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A DISCUSSION OF SOME PRIORITIES IN SCIENTIFIC RESEARCH IN BRAZIL

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A DISCUSSION OF SOME PRIORITIES IN SCIENTIFIC RESEARCH IN BRAZIL*

Reinaldo Guimarães

I. Introduction

Brazil in 1988 had some 50,000 active researchers, which represented a ratio of one researcher for every 2,500 inhabitants. This is a ratio between five and ten times less than that found in the developed countries. Of these, 26 per cent have a doctorate and 56 per cent have a doctor's or master's degree. The distribution of this population throughout the Brazilian national territory is markedly irregular, being concentrated in the south-eastern region. In the states of São Paulo and Rio de Janeiro, which have 31.4 per cent of the Brazilian population, 23,500 researchers are concentrated, 45 per cent of the total. The shortage of researchers is general, not being concentrated in any area of knowledge. The figures are as shown in Table 1:

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Table 1

Distribution of Research Workers in Brazil, by subject

Exact and earth sciences	12.6%	
Biological sciences	9.7%	
Engineering	14.7%	
Health sciences	11.5%	
Agrarian sciences	14.4%	
Applied social sciences	8.6%	
Human sciences	9.4%	
Languages, letters and arts	2.8%	
No information	16.3%	
Total	100.0%	

Source: Martins, G.M. and Queiroz. R (1987). "Profile of the Brazilian Researcher", Revista Brasileira de Tecnologia, 18(6):34-46.

The activity of scientific research in Brazil is carried out almost entirely in the public, federal and state universities. The only private university in Brazil that produces research in appreciable volume and quality is the Pontifical Catholic University of Rio de Janeiro. In addition, scientific research is carried out in research institutes and some state-owned companies.

It has been estimated that the aggregate value of the science and technology budget in Brazil in 1988 was around 0.7 per cent of the GNP. However, in view of the multiplicity of government agencies and the generosity with which funding is incorporated into this budget, this is probably an overestimate.

Direct financing of scientific research activities is exclusively public and almost all federal. I am deliberately excluding technological research activities in industry. Sources of financing are basically of two types: on the one hand, there are funds from the budget of the Ministry of Education, responsible for the financing of salaries of researchers and technicians, and for the construction and maintenance of the physical installations of the laboratories and offices. On the other hand, there are four financing agencies. The Financiadora de Estudos e Projetos (FINEP) and the National Council for Scientific and Technological Development (CNPq) are both connected with the Ministry of Science and Technology (MCT); the University Graduate Personnel Training Bureau (CAPES) is connected with the Ministry of Education (MEC) and, finally, the Research Support Fund (FIPEC) is connected to the Bank of Brazil.

For 1988, funding making up the budgets of these government agencies reached an amount of approximately US\$500 million. It should be noted that this funding was to finance post-graduate studies (around two-thirds of the amount), as well as to encourage additional salary payments for the more active and productive researchers. Moreover, it was to finance the infra-structure that was directly connected to the development of projects (input materials for research and equipment). Not included in this figure were funds for payment of researchers' salaries. It should also be noted that this funding was approved in cruzados, and that its value in dollars would necessarily be eaten away by inflation over the period.

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The start of Brazil's science policy dates back to the beginning of the 1950s, with the setting up of the CNPq and CAPES. Up to the early 1970s, these were the only two instruments of policy-making - mainly the CNPq - as well as of financing. This was summed up in meeting a spontaneous demand for scholarships and minor individual assistance with research projects. During the 'enlightened despotism' of the Geisel government, at the start of the 1970s, FINEP was set up, as well as the National Scientific and Technological Development Fund (FNDCT) which, by the end of this decade (1978) had turned into the main instrument for financing scientific research in the country. Between 1979 and 1984, the period of the last military government, the policy for science and technology was almost entirely abandoned and reached its lowest level since the 1950s. This was noted in various aspects. First, through the drop in funding for research which affected all sources, but mainly the FNDCT (whose budget for 1984 in real terms was worth some 25 per cent of that for 1979). In addition, over this period, the capacity for planning scientific and technological activities was lost or at least seriously hindered. This was, at the time, CNPq's responsibility (curiously enough, in the government's organisation chart, CNPq - which was the head of the Science and Technology System - was subordinate to the Ministry of Planning).

What characterises the current environment in terms of scientific policy is undoubtedly the establishment of the Ministry of Science and Technology in 1985. This gives rise to the possibility - only partly realized - of bringing the science and technology business up to a level of being a strategic concern of the Government. This has never yet been the case in Brazil, with perhaps a brief period of exception during the Geisel Government and, even then, the strategic question was technological, not scientific.

The importance of the Ministry of Science and Technology has become evident from two points of view. First, by the improvement in the system's capacity to link up with other government sectors. This is very important, on one side, due to the ferocious competition for financial resources and, on the other, in the sense of coordinating itself with other sectors, governmental or not, with real interests in the science and technology area. With regard do negotiating funding with economic sectors of government, it may be said that the Ministry of Science and Technology has put up a highly successful performance, as shown by the continuous growth in funding through the late 1980s. However, in my view, this growth was still well below needs. Unfortunately, in the 1990s Brazil faces the possibility of a new period of compression of funds, because of the country's return to IMF policy requirements. In addition, the effort expended each year to balance these budgets and to obtain additional credits is excessive, and could be channelled into more rewarding tasks. This competition for funding has two aspects. On one hand, funding in Brazil is really in short supply, and this is a relevant factor. However, when dealing with funding which we may classify generically under the category of pre-investment, its volume is marginal in relation to the figures

necessary Minister Renato Archer reached a successful conclusion of talks with the Ministry of Planning, when he mentioned that all he needed at that time, something around US\$150 million, was the price that the country was paying for importing two cranes for the port of Rio de Janeiro. Therefore this leads one to believe that, in addition to the real shortage of funding, there are difficulties of a political nature in some sectors of the economic area; these difficulties arise from the lack of understanding in these sectors of the strategic importance of science and technology for the country.

Secondly, with regard to coordinated action with other sectors of national life that have an interest in science and technology, in the 1980s mechanisms were set up on an ad hoc basis. Before the Ministry of Science and Technology was established, there was within the sphere of the CNPq, an organisation called the Scientific and Technological Council (CCT) which fulfilled this function. Only now can the Ministry of Science and Technology re-organise the CCT on other bases, including the presence of researches, businessmen involved with technological development and ministries with a significant interface with science and technology. It is believed that this Council may fulfil in permanent organisational fashion the function of inter-setorial coordination.

In addition to these aspects, the presence of the Ministry of Science and Technology in the Brazilian science and technology scene is due to the policy which it has sought to impose on this sector. I will try to discuss this below, organising the matter somewhat arbitrarily into four headings, which are:

- (a) Does it make sense for a Third World country to waste funding in short supply on areas subject to international competition, without the basic problems of survival having been solved? In other words, and simplified: is it worth while investing in graduate studies while thirty million Brazilians do not know how to read and write?
- (b) How can science be made a priority? Does it make sense, when we speak of scientific development, to give priority to certain areas of knowledge to the detriment of others?
- (c) Among the various 'production factors' which come together to produce the final result - fresh knowledge - what is the most scarce or most important to be taken first in a country such as Brazil?
- (d) Is the institutional profile, concentrated on the production of scientific knowledge, which exists today in Brazil, suitable to the country's needs?

III. Standards for Brazilian Scientific and Technological Development

It becomes clearer that economic and social development worldwide is connected to scientific and technological advances. In the developed countries, this affirmation has been evident for some years, through the increasing amount of funding made available for activities connected with science and technology, both by the public sector and by private companies. None of the First World countries invest less than 2.5 to 3 per cent of their GNP in science and technology, and the nationwide budget for these activities in the United States reached a figure in 1987 equal to the value of Brazil's foreign debt, something in the range of US\$120 billion.

Although Brazil does not belong to this closed club, it does have, together with certain other Third World countries, a peculiar situation. Our capacity for producing wealth already excludes us from the group of low income countries and puts us together with the middle income nations. This comes about from our having reached an economic level where the industrialization process has been virtually completed, both in installed capacity and in terms of industrial sectors covered. This means that the crucial point for leverage of development nowadays lies in its modernization and the extension of its capacity, through an increase in its technological threshold. In this sense, in spite of the Third World, our view of science and technology should be more and more identified with that of the developed countries. Our development is already and will be increasingly dependent on our capacity to produce or adapt our knowledge and transform it into new processes and products available to society as a whole.

It is true that no type of development, whether industrial, scientific or technological, occurs in today's world in an exclusively independent fashion. On the other had, it is equally true that an excessive degree of dependence hinders. possibly even halts, the capacity of a country to define itself strategically. Just in order for to us to remain in the field of technology, it is generally agreed that the best technologies are not available for trade.

Discussion on the standards for Brazilian scientific and technological development is extremely up-to-date, in view of the growing international opinion, which puts forward the idea of channelling funding to science and technology programmes which are directly focuses on solving social problems and if not actually abandoning, then cutting, investments in state-of-the-art research at the level of international competition. The current Board of Directors of the World Bank, for example, has had the opportunity to express this point of view in discussions held within the sphere of action of the Ministry of Science and Technology. The Brazilian Government, however, has adopted the opposite view, whereby scientific and technological development should be carried out in a wide-ranging fashion, with investments being made in all state-of-the-art research areas so as to lessen the gap that separates Brazil from the First World countries. This way of looking at the problem has been supported by the scientific community and the most mature example of this policy may be seen in the informatics and micro-electronics sectors.

IV. Priorities

In any area, priority has to be given to something. What changes is the manner of doing this and, in this particular case, giving priority to science and

technology is not an easy task. To begin, it is essential to separate this area into two distinct chapters - science on one hand and technology on the other. This is particularly so when dealing with basic scientific research, where the support for some disciplines to the detriment of others is almost always catastrophic. Insofar as we are moving towards applied scientific research, and mainly in the area of development, the allocation of priorities becomes imperative. In the area of basic research, the good project defines *per se* the priority. In the field of applications, the basic priority is a good project in those fields which are defined as having priority.

The Ministry of Science and Technology defined five areas of knowledge as having priority: informatics, fine chemicals, new materials, precision mechanics and biotechnology. It is not without a touch of irony that they have been nicknamed 'the five sisters' by the scientific community. This decision arose as a result of the diagnosis that international competition is found in these areas and that efforts should be made so that the distance between Brazil and the First World would not increase.

Some criticisms have been heard from the scientific community to the effect that the Ministry of Science and Technology should have had a well-formulated technology policy and may not have given due attention to scientific policy. This arises precisely from the definition of those areas of priority, seen by the scientific community as merely technological options. I would like to make two comments on this. First, in my opinion, each of these

areas constitutes an integrated research field on both vertical and horizontal planes. Vertical integration, insofar as it incorporates knowledge and projects right up from basic research to the most remote stages of development of products and processes, which are frequently carried out in industry. Horizontal integration because it integrates knowledge of various sciences and disciplines. However, the choice of these areas as priorities involves a choice that is a much one of technological policy as it is of scientific policy. Still more, in terms of scientific policy, it introduces a modern view of integration, interdisciplinary, which is in part what gives rise to resistance by some scientists who are excessively attached to a more traditional definition of scientific disciplines. If we look carefully, everything, or almost everything, that is done in the world today in terms of state-of-the-art scientific research has a close connection with some of the vertical integration links with one of the 'five sisters' - with the notable exception on research into the social sciences.

The second consideration with regard to this matter is what micro-electronics and informatics researchers call the research environment. More and more, the environment for technological development is the same as that for scientific research, whether basic or applied. It is not necessary to recall the Nobel prizes awarded to IBM scientists or the fact that the major corporations that work with state-of-the-art technology are giving contracts to thousands of basic researchers; or the growing number of patents registered by university researchers and the setting up of companies with high technological content by groups of researchers.

In Brazil there are two examples where it is possible to get an overview of this situation. One of them is a laboratory designed specifically for the assembly and quality control of high-tech products; this is the Integration and Tests Laboratory of the National Space Research Institute (INPE). In this case - a typical technological environment - a team of basic researchers may be found carrying out experiments which require conditions found only in space. On the other hand, the largest particle accelerator operating in Brazil - the Pelletron, at the University of São Paulo Physics Institute - a typical basic research environment, has been more and more in demand by groups working with applied research and technology (sometimes even by industries) for testing the purity of the air or of crystals. It may be objected that although there may be integration taking place, this is at the cost of the original purpose of the laboratory. Or, in other words, there will always be a more important purpose. I therefore ask, what will be the most important task of the Sincrotron National Laboratory in ten years time when it is running at full blast? Fundamental, applied or technological? I think that all three will be living side by side in the same environment.

The fundamental question is that the notion of competitiveness, present for over a century in the domains of technology, is shifting at an ever-increasing speed to the area of scientific knowledge. It is a recognised fact that state-of-the-art technology is secret. It is not published. It is worth money. On the other hand, scientific research is published. The logic is historically in opposition. The success of whoever has the mastery of a technology is measured

by the time during which it can be kept secret. On the other hand, the success of scientific results is measured by who publishes first. Today there are not only areas of basic research in which results are admittedly not published in full (plasma confinement, for example) just as we do not know, no-one knows, to what extent results are hidden in all areas of scientific knowledge. I do not wish to adopt a gloomy view of a world in which the ideal of knowledge without frontiers is brought down to earth by competitiveness. But it is undeniable that today the environments are becoming more and more interprenetrated and the tendency is for them to blend still further.

V. Resources

As may be noted from the figures given at the start of this study, Brazil is short of science and technology in general. It has fewer researchers, fewer laboratories, less - and worse - equipment, in fact, fewer resources in general than it needs. It was therefore necessary to give priority to the 'production factor', which was found in the most critical situation. For a number of reasons, the conclusion reached was that the main bottleneck in the process of production of scientific knowledge lies in the shortage of qualified human resources. In the first place because it is always the most precious of the production factors. Without the rest, research can be carried out although under precarious conditions. Without this factor, no research whatsoever can be carried out. In addition, in the opinion of many well-established scientists, the relative shortage of researchers is greater than the lack of laboratories.

equipment etc. Added to this is the appearance of a very dynamic sector made up of industries which use state-of-the-art technology, and which has considerably increased the demand for researchers. It has not been uncommon for researchers to leave the universities for these companies, and - in principle - there is nothing wrong with this process. The problem is that among those who are leaving are the 'cream', the 'breeder-stock', men and women who, by their experience and capacity, should have stayed there in order to train new researchers.

In order to try to overcome this problem, a National Human Resources
Training Programme has been launched under the aegis of the Ministry of
Science and Technology and the Ministry of Education. In 1989 its targets were
to provide 10,000 scholarship students a post-graduate level abroad and 30,000
within Brazil. In 1986 these figures were 2,000 and 10,000 and for 1988 funding
was guaranteed for 6,000 and 20,000 respectively. In spite of some difficulties
in negotiating the funds, in general the programme succeeded in achieving its
aims.

In spite of the correct diagnosis and the formulation of a suitable programme, it is necessary for us to think seriously about the remaining production factors. Without this some highly undesirable side-effects may appear. I refer to the capacity of the job market to absorb the new PhDs coming home from abroad or those who have successfully completed their theses in

Brazil, and the enlargement of the installed research capacities at levels compatible with work carried out under good conditions.

With regard to the first question, the root of the problem lies in the fact that the main demand for researchers comes from the universities, which have had their doors closed to new staff for some years. No possibilities are insight of modifying this situation in the short term, in view of the serious suspicion that most universities have too many staff, frequently with low qualifications and with no commitment to research activities. If this hypothesis is in fact true, it will be difficult to convince the authorities to release fresh funding for more positions.

The second question seems to have a less complex solution, although it is also crucial. The research park installed in Brazil went through its last phase of renovation during the 1970s (between 1973 and 1979). It is supposed that a large part of the equipment acquired over this period has already reached a fair level of obsolescence: added to this the need to enlarge installed capacity, so as to offer a place of work for new post-doctoral research workers, sizeable funding will be necessary. The main source of financing to fulfil this objective is the FNDCT, managed by FINEP. It was through this Fund, made up of funds from the National Treasury and set up during the last decade, that it was possible to equip laboratories during the 1970s. Funding was approved for 1988 to the value of around US\$60 million (when approved in October 1987, this was worth almost US\$100 million). Taking as a parameter the growth in real terms of funds

for the Human Resources Training Programme, in order for the FNDCT to carry out its task, there should have been a real increase factor of 4 or 5 (between US\$200 and US\$250 million). This decision cannot be put off, without running the risk of seeing the effort of training researches going to waste. The most negative aspect of our keeping this lack of balance between personnel and the other production factors is the danger of a brain-drain. It would be the first time under a democratic regime that this would have happened, and the example of our neighbour Argentina, where the exodus of scientists has been going on for a long time (there are today some seventy Argentinian post-doctoral physicists working in Brazil) should serve as a warning to us.

VI. Institutional Reorganisation

One of the major public discussions that has been under way in the science and technology area in Brazil can now be summed up in the following question: is the institutional organisation concerned with the production of scientific knowledge a suitable place for the requirements of a science which is competitive on an international level?

Leaving aside research carried out by industries which is still incipient in Brazil, science and technology research is carried out in two types of institution: first - and most important - in the university and, apart from this, in research institutes. There are at present in these institutions (particularly in the university) three types of problem.

The first one derives from the cut in funding for research and the deterioration in the salary levels of researchers between 1980 and 1984, which still continues in some places. If this is true for the universities, it is even still more so for the institutes, some of which - among them certain very old onesalmost closed their doors. The second type of problem, particularly found at the university, is the downgrading of research activities by reduction or even elimination of specific benefits for this activity. Fundamental for this process was the setting up of an academic career path which favours length of service over merit and more recently the corporate attempt to set up an independent salary scale, free from appraisal of scientific output, which would eliminate once and for all a bonus for academic achievement.

The third type of problem is more structural in nature and refers to the probable inadequacy of university structure for the requirements iaid down by modern science and technology. More explicitly, I have in mind the departmental organisation of the university stemming from an outmoded division of disciplines. Thus, in the bio-sciences, we have departments of morphology, biochemistry, biophysics, parasitology etc. or, in engineering, the departments of civil, mechanical and metallurgy. I believe that this model of organisation has nothing to do with the current organisation of knowledge which in more advanced areas spreads across the walls of the university departments. Thus, robotics research extends across electrical, mechanical and systems engineering, just as biotechnology research includes several departments of traditional biology. This is perhaps the greatest problem and the major

challenge facing current research institutions in Brazil and solving it implies a fundamental reorganisation of the entire university and all the research institutes. This reorganisation will have to confront powerful interests which have been firmly entrenched for a long time.

The discussion under way at present concerns the most suitable strategy for the creation of modern, stable research institutions able to respond to the challenge of science and technology as the century draws to a close.

Various alternatives have been put forward regarding the institutional format. Some people are putting all their cards on strengthening top level research centres in universities. In radical opposition to this, others are betting on the setting up of new institutions outside the universities, with greater flexibility and designed from the start solely for research. Various graduations of opinions lie between these two points of view.

Some 90 per cent of Brazil's scientific output, measured in terms of articles published in periodicals, are carried out within the university. This fact alone eliminates the possibility of abandoning or even slowing down investments in assets already in existence. What is necessary is to differentiate within the institution between productive centres (at each level of output) and non-productive areas, in terms of research. This differentiation will give rise to distinct standards of financial support from the various sources available. The more productive sectors should have longer-them support, for four or five years,

with relatively more resources, management and supervision. Evaluation should be carried out by a committee that includes members from outside the institution. Less productive areas will have a type of financing which can bear a higher risk of lack of success, implying shorter periods and fewer funds. The former may be operated along the lines of an associated institution model, incorporating the positive aspects of experience with this model in France.

This is obviously not a matter of reproducing the centres of excellence policy. It means differentiating and rewarding competence, while keeping open the necessary space (when possible) for carrying out high-risk operations, heavily financing the emerging centres which, by their location or field of interest, have been strategic for the development of the system.

Proposals for investment outside the university have blossomed, due mainly to the difficulty encountered by some reform-minded managers in breaking away from departmental conservatism. In order to circumvent this problem, these same managers have put forward conciliatory formulae that vary from setting up new research institutions or groups that bring together researchers active in various departments, to programmes which, with no physical or administrative expression, encourage activities directed towards specific objectives. The University of Campinas (UNICAMP), the University of São Paulo (USP) and the Federal University of Rio de Janeiro (UFRJ) have put forward a number of proposals of this type, with great possibilities of

success. Should they become politically feasible, they should have priority, as defined by university management, in the allocation of funding.

Regardless of these opportunities within the university, it is necessary to reflect on successful experiments in setting up new institutions designed exclusively for the production of scientific knowledge and the training of highly qualified human resources, particularly in new areas or with a complex interdisciplinary design. Experiments such as that of Tsukuba in Japan or Novosibirsk in the Soviet Union should be appraised in detail for possible application in Brazil. Even the setting up of 'science cities' or technological complexes that bring together public institutions and the research and development departments of companies should be considered. There are already some experiments under way in Brazil which could be placed under analysis. The INPE in São José dos Campos and the Oswaldo Cruz Foundation in Rio de Janeiro are two of them.

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