960 to over 400 in 2000, and still climbing steeply, especially in relation to private provision: YET (a) many countries still have only one, two, or three universities; and (b) there has not been much diversity in institutional forms and functions.
- University enrolments have exploded over the period, rising four-fold between 1975 and 1985, almost tripling again over the next decade, and still rising: YET, with an average participation rate of barely 5%, pressure for enrolment expansion is unrelenting.
- Expenditure *per* student as a proportion of GNP, i.e., relative to national wealth, is far higher in Africa than anywhere else in the world: YET owing to a combination of (a) difficult economic conditions in most countries (recent improvements in economic growth in some countries

notwithstanding) and, (b) the fact that most universities depend on public support, the provision of resources has not kept pace with enrolment.

Another problem of relevance to our discussion is the ageing of the faculty in virtually all universities, as senior faculty have aged and moved on to retirement, without being replaced at the rate required to maintain the appropriate levels of leadership of research and graduate programs. This can be seen from the following selective and often dated figures:

- Since 1990, Africa has been losing an estimated 20,000 professionals each year (International Organization for Migration) – many of them academics;
- Makerere University (2006) and the Ghana university system (2003) have estimated vacancy rates of ~40%;
- Nigeria: 400 professors (45% of the top-level professoriate) will reach mandatory retirement age in 2008;
- South Africa: 50 percent of academic staff are over age 50 (2004)
- Makerere University: only a third of academic staff have doctoral degrees (December 2006);
- For the first time, teaching positions (~91) in the University of Dar es Salaam are to be filled by staff with only a bachelor's degree (2008).

The overall results include:

- Heavy teaching loads resulting from hugely expanded enrolments, unmatched by commensurate faculty increases or the benefit of modern teaching aids ;

- Involvement of academic staff in non-academic activities as a means of supplementing low official incomes, cutting down on time for staff development and research; and
- The absence of mentoring by senior colleagues, and of a critical mass of other researchers, heightening the isolation of young researchers and reducing the scope for “learning on the job”.

All these results had obvious implications for the quality of provision and research.

Though there have been remarkable instances of coping and pockets of significant revitalisation, and though there has been, particularly in the past couple of years, a general awakening at the institutional, national and continental levels to the need for drastic action, the general picture, as it relates to our topic remains basically problematic. This is in part because the attempt at revival has coincided with the rise of the knowledge society and the imperative of global competitiveness, which means that Africa’s institutions, unlike most others in the world, face a dual challenge:

- The old task of managing the essentially primary-production economy and “Third World” social conditions by producing experts for public and private service, and
- The new one of helping to create/manage a modern society and economy in a situation of global competitiveness, through the provision of cutting-edge knowledge, advanced management and innovation.

If this picture of degeneration in the conditions for knowledge production and innovation appears unduly bleak, we are sure there are people here who can correct for our distance from direct current experience. Our concern is to highlight the

challenges as a backdrop to a better appreciation of the basic capability of the higher education system to respond effectively to the needs of industry.

Turning directly to issues of university-industry linkages, it must be noted that Sub-Saharan Africa has, as appears from Tables 1 & 2, the lowest tertiary enrolment rate in the world, particularly in the scientific and technical fields. A gross tertiary enrolment rate of 5% compares with 70% for North America and Europe, and a world average of 24%! As to tertiary-level enrolment in the technical fields, the rate of enrolment in 1995 was 0.28% in Sub-Saharan Africa, compared to a developing country average of 0.82%, and 4.06% for the developed countries. (Table 2) With 12% of the developing world's population, Africa accounts for only 4.4% of tertiary-level enrolment, 3.1% of *technical* tertiary enrolments, and 1.7% of *engineering* enrolments of this group of countries. The total number of engineers enrolled in the whole of Africa represents around 12% of the corresponding figure for South Korea alone. For instance, in 2002 the three universities with substantial technology programmes in Uganda had a total student enrolment of approximately 1,000 in four-year engineering degree programmes. This compares with Australia, for example, which, with a lower population, had 53,000 students enrolled for similar engineering degrees.

Orientation

The general state of the African higher education system as it relates to our topic, as revealed in the literature, especially the case studies, is captured in the statement:

“The skill base is very weak and the educational system is generally not geared to meeting the skill needs of industrial competitiveness.” (United Nations 2003, 16)

In fairness to higher education institutions, it must be acknowledged that most are fully aware of this situation and have made efforts to improve it both within their institutions and by reaching out to industry. Outreach to the productive sector has been seen as an extension of the conventional objective of community service as well as a means of generating income. It has taken several forms, including incentives to staff to undertake industry-relevant research, take on research contracts, provide consultancy and other services; structures to facilitate interaction with industry; and in some cases spin-off companies for the commercial exploitation of research outcomes and fuller integration into the productive sector. Notable examples include:

Makerere University

- The *Uganda Gatsby Trust*: an NGO established in 1994 with seed funding from the Gatsby Charitable Foundation (GCF) in the United Kingdom. Based at the Faculty of Technology, Makerere University, it seeks to support manufacturing and value adding businesses with growth potential. Its activities include training courses; business development services; student attachments; technology development and transfer; and a business park
- The *Makerere University Private Sector Forum*: a platform for interaction between the university and the private sector, with a view to encouraging support for university programmes and promoting entrepreneurship training, joint research, curriculum review, technology innovations and transfer, and business cluster development.

University of Dar es Salaam

- The *Institute of Production Innovation* was founded in 1981 at the University of Dar Es Salaam to carry out product innovation and transfer it to industry, and to provide technical consultancy for enterprises.

Kwame Nkrumah University of Science and Technology

The *Technology Consultancy Centre*: originally established in 1972 as a production unit of the University of Science and Technology in Kumasi, the Centre serves as a conduit through which university research is made available to industry. Most of its clients are small and medium-sized enterprises in the informal sector, and technologies transferred are mainly on food processing, fabrication of small-scale machinery and parts, and ceramics manufacture and foundry works.

Similar examples could be found be found in anywhere on the continent.

In the end, though, the conclusion has to be drawn that these initiatives have not proved substantial or sustainable for reasons to do partly with the histories and ways of work of our knowledge institutions, making it difficult for their full embedment within the institutions, partly with the state and orientation of industry, as will emerge from the discussion that follows, and partly with the overall policy framework within which the interaction takes place, especially the dependence on donor funding for survival.

Taking up the general situation within the institutions, we note that the fundamental factors relate to curriculum coverage and enrolment spread, the extent and nature of research activity, and attitudes towards involvement with industry and commerce.

Curriculum and Enrolment Spread

Enrolment is still heavily biased in favour of liberal arts courses, with not enough science and even less engineering and mathematics graduates. (See [Table 2](#)) The roots of the problem lie largely outside the university, in that the secondary schools do not turn out enough science-ready university entrants. It is also the case, however, that

with the unit cost of producing science and technology graduates so much higher than for liberal arts graduates, virtually all the private universities, which account for a large part of the recent institutional expansion, concentrate of non-S&T courses. The upshot is that the pool of science trained graduates from which industry would draw its high level technical workers is much shallower than in other regions of the world.

Apart from the poor presence of S&T students and courses, the teaching and learning process does not privilege the development of problem-solving skills or exposure to real life situations. There are notable exceptions, of course, especially in the medical schools and in those institutions where problem-based learning, community work and industrial attachment still form part of the teaching and learning process. The situation in most institutions which had these is that they are no longer affordable, especially in view of bloated enrolments, overcrowded classrooms and laboratories and grossly inadequate staffing.

A particularly serious aspect of this is the absence or virtual collapse of graduate study in most universities. While the issue is all-encompassing, affecting all parts of the academic enterprise and research culture in particular, the relevant point for present purposes is that we are not turning out the numbers of PhDs in mathematics and engineering required for high-tech take-off, nor the Masters for leadership in SMEs, if our economies and societies are to be globally competitive.

This is not to say that a shortage of science graduates with problem-solving skills or PhDs is currently handicapping local industry. There is evidence to the contrary, with the arrival of the unemployed science graduate. While the nub of the issue appears to

lie in the absorptive capacity of local industry (which we address later), the point of note is that our institutions are currently in no position to provide the depth and range of basic science and high level problem-solving skills needed to support industrial development of the sort and at the levels required to move African societies out of poverty and into a solid competitive posture such as is demanded by the times.

Research

In the second place, there is not enough research, basic or applied, in our universities, and what there is neither of the type nor the quality to attract the interest of industry, or to lift it to a higher level. This is partly to do with the quality of human resources available at the universities and the incentives for undertaking industry-relevant research. Apart from the fact that many of the faculty do not hold the PhD, time for research is constricted by heavy teaching loads. This is especially serious in the technological fields where, additionally, issues like the development of new products and successful linkage with industry are rarely taken into account for purposes of promotion and career advancement. This is a major disincentive to engaging in R&D activities that do not lead to scientific publications.

A further issue concerns the relevance of such research as is undertaken. Because of the “publish or perish” syndrome, research agendas tend to focus on purely academic and scientific objectives, to ensure publication in refereed journals, with little regard to developmental needs. Not surprisingly, the results of such research are rarely relevant to the local entrepreneurs and industries, who in consequence, feel no inclination to forge partnerships with such researchers or their institutions.

Attitudes

In the third place, and linked to some of the factors identified above, there is little understanding in the university setting of the ways and constraints of industry, and what it takes to prepare for and work effectively with it. There are, of course, instances of attempts to mediate this by establishing structures within the university or

centre for facilitating and promoting industrial outreach and interaction. We mentioned some of these earlier. But, by and large, this has not been able to overcome the drag of the factors mentioned above.

Finally, there is a line of thinking, particularly within the leading public universities, which holds that the role of universities is to develop knowledge through research, publication of research results and the training of students, and not with solving routine problem. In such circles, research commissioned by industry is often considered as being “not real science”. This is linked to the insistence on publication in peer reviewed journals as the basis for academic career advancement.

INDUSTRY

Turning to the situation of industry in relation to linkage with higher education, we start with the recognition that the basic unit of technological activity is the industrial firm, which is responsible for the acquisition, development, adaptation and use of technology. Its activities, particularly in a competitive setting, stimulate innovation in technology and its application, which usually drive the higher education and research sector. Thus the presence and activities of such firms are key to the technological and broader development of any society in the contemporary world. Experience shows that factors that drive technological development of such firms include competition and trade policies, governing rules and regulations, physical infrastructure, skills and financing. But, though only one of several such factors, skills acquired through high-level and specialised training as well as knowledge generated from relevant research are determinant of success in the new competition.

Against that background, what can we say about the industrial firm and the condition and structure of industry generally in Africa, in relation to technology development and knowledge acquisition? In what follows, we rely primarily on country case studies of Kenya, Ghana, Uganda and Tanzania, published by UNCTAD in 2003. While these four studies could not represent the total situation on the continent, the main findings are confirmed by other studies, and are sufficiently robust to form the basis of our comments on Africa (outside South Africa and the Maghreb).

By and large African manufacturing, as portrayed in the case study countries, is dominated by low level processing of natural resources and the production of simple consumer goods for local consumption. Describing a typical situation, the 2003 UNCTAD study observed that

Ghana's industry structure consists mainly of a large refining industry and aluminium smelting facility, with very limited manufacturing capacity. The modern sector, largely owned by foreign companies, is concentrated on food processing and on industrial intermediaries manufactures (Pietrobelli, 1994). Most of the semi-modern enterprises are relatively small-scale African-owned operations running on simple machinery and on low-level technical and managerial skills. They generally produce lower-quality goods geared to the domestic market. The informal sector is entirely African and operates on even simpler technologies. (United Nations 2003, 43)

What this says is that, rather like its systems of higher education, Africa's industry has remained substantially untransformed from its colonial raw material production and export origins. At a time when world trade has shifted strongly from resource-based to technology-based products, Africa has the highest share of resource-based exports, while its share of high-technology products is the lowest. Over three-quarters of all exports are based on primary products, and two-thirds of export revenues come from petroleum alone. The share of engineering, food, and garments exports are relatively low, except for Mauritius. Further, it tells us that there is hardly any high-tech, that is,

truly R&D-intensive industry, such as wireless technology, advanced biotechnology, materials science, etc.

What industry there is consists essentially of light manufacturing, often involving simple and relatively self-contained engineering activities and agro-processing, relying largely on technology embodied in simple equipment, and requiring limited skills. Not surprisingly manufacturing value-added in Sub-Saharan Africa, excluding South Africa, grew at only 0.10% per annum over the period 1990-97, and has stagnated at 0.4% as a share of global manufacturing value added, in a situation where the developing country share of global manufacturing value-added had moved up from 17% in 1990 to 24% in 2001.

Nevertheless, these medium technology enterprises being the most significant forms of industry in Africa, their performance is vital to the development and competitiveness of African economies in the near term. Improvements in their productivity and coverage through engagement with local and foreign knowledge and technology sources are, therefore, of the first importance. That is the perspective that shapes the focus of the discussion that follows.

The key findings of the UNCTAD case studies can be summarised as follow:

- In general the industrial structure is characterized by an emphasis on low technology products, with little evidence of technology deepening or adaptation of foreign technologies to produce improved or new products.
- The prevalence of passive importation of relatively simple technologies and their use at relatively low levels of technical efficiency, as well as the relative

absence of local capital goods production and design engineering, mean that technological learning and diffusion are limited.

- The employment of technically qualified personnel such as trained engineers is low³, and in-house training is limited to creating the basic skills needed to operate equipment.
- In general firms show little awareness of the importance of science and technology activities and of technological capacity in ensuring industrial competitiveness. This reflects the absence of what may be described as a “technology culture”. In consequence firms are reluctant to pay for technology services, nor do they spend enough on R&D.
- As appears from Table 3, R&D spending in Sub-Saharan Africa was 0.28% of GNP in 1997, as against a developing country average of 0.39 and a world average of 0.92. Indeed, formal R&D is confined to a very few large enterprises, while the bulk of R&D is conducted in the public research institutions and universities, mainly with public funding. For instance, it is reported that, on average, 90% of what little R&D expenditure there is in both Ghana and Kenya is funded by Government.

Considering its percentage of the world’s total population, it is estimated that Africa carries out only about a tenth of the R&D it ought to be carrying out. And where it occurs, the research outputs are often prematurely abandoned, rarely transformed into usable technologies. Ironically, the low volume of R&D carried out and the low rate of transformation of research results into

³ While this holds for the typical medium- to low-technology enterprise, the situation is significantly different for the larger firms and major public enterprises and utilities, where the top engineers and managers are drawn from local graduates, occasionally with foreign post-graduate qualifications.

practical use lead to low returns to R&D investment in Africa, as compared to the developed and emerging countries, which in turn leads to low investments, in a downward spiral.

- Links with technology institutions are confined to necessary, basic activities, such as mandatory certification of products or material testing. There is very little research contracting or use of institutions to search for and adapt new foreign technologies.

This general absence of a technology culture is attributed in part to the lack of competition such as would spur demand for better and more efficient technology, which in turn could stimulate science and technology organizations to create more advanced, useful and affordable products.

As will be noted later, most countries have extensive public infrastructure devoted to the production and transmission of industrially useful knowledge and technology to industry - research centres, industrial promotion units and funding arrangements. Yet the evidence from the case studies and elsewhere is that, by and large, firms are unaware of the technological services or capabilities available within the official technology infrastructure and universities, or regard them as irrelevant or inefficient. There are, thus, few links with these institutions, their facilities and their resources.

For all these reasons, especially the generally weak skill base, lack of a technology culture, and resulting low inflows of high technology, most industries lack the ability

to absorb sophisticated technologies, which is the cutting edge of industrial dynamism and competitiveness. Further, due particularly to the low level of in-house technological activity, the majority of firms are not always able to identify their specific technological needs and, on that basis, seek, acquire and absorb essential knowledge and technology inputs through research contracting, collaborative ventures, etc.

This, together with the weak drive for technological innovation in private industry creates a formidable barrier to linkages with agencies that can conduct research for, or in collaboration with industry, or have the means to secure such research, and constitute the main constraint on the provision of technology support by research and development institutions.

As succinctly put in the UNCTAD study:

Where such [in-house] capabilities are lacking, even good technology institutions can do little. (United Nations 2003, 33)

Without a more dynamic technology culture in private industry, an institution such as the Kenya Industrial Research and Development Institute cannot provide much more than mundane technical services. (United Nations 2003, 31)

A final feature of note is that the major industries in Africa are for the most part affiliates or subsidiaries of multinational companies established in developed countries, and operating mainly in the primary sector and the services. These affiliates and subsidiaries carry out very little research on the continent, almost all the needed research being undertaken at the headquarters or other locations of the parent companies. In consequence, their presence has little impact on domestic technology development.

CONCLUDING COMMENT

It is difficult to bring such a wide-ranging discussion to a neat conclusion. Nor is there much point in attempting to offer “recommendations” What we do instead is to offer some initial ideas, aimed at encouraging a systematic approach to what ought to be a burning national and continental issue.

Given the lack of data and clarity on such a crucial issue as the mobilisation of Africa’s knowledge resources in support of its sustained growth and development, a first concern has to be the establishment of a well-resourced facility and process, involving industry, government, universities and the technology institutions, for the study and proper foresight of this phenomenon in its evolution over the coming decade. Experience elsewhere should be carefully examined as a supplement to thorough study of the evolving reality of African conditions.

An obvious second thrust is the revitalisation and strengthening of Africa’s universities and facilitation of their repositioning to provide the intellectual sinews of a new drive for African development on all fronts. The case for such a revitalisation drive is now generally accepted – nationally, continentally and among Africa’s donor partners. The principal gain will be the combination of increased access with quality and lifelong learning skills, as well as the general spread of the scientific approach to life. This will have immediate benefit not only for the quality of individual and social life, but also for the quality of the labour force as a whole, and thus for the productive sector, including industry.

This general improvement of education should be complemented by a special programme for the strengthening of higher education, research and graduate study in carefully selected priority areas, aligned to specific national industrial development objectives. Appropriate intermediary arrangements, including laboratories and other facilities, should be made, both to support such research and to promote linkage to

targeted industrial activities. Additionally, a technology culture should be stimulated in industry generally, but in the targeted ones in particular. Part of this will consist in the progressive exposure of such industry to competition, internal and external. But note should be taken of the positive East Asian experience and our own not-so-positive experience, both of which show that such macro policy does not yield the right responses without specific and targeted support for local industry and enterprise. What is needed is carefully considered but pro-active state support aimed at strengthening the competitive position of local industry, while helping it build up a strong technology culture. This latter should be linked to increasing involvement with, and reinforcement of the local knowledge and technology infrastructure, in what was known in Brazil as a “Sabato Triangle – close government-universities-industry collaboration.

While the primary locus of the effort must be national, the scale of the problem (in terms of resources, skill pools, and markets) transcends national boundaries. In this connection, it is encouraging that the African Union is providing leadership for a continental contribution to the broad revitalisation process. In relation specifically to science and technology, this is symbolised by the *Science and Technology Consolidated Plan of Action*, launched by the African Union (AU) and the New Partnership for Africa’s Development (NEPAD) Secretariat in 2005. The Plan aims at developing and using science and technology for the socio-economic transformation of the continent and its integration into the world economy. Though its implementation is stalled by the failure, so far, of African leaders to reach a consensus on how to finance it, the significance of the Plan lies in its indication of the engagement, finally, of Africa’s political leadership. More recently, the African

Development Board has approved a *Strategy for Higher Education, Science and Technology*. The strategy is aimed at, among other things, helping member countries to *link higher education to the productive sector*.

Supplemented by appropriate national level policies and structures, such as outlined above, and combining with well-resourced regional nodes of strength in selected areas, these efforts provide a starting point for productive higher education-industry collaboration nationally and across the continent.

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TABLES**Table 1: Tertiary Gross Enrolment Ratio (GER) in 2004**

Region	GER (%)
Arab States	21
Central and Eastern Europe	54
Central Asia	25
East Asia and the Pacific	23
Latin America and the Caribbean	28
North America and Western Europe	70
South and West Asia	11
Sub-Saharan Africa	5
World (average)	24

Source: Enesco. 2006. Global Education Digest 2006. Comparing Education Statistics Around the World. UIS: Montreal

Table 2: Tertiary-level enrolment total in technical subjects, 1995

	Tertiary-level enrolment		Technical subjects			
	Total students	% of population	All technical subjects	Natural sciences	Mathematics/computing	Engineering
Developing countries	35 345 800	0.82	7 021,929	2,046,566	780,930	4,194,433
Sub-Saharan Africa	1 542 700	0.28	220,660	111,500	39,330	69,830
Kenya	31 300	0.115	4,600	3,600	...	1,000
Tanzania	12 800	0.043	3,600	800	100	2,700
Uganda	27 600	0.140	2,600	800	300	1,500
Ghana	9 600	0.055	2,100	1,200	200	700
Zimbabwe	45 600	0.408	9,700	2,200	800	6,700
South Africa	617 900	1.490	72,200	21,700	30,500	20,000
Mauritius	5 500	0.492	500	100	100	300
Latin America	7 677 800	1.64	1,404,402	212,901	188,800	1,002,701
Asia	21 553 400	0.72	4,584,300	1,513,100	438,600	2,632,600
Transition economies	2 025 800	1.95	440,800	55,500	30,600	354,700
Developed countries	33 774 800	4.06	5,754,419	1,509,334	1,053,913	3,191,172

Source: Calculated from UNESCO (1999) and national sources.

Table 3: Research and development in major country groups

Countries and regions	Scientists/engineers in Research and development		Total R&D (% of GNP)
	Per million inhabitants	Numbers	
Industrialized market economies (a)	1,102	2,704,205	1.94
Developing economies (b)	514	1,034,333	0.39
Sub-Saharan Africa (exc. So. Africa)	83	3,193	0.28
North Africa	423	29,675	0.40
Latin America & Caribbean	339	107,508	0.45
Asia (excluding Japan)	783	893,957	0.72
World (79-84 countries)	1,304	4,684,700	0.92

Notes: (a) United States, Canada, West Europe, Japan, Australia and New Zealand; (b) Including Middle East oil states, Turkey, Israel, South Africa, and former socialist economies in Asia.

Source: Calculated from UNESCO (1997).

