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Knowledge for the future: research capacity in developing countries

Bikas C. Sanyal
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List of abbreviations

CIS	Commonwealth of Independent States (formerly the USSR)
CNRS	National Center for Scientific Research, France
CSIR	Council for Scientific and Industrial Research, India
EAP	East Asia and Pacific
EU	European Union
EUSR	European Union Science and Research
FIT	Foundation for International Training
GDP	Gross domestic product
GERD	Gross domestic expenditure on R&D
GNP	Gross national product
IDPAD	Indo-Dutch Programme on Alternatives in Development
IIEP	International Institute for Educational Planning
LAC	Latin America and the Caribbean
MIRDC	Metals Industry Research and Development Centre, Philippines
OECD	Organisation for Economic Co-operation and Development
R&D	Research and development
RRI	Rubber Research Institute, Malaysia
SISIR	Singapore Institute of Standard and Industrial Research
SSA	Sub-Saharan Africa
UIS	UNESCO Institute for Statistics
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
USSR	Union of Soviet Socialist Republics (now Commonwealth of Independent States)

Abstract

The present phase of development is characterized by knowledge-based production. The knowledge economy places greater value and stronger emphasis on the production and distribution of knowledge – research and development (R&D). Knowledge production used to be an activity co-ordinated by the public authorities, and public universities played an important role in R&D activities. At present, knowledge production in many developed countries is critical for industrial production and has become an important corporate concern.

Based on the available sources of information, this paper argues that the knowledge divide is deep and is heavily tilted in favor of developed countries. Developing countries suffer from a lack of both financial and human resources in R&D. They need to improve their capacity to produce knowledge domestically and absorb the knowledge produced elsewhere. This can happen when allocation of financial resources to R&D activities increases, human resources are trained in adequate numbers and an institutional framework to carry out R&D activities is created.

Changes in the investment priorities in education during the structural adjustment regime have paved the way for a decline of higher education and research in public higher education institutions in developing countries. Yet, while universities play a less significant role in funding and carrying out research, their role remains unchallenged in the area of research training. There is a need for reviving and strengthening the university system in developing countries to strengthen their research capacities. This change should be reflected in resource allocation to higher education and research, and in the provision of opportunities to expand graduate programmes and improve female participation rates. The experience of developed countries shows that the private sector investment in R&D increases when the country's research environment and facilities improve. Therefore, initial investments to strengthen research capacity in developing countries have to come from public sources.

1 Introduction*

The knowledge divide between developing and developed countries is both deep and wide. A country's existing R&D activities are a reflection of its capacity to create knowledge. The skills and know-how needed to compete in knowledge economies are different from those needed in manufacturing-based economies (see Sanyal, 2004 for a listing of skills). The technological transformations leading to the creation of the knowledge society, unless closely monitored, carry the real danger of aggravating the digital divide both between and within nations (World Bank, 2002). This divide is evident when looking at the technology achievement index (UNDP, 2004). Based on this index, countries can be classified as:

- a) leaders: those at the cutting edge of innovation – the highly developed countries such as USA, UK, France, Germany etc.;
- b) potential leaders: those with high skill levels, who have applied old technologies but have not innovated – countries such as Spain, Chile, Mexico and Argentina;
- c) dynamic adapters: those that are rapidly expanding their use of new technologies, with important high-tech industries, whereas diffusion of old technologies has been slow – countries such as China, India, Brazil, Ecuador, South Africa, Tunisia etc.;
- d) marginalized countries: those with very low skill levels, with a large segment of the population yet to receive benefits from old technologies – countries in sub-Saharan Africa, Nepal, Nicaragua etc.

This classification highlights the distance between the leaders and marginalized countries in R&D.

The present level of research capacity is a reflection of past investments made by countries in R&D activities focusing on two aspects, namely investment in physical capital (investments in R&D) and human capital (personnel to manage and carry out research activities). This paper discusses the variations in research capacity among countries and highlights the gap between developing and developed countries in this regard. It argues that in the absence of strategic interventions, the inequalities in research capacities between countries will widen in the future. Higher education being the sector contributing to and sustaining R&D activities, investment in this sector will have a determining influence on the future potential of knowledge production in the economy.

* Revised version of the paper presented at the Colloquium on Research and Higher Education Policy, 29 November – 1 December 2006, Paris. The views and opinions expressed are those of the authors and do not necessarily represent the views of the IIEP.

2 The knowledge economy and R&D

It was during the Second World War that governments, notably the US government, recognized the significant contribution made by university research, especially by the scientists and engineers, to their success in the war. Supporting research, in particular university-based basic research, was considered to be an important element in the strategies to promote and sustain economic growth. This helped create a favorable political attitude to funding research and supporting research staff in many countries. Furthermore, basic research was considered to be of critical importance for development and was supported by public money (OECD, 1999). Universities were relied upon for carrying out a major part of the publicly funded basic research.

The nature of research activities and motivations has changed in the knowledge economies. A knowledge economy is characterized by the production and use of technology, and information is key to its activities. The quantity of knowledge embedded in the goods produced and exported has increased considerably (World Bank, 1999). It is found that investment in sectors that generate knowledge (R&D activities) is a rewarding activity. Investments in R&D contribute to increases in national income and it is estimated that a one percentage point increase in the ratio of R&D expenditure to GNP increases the growth rate of GDP by 0.78 per cent (Chen and Dahlman, 2004). Furthermore, an analysis of growth patterns between countries indicates that productivity gains and growth rates depend on the performance of the knowledge-based sectors. In fact, knowledge-based sectors are the prime drivers of high growth and are growing faster than other sectors.

This leads to believe that the future growth potential of the knowledge economy depends more on its capacity to produce knowledge than knowledge-based goods. Hence knowledge economies place greater value and stronger emphasis on the production and distribution of knowledge itself – R&D activities. These remain at the heart of the capacity of economies and enterprises to expand their knowledge base. Consequently, the share of investments to expand the knowledge base (R&D) is increasing.

3 Research capacity: R&D investments

As knowledge economies and knowledge-based production are research-driven, their growth depends on the capacity of countries to invest in R&D activities. One general trend that can be seen is that developed countries invest a higher share of their GDP in R&D activities than developing countries (UIS, 2006). The disparity in investment in R&D between the developed and developing world is quite wide (UNESCO, 2005). For example, the gross domestic expenditure on R&D (GERD) shares of Sweden and Finland are respectively nearly 400 and 350 times that of Zambia. All developing countries invest less than 1 per cent of their GDP in R&D activities while almost all developed countries invest more than 1 per cent, while many invest more than 2 per cent and a few invest over 3 per cent. It is not surprising that Sweden, Finland and Japan, which have a high share of information and communication goods in their exports, also invest a high share of their GDP in R&D activities

A closer scrutiny of data over a period of time (1996-2003) indicates that developed countries not only have a higher GERD share, but also that, with a few exceptions, they have also increased it. There is a decline in the GERD among the countries of Central and Eastern Europe and among many countries of the Latin American and Caribbean region. While countries in South Asia, except for India which has a GERD of 0.85 per cent, invest very little in R&D activities, countries in South East Asia have a higher GERD. More importantly, during this period, this share increased in all South-East Asian countries except Indonesia. The share of GERD remains low in the Arab States even when income levels are high. Many countries in sub-Saharan Africa (SSA) have not reported their GERD share in GDP. Among the countries where data was available, Zambia had the lowest share with 0.01 per cent and Uganda had the highest with 0.74 per cent.

The above shows that the efforts to build and maintain research capacity as measured by the GERD vary across countries. Developed countries in general invest a higher share of GDP in R&D activities and have increased this share in the recent past. East Asian countries invest a relatively higher share of their national income in R&D than other developing countries. With SSA countries investing very little and with a decline in R&D investments by countries of the Commonwealth of Independent States (CIS), the gap in investments between developed and developing countries seems to have widened. Moreover, the Lisbon European Council in 2000 set a target of increasing investment in R&D from the present level of 1.9 per cent to 3 per cent of its GDP to make the European Union (EU) “the most competitive and dynamic knowledge based economy in the world by 2010” (EUSR, 2006). This, in the absence of corrective measures, will further widen the gulf between developed and developing countries in their research capacities.

3.1 The private sector in R&D

R&D activities have been concentrated in the public sector, whether in universities or laboratories. Part of the reason for this lies in the fact that the defense sector is one of the main sponsors of research and an important consumer of R&D results. This trend has been changing over the past years. The private sector seems to have recognized the economic incentives to invest in R&D since such investment increases profitability at the enterprise level. However, the private sector is more active in specific areas such as electronics, communications, medical devices, bio-technology, pharmacology etc., where production is research-driven and profitability is high. In fact the R&D

intensity of some of these sectors such as medical devices, information technology and electronics is two to three times higher than the average for the top 500 firms in R&D (US Corporate R&D, 2006). The presence of private corporations on the R&D scene, especially in these sectors, is not only very strong but these corporations have also entered into the area of fundamental research, thus ending the near-monopoly enjoyed by the public laboratories and universities.

A report on corporate R&D in the top 500 firms in the United States of America (USA) indicates that not only is the investment by the corporate sector high but also that it is increasing rapidly (US Corporate R&D, 2006). For example, the corporate R&D investment in information technology and electronics was around US\$46 billion in 1997, having grown at a rate of 15.2 per cent the previous year. The trend was similar in the second largest R&D sector, namely medical substances and devices, where investment was around US\$20 billion. The division of labour between public and private investment in research in the USA further substantiates this point. For example, in 1996, 65 per cent of the aerospace industry's R&D came from federal sources while 100 per cent of drugs and medicines, and 99 per cent of machinery came from the corporate sector. The Canadian experience, based on the top 100 companies (reported by Research Infosource Inc., 2002), shows that even when there is a decline in market demand for goods, R&D investment continues to increase.

The private sector plays an important role in funding and carrying out R&D activities in many countries. This is reflected both in terms of the research activity and the sources of funding as shown in the UIS tables (UIS, 2006). However, although the private sector is very active in R&D in most of the developed countries, in the developing world it is the government who actively funds and carries out R&D activities. In Luxemburg, the business enterprises play the biggest role as they carry out 89.1 per cent of R&D activities. The business sector also plays the most important role in the Russian Federation (68.4 per cent), although this share is low in other CIS countries.

Among the countries in the East Asian region, the Republic of Korea and Japan have the largest involvement of business enterprises (above 75 per cent) in funding R&D activities. In Central Asia, business enterprises play the most important role in Kyrgyzstan with 50.9 per cent of the funding and the smallest role in Azerbaijan with 21.1 per cent. In Latin America and the Caribbean (LAC) business enterprises play a more moderate role, in South Asia they have a relatively small role, and sub-Saharan Africa is the region where the business sector is least involved in R&D investments. In all these countries R&D activities are essentially centred around the public sector.

The role of the higher education sector in carrying out research is highest in Europe and North America, followed by some countries in Latin America. In Asian countries, the contribution of higher education to R&D activities is rather limited. In the East Asia and Pacific (EAP) region, it is interesting to note that not a single country shows a high involvement of the higher education sector. In countries in Latin America and the Caribbean (LAC), the higher education sector's share is rather high, such as Colombia (60 per cent). Among South Asian countries, the higher education sector has the smallest role in research, such as in India where it performs 2.4 per cent of all research. In the SSA region, only Uganda reports having a share of 27.4 per cent of research being undertaken by the higher education sector. Most of the research is performed by the government (66.3 per cent).

3.2 Internationalization of R&D activities

Knowledge is an international public good and knowledge economies by their very nature are global (Bourne, 2000). However, even when knowledge-based production transcends national boundaries, knowledge production remains relatively confined to the developed world. The pattern

used to be that knowledge was produced nationally and distributed internationally. But this trend is changing, especially in industrial R&D thanks to the contribution of multinational companies and corporations. In 1994, R&D investments by foreign affiliates in OECD countries alone constituted 12 per cent of the total R&D investment in OECD countries. However, there were wide variations between countries, with Ireland investing 68 per cent in its affiliates, Switzerland 46 per cent, the UK 36 per cent etc. (OECD, 1998). Like the private sector investments in the domestic sector, R&D investment of multinational corporations in their affiliates were concentrated on selected industries such as computer, pharmaceuticals, electronics, chemicals, and automobiles. What is equally interesting to note is that R&D investments in foreign countries continued to increase and expand even when there was a decline in domestic R&D investment. The improvements in communication technology and the profitability of such investments are perhaps conducive to the expansion of external research funding.

A major share of the research conducted abroad by multinational corporations takes place in developed countries whilst little research is conducted in the affiliates located in developing countries. This is one of the reasons why research funding from abroad is higher in North American and European countries. There are some exceptions such as Singapore, where it is estimated that the private sector's share in R&D is around 62 per cent, with the share of the foreign private sector standing at 44 per cent (Amsden *et al.* 2001). Foreign companies were ready to invest in R&D in Singapore because of government support.

In many countries, especially in Africa, the higher education and research sectors receive bilateral and multilateral aid. These are provided by multilateral agencies such as the World Bank and the EU, and bilateral agencies from countries such as the USA, Canada, France, and the UK. Support from these sources, unlike the industrial research, is devoted to strengthening the research capacities of universities and reviving the higher education sector. In fact very little research in Africa is funded by the national authorities and the share of foreign funding, in many cases, varies from 70 to 90 per cent (Teferra and Altbach, 2003). The research support received by countries such as Uganda is around 90 per cent (UIS, 2006) of the total research funds, i.e. research in these countries is essentially a donor-driven activity.

One of the lessons that can be learned from the above discussions is that the role of the private sector in R&D is already high in many countries and on the increase. More interestingly, the active presence of the private sector is felt in all countries that are investing a higher proportion of their national income in R&D activities. It also implies that the monopoly on research enjoyed by the government and universities has come to an end. One of the reasons for this trend may be the importance of industrial R&D, which the firms are more than willing to fund and promote. Another may be that industrial research has become more and more inter-disciplinary and hence is less amenable to the departmentalized and discipline-oriented research carried out by the universities. The private sector is expected to play an increasingly important role in R&D activities. As noted earlier, the investment in R&D in the EU will be increased from the present level of 1.9 per cent to 3 per cent of its GDP and it is expected that at least two thirds of the investment will come from private sources (EUSR, 2006). At present the private sector contributes 54 per cent of R&D investments in the EU, and countries such as Germany and Japan have already surpassed the target of a two-thirds investment from the private sector.

4 **Research capacity: human resources in R&D activities**

While investment in R&D is a good indicator of a country's research capacity, the number of personnel engaged in R&D activities provides a fuller picture. UNESCO's Institute for Statistics (UIS) estimated the human resources stock per region for the year 2002 along with the gross domestic expenditure on R&D per researcher (UIS, 2006: Table 8). The disparity in the research capacity among the different regions in terms of human resources engaged in research is very wide. North America is a world leader in terms of the number of researchers per million inhabitants (4,280) while Africa is at the bottom with only 73 researchers per million inhabitants. Oceania is a distant second with 2,397 followed by Europe with 2,319 and Asia has on average 555 researchers per million inhabitants.

A country by country analysis of researchers per million inhabitants shows that Finland with 7,992 researchers per million inhabitants is at one end of the spectrum while Burkina Faso with 17 and the Republic of Congo with 30 are at the other. This shows that the disparity in research capacity among countries and between regions is wide. In terms of personnel engaged in research, Africa has the lowest research capacity and North America and Europe have the highest.

5 Research capacity: training for R&D

The discussions in the earlier sections have shown that universities are no longer major players in carrying out research in many countries. However, universities continue to play a dominant role in research training. Research training also depends on the way the research system is organized in a country, and in some cases may be provided by the non-university sector. However, in all cases, the initial research training is provided by the universities through their graduate and other advanced level programmes.

The institutional arrangement for carrying out research varies, even when research funding is from public sources. Three different patterns can be identified:

- a) in universities as in countries such as USA, UK etc.;
- b) in central national agencies such as the CNRS in France;
- c) in national academies separate from the higher education system as existed in the USSR (Neave, 2002).

In the Asian countries there was a proliferation of R&D institutes, separate from the universities. These institutes can be classified (FIT, 1983) into:

- a) government controlled;
- b) quasi-governmental and multi-disciplinary R&D institutes;
- c) university applied research centers;
- d) private R&D institutes;
- e) regional R&D institutes; and
- f) research associations such as the Council for Scientific and Industrial Research (CSIR) in India, the Rubber Research Institute (RRI) of Malaysia, the Metals Industry Research and Development Centre (MIRDC) in the Philippines, and the Singapore Institute of Standard and Industrial Research (SISIR), which are examples of research carried out outside the university sector. In all these cases, the institutions were carrying out research in specific areas and were relatively free from teaching responsibilities.

Another trend, which is very important from the organizational aspect of research, is the establishment of centres of excellence within universities (OECD, 1999). These centres are created to focus attention on certain critical areas where research is needed for the country. Whether specialized institutions or centres of excellence, they provide more flexibility in terms of carrying out research on an interdisciplinary basis rather than relying entirely on disciplinary boundaries as in the case of traditional university-based research. This strategy helps to target limited resources to priority areas.

The practical research experience gained by young researchers varies according to the situations described above. There are different forms in which research training is organized. The post-graduate study programmes are mainly for training in research and teaching. The academic staff recruitment pattern in universities and in research institutions is a good indicator of the research training of a country. Globally, in the 1960s and 1970s the higher education system was expanding and this was a period of increasing staff strength in the universities. A major share of staff appointments were tenured positions which was favorable for sustaining research activities in the university.

The growth of the higher education system slowed down in the 1980s as did staff appointments. Even when university enrolments increased in the 1990s, staff recruitment lagged behind, leading to declining staff:student ratios. Moreover, staff appointments during this period were mostly short-term or fixed-term. Part-time employment in many universities in the developed world increased. In some countries such as Canada, part-timers constitute a large share of the academic staff and they remain part-timers for an extended period of time. In countries such as the USA, post-doctoral students are a good source of academic research support. However, this support is mainly on a project-to-project basis and many continue in post-doctoral positions for several years before obtaining a tenured appointment (OECD, 1999). All these observations point to the fact that the insecurity of appointments of academic staff in universities does not create a favorable environment for research.

The increasing share of the private sector in research has affected the nature of research carried out through contracts. While universities very often engage in basic research, industrial research is centred on applied research. When research is funded by the public authorities and the funding is institution-based, research to advance the frontiers of knowledge is encouraged, whereas when research is funded by private agencies and is project-based, research activities follow the lines of applied research.

The 1960s was a period of national liberation, when developing countries were establishing and strengthening their national universities. Public investment in higher education was encouraged. Many countries relied on sending students abroad to acquire higher degrees. Foreign aid played an important part in the development of higher education in many countries of the African region (Ilon, 2003). Many established bilateral agencies encouraged the creation of graduate programmes and research centres in selected countries to promote research. Some of the agencies considered that introducing Master's level courses locally was cheaper than overseas training and the same amount of money would be sufficient to train a larger number of post-graduates and that also led to doctoral programmes (Coleman and Court, 1993). The structural adjustment programmes of 1980s shifted the focus of attention from higher to primary education and this shift in policy substantially affected the higher education sector in general, in particular the quality of education imparted and research capacities. The universities' lack of funds, the deterioration of staff facilities and the low quality of services extended by the universities did not help to promote research activities. Whatever minimal research was carried out by the universities was for generating income rather than for solving issues of national concern. Research was seen as a commodity for those who were willing and able to pay for it (Neave, 2002).

6 Higher education enrolment and its implications for research capacity in the future

The current levels of research capacity are the result of the investments made and the expansion that has taken place in higher education. Therefore, trends in enrolment in higher education are an indicator of the widening or narrowing gap between developing and developed countries in terms of research capacity.

We shall consider participation in overall higher education at each of its three levels following the International Standard Classification of Education (ISCED): Level 5A (directly providing the potential stock for building research capacity), Level 5B (increasingly providing an indirect potential stock for building research capacity) and Level 6 (leading to an advanced research qualification, directly providing research capacity). The gross enrolment ratio, as defined by UNESCO, will be used as the indicator.

Data on enrolment in tertiary education institutions (UIS, 2006) show that the enrolment ratio varies widely between different regions. The world average was 24 per cent participation in higher education in 2004, the highest being in North America and Western Europe at 70 per cent and the lowest being 1 per cent in countries such as Burkina Faso and Tanzania. In fact many of the countries in sub-Saharan Africa have a GER of less than 5 per cent. This divide in the higher education GER will continue to increase inequalities in research capacities between these countries in the future.

While the share of Level 6 remains very small, at 1 per cent of total higher education enrolment in four regions (Central and East Asia and the Pacific, South and West Asia and sub-Saharan Africa) and 2 per cent in two regions (Central and Eastern Europe, Latin America and the Caribbean), we note that with 2 per cent of the 132 million students in higher education at this level in 2004, the world has a total of 2.64 million citizens working for an advanced research qualification in higher education institutions. Of this population, close to one million are in North America and Western Europe (equal to 3 per cent of its total enrolment of 32.9 million students), followed by East Asia and the Pacific with approximately 389,000 students (China alone has 194,000). Central and Eastern Europe follows closely with approximately 370,000. Latin America and the Caribbean have approximately 290,000, the Arab States have 250,000 (which represents the highest share – 4 per cent of higher education enrolments), South and West Asia have 155,000 (India alone has 113,000) and sub-Saharan Africa has a mere 33,000.

7 Gender disparities in R&D activities

Another aspect of the growing inequalities concerns the gender disparities in the participation in R&D activities. Female researchers constitute a relatively small share in all countries except the CIS countries. Even in countries such as the USA, women represent less than 20 per cent of the total number of researchers, and in Germany they represent 16 per cent (UIS, 2006). The low representation of women among research workers in developed countries needs to be seen against the background of the large share of women enrolled in institutions of higher education in these countries. One of the reasons for their low representation in R&D activities may be their low participation at Level 6 of education.

In developing countries, the number of research personnel is low, and females constitute only a small share of the research workers. The reasons could be their low participation in higher education in general and in Level 6 of education in particular. However, the solution may not lie in improving enrolment ratios at Level 6 of education. The reasons for the low participation of women in research need to be analyzed in more depth to develop more gender-friendly strategies.

8 Research capacities in the future

In the future, a country's research potential will depend on four factors:

- a) the amount of money invested in research;
- b) staff training and availability;
- c) the capacity of the system to retain these people in R&D activities; and
- d) an expanded higher education system.

In developed countries, the research investment (GERD) is high and there is a concerted effort to increase it. Contributions from the private sector are expected to help considerably in sustaining R&D efforts. The higher education system and graduate study programmes are expanding. All these are positive indicators of growing R&D activities. However, university research may not benefit from increased R&D activity for several reasons. Firstly, public investment, which used to be the cornerstone of university research funding, is not increasing. The employment pattern in universities and research institutions is not favorable for reinforcing and institutionalizing research capacities. Secondly, in many countries a large number of university professors who entered the system during the 1970s will be retiring over the next few years (OECD, 1999) and there is no active recruitment underway to replace them. Thirdly, the shift in the staff recruitment pattern from tenured to short-term appointments, which is common in many OECD countries, has adverse effects on research capacity and potential. While the post-doctoral programmes help carry out research in the short term, the insecurity of employment in the R&D sector may force many to leave for other avenues of employment. All these contribute to a reduced focus on basic research in the developed world.

Developing countries are disadvantaged from the outset in terms of R&D activities. The levels of funding for research are low, well trained researchers are in scarce supply and, above all, a supportive research environment is conspicuously absent. Whatever research has taken place has been as a part of applied research funded under a project mode. In fact, applied research took the form of contract research in many countries. The contract research got its stimulus either directly from aid agencies or from governments seeking aid or loans. It was attractive for academics and seduced many from the universities of the developing world (Coleman and Court, 1993). At times these research activities were also seen as a source of mobility to other sectors.

These short-term contract research activities did not lead to sustainable research capacities in the universities of the developing world. In fact the low salary structure and high inflation in some of the developing countries paved the way for academics to become more attracted to this type of research rather than engaging in publicly-funded research in universities with limited or no economic incentives. This led to a situation where institutional research capacity did not take root even when there were individual researchers.

One of the major difficulties in the universities of the developing world is that they maintain strong teaching functions and weak research functions. Research is not yet seen as an integral part of the responsibilities of the academic staff. Therefore, there is a need to evolve a research culture in many of the universities. This can happen only when the universities themselves see their role as teaching and research institutions. An analysis of strategic plans developed by many universities reveals that research is an element in these plans. Research in the new plans is seen

as a convenient way of mobilizing resources. While this type of research is beneficial, there is a need to take corrective measures so that the university research will not be confined to this.

Another problem faced by some of the institutions and countries in the developing region is the migration of academic staff to other sectors or other countries. This has severely affected national research capacities (Altbach, 2003). In some instances the migration of senior academics adversely affected the research training of the next generation. While it will be difficult to arrest migration altogether, governments should also try to establish and continue linkages with these academics in order to benefit from their expertise and understanding of the country's situation.

The best way to protect university research in developing countries may be to maintain pressure to retain, if not increase, the share of public funding in R&D activities, since the universities get a substantial share of public funding for research. This will also help attract a steady flow of trained researchers. It is equally important that researchers are rewarded sufficiently to keep them in this sector. Given the low level of salaries, adequate incentives for research staff become crucial for retaining them. Moreover, developing countries, especially in the African region, are experiencing very low GER. Many governments are not willing to further expand or invest in the public sector of higher education. In fact the fastest growing sector is private higher education. Very often private universities are teaching institutions relying heavily on part-time teachers and virtually free of research activities (Varghese, 2006). Therefore, while the expansion of higher education is necessary, this alone will not create sufficient conditions to promote R&D activities in developing countries.

A sustainable model of research capacity development requires an expanded higher education system with more graduate study programmes and the creation of a research environment at the institutional level. This may demand a larger share of funding for higher education in general and a bigger allocation of higher education funds to graduate study programmes. The experience of Ireland in the late 1980s and India in the late 1990s shows that a reliance on the diaspora can be a useful source to create research facilities, establish academic linkages and mobilize funds to strengthen institutional research capacities in developing countries. Given the fact that the market for research is relatively under-developed in low income countries, the state needs to be proactive in the initial stages of investing in R&D, creating a research environment and training researchers.

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The book

Knowledge has become a critical factor for economic growth. Governments and public universities play an important role in its production and distribution. At present, given its role in production and profitability, producing knowledge has also become an important corporate concern. Investments in research and development (R&D) have therefore increased substantially in the developed countries.

Public investment in R&D in developing countries is rather low, however, and private investment is not forthcoming. This is contributing to a widening of the knowledge divide between developed and developing countries. There is a need for the developing countries to improve their R&D capacity by investing in their financial and human resources.

The role of universities remains unchallenged in the area of research training. This paper argues for reviving and strengthening the university system in developing countries to reinforce their research capacities. This implies increased levels of resource allocation to higher education and research, encouragement of private investment in R&D activities, an expansion of graduate programmes and greater female participation in R&D.

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