

Research Capacity of the Higher Education Sector in Developing Countries

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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 – R&D. Knowledge production used to be an activity coordinated 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.

While universities play a less significant role in funding and carrying out research, their role remains unchallenged in the area of research training. Changes in the investment priorities in education during the structural adjustment regime paved the way for a decline of higher education and research in public institutions of higher education in developing countries. 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 research environment and facilities improve in the country. Therefore, the initial investments to strengthen research capacity in developing countries have to come from public sources.

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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 transformation leading to the creation of the knowledge society, unless closely monitored, carries the real danger of a growing digital divide between and within nations (World Bank, 2002). This divide is evident from the classification of countries, based on the technology achievement index (UNDP, 2004), into 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 rapidly expanding their use of new technologies, with important high-tech industries, but 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 indicates 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.

2. 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). The universities were relied on for carrying out a major part of the public funded basic research.

The nature of research activities and motivations changed in the knowledge economies. Knowledge economies are characterized by production and use of technology and information is key to its economic 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 indicate 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 they 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 – 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

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 (GERD) 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 GERD shares of Sweden and Finland are respectively nearly 400 and 350 times that of Zambia. All developing countries invest less than one per cent of their GDP in R&D activities while almost all developed countries invest more than one per cent, whilst 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 export, 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 the South Asia, except for India which has a GERD of 0.85 percent, 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 countries except

Indonesia. The share of GERD remains low in the Arab States even when their 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 analysis 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 CIS countries, the gap in investments between developed and developing countries seems to have widened. Moreover, the Lisbon European Council in 2000 put 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 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.

Private Sector in R&D

R&D activities were concentrated in the public sector whether in the universities or laboratories. Part of the reason for this lies in the fact that the Defense sector is one of the important sponsors of research and consumers 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 they increase profitability at the enterprise level. However, the private sector is more active in selected sectors 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 in the R&D scene, especially in these sectors, is not only very strong but they have also entered into the area of fundamental research thus ending the near-monopoly enjoyed by the public laboratories and universities.

A report on US Corporate R&D in the top 500 firms (US Corporate R&D, 2006) indicates that not only is the investment by the corporate sector high but also that it is increasing rapidly. For example, the corporate R&D investment in information technology and electronics was around \$ 46/ billion in 1997 and 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 \$ 20/billion. The division of labor between public and private investment in research in the US 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, 99 per cent of machinery etc. 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, the 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). The private sector is very active in funding and carrying out research in most of the developed countries, whereas 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 plays the most important role in the Russian Federation (68.4 per cent), although this share is low in other CIS countries. The private sector is less active in research in Latin American 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 in Sub-Saharan Africa, the business sector has the least involvement in R&D investments. In all these countries R&D activities are essentially centered 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 EAP region, it is interesting to note that not a single country shows a high involvement of the higher education sector. In LAC countries, the higher education sector's share of 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 to have a share of 27.4 per cent of research being performed by the higher education sector. Most of the research is performed by the government (66.3 per cent).

Internationalization of R&D activities

Knowledge is an international public good and knowledge economies by their very nature are global (Bourne, 2000). 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, UK 36 per cent etc. (OECD, 1998). Like the private sector investments in the domestic sector, R&D investment of multi-national corporations in their affiliates were concentrated on selected industries such as computer, pharmaceuticals, electronics, chemicals, and automobiles etc. What is equally interesting to note is that the R&D investments in foreign countries continued to increase and expand even when there was a decline in R&D investment

domestically. The improvements in communication technology and 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 and the share of the foreign private sector is 44 per cent (Amsden et.al. 2001). The 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, European Union etc. and bilateral agencies from USA, Canada, France, and UK etc. The 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 in fact 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 its role is increasing. More interestingly, the active presence of the private sector is felt in all countries, which are investing a higher proportion of their national income (GERD) 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 be coming 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 estimated the human resources stock per region for the year 2002 along with the gross domestic expenditure on R&D per researcher (UIS, 2006). The disparity in the research capacity among the different regions is much wider than noted in the potential for building research capacity earlier. 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 stays at the one end of the spectrum while Burkina Faso with 17 and The Republic of Congo with 30 remain at the other end. 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 indicated 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. Universities play an important role in research and research training in some countries while in others it's 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 i) in universities as in countries such as USA, UK etc; ii) in central national agencies such as the CNRS in France; iii) in national academies separate from the higher education system as existed in 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-government 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 Metal Research and Development Centre (MIRDC) in the Philippines, the Singapore Institute of Standard and Industrial Research (SISIR) in Singapore are examples of research being carried out outside the university sector. In all these cases, these Institutions were carrying out research in some selected areas and were relatively free from teaching responsibilities.

Another trend, very important from the organizational aspect of research, is the establishment of centers of excellence within universities (OECD, 1999). These centers are created to focus attention on certain selected critical areas where research is needed for the country. Whether specialized institutions or centers or excellence, they provide

more flexibility in terms of carrying out research on an interdisciplinary basis rather than relying entirely on the disciplinary boundaries as in the case of university based research. This strategy helps to target limited resources to priority areas.

The practical research experience gained by young researchers varies in all the situations described above. There are different forms in which research training is organized. The post-graduate study programmes are mainly for training 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. 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 to 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 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 getting a tenured appointment (OECD, 1999). All these point to the fact that the insecurity of appointments of academic staff in universities is not a favorable environment for research.

The increasing share of the private sector in research has impacted on the nature of research carried out through contracts. While universities very often engage in basic research, industrial research is centered on applied research. When research is funded by the public authorities and the funding is institutional 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 and developing countries established and strengthened 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 centers in selected countries to promote research. Some of the agencies considered that introducing Master 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 would also lead 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, and 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: 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 the enrolment in institutions of tertiary education (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, Tanzania etc. In fact many of the countries in Sub-Saharan Africa have a GER less than 5 per cent. This divide in the GER in higher education will have significant influence in increasing 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 the institutions of higher education. From this population, close to 1 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 thousand students (China alone has 194 thousand), Central and Eastern Europe follows closely with approximately 370 thousand. Latin America and the Caribbean has approximately 290 thousand, the Arab States have 250 thousand (which represents the highest share - 4 per cent of higher education enrolments), South and West Asia have 155 thousand (India alone has 113 thousand) and Sub-Saharan Africa has a mere 33 thousand.

7. Gender Disparities in R&D Activities

Another aspect of the growing inequalities is 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 advanced countries such as the US, women only represent less than 20 per cent of the total number of researchers; 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.

6. Research capacities in the future

In the future, a country's research potential will depend on four factors: i) the amount of money invested in research; ii) the staff training and availability; iii) the capacity of the system to retain these people in R&D activities; and iv) 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 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 conspicuous by its absence. Whatever research has taken place was in the nature 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 be more attracted to this type of research rather than engaging in publicly funded research in the universities which had 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 retain 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 to other countries. This has severely affected the 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, the governments should also try to establish and continue linkages with these academics 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 enough 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 expand or invest more in the public sector in 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 reliable 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 in investing in R&D, creating a research environment and training researchers.

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