Coming Full Circle: A Reappraisal of University Research in Latin America

SIMON SCHWARTZMAN

SCIENTIFIC and technological activity in countries which are economically poor and have no scientific tradition are in a permanent crisis of self-confidence and sense of purpose. There is acute awareness that such activities are unequally distributed between countries, and that a great deal of what is produced in peripheral areas is usually based on questions asked and interests pursued in other countries.[1] There are also mounting doubts as to whether the little science and technology produced in peripheral countries have any useful impact on the pressing social and economic problems they face.[2] In the 1960s, awareness of these difficulties led to a profusion of national and international science-planning agencies, and to efforts to direct scientific and technological research towards relevant social and economic tasks. However, it is now increasingly clear that the administrative and bureaucratic arrangements created for this purpose are neither fulfilling their goals nor inclined to reduce their size or powers to allow research workers a freer hand. In Brazil, one of the earliest decisions taken by the first civilian government to emerge after 20 years of military rule was the creation of a ministry of science and technology. Support for research did not, however, improve.

The situation is compounded by the emergence of the so-called "high technologies"—mostly electronics and biotechnology—which seem to flourish within market-oriented companies with all kinds of unusual links with university and governmental research centres; they possess an institutional flexibility which tends to be scarce in less developed countries. High technologies require extremely sophisticated research and research institutions; innovations may offset each other very rapidly, turning obsolete recently acquired equipment and scientific skills; and they spread out through all areas of scientific and technological work, bringing new instruments and concepts as well as the threat of widespread scientific and technological obsolescence.

How can countries without much tradition of scientific and technological research confront this situation? I have conducted a survey of about 300 scientific and technological "research units" in Brazil[3] and I have concluded

[1] On the contributions of Latin American countries to international science, see Garfield, E., "Latin American Research", *Current Contents*, XVI (7 May and 14 May, 1984).

[2] See Wade, Nicholas, "Third World Science and Technology Contributes Feebly to Development", *Science*, CLXXXIX (5 September, 1975), pp. 770–776; and Salomon, Jean-Jacques, "La Science ne garantit pas le développement", *Futuribles* (June 1984), pp. 37–68.

[3] The research reported here is part of the "International Comparative Study on the Organization and Performance of Research Units", co-ordinated by the Division of Science

that, despite its known problems, university research may still be the best approach to making science better and more useful to society.

The Search for Solutions, Old and New

The traditional approach to scientific growth in less developed countries was to invest as much as possible in the education of scientists of high quality, in the hope that they would stimulate the improvement of educational institutions and make local governments and firms aware of the importance of scientific research. Investment was centred mostly in university research departments, or, in a few cases, oriented towards isolated institutes of high-quality research.[4] General optimism regarding the beneficial role of scientific research reinforced the scientists' prestige and autonomy, but did not necessarily improve their contribution to the solution of short-term problems. This led to growing scepticism and reaction against the claims made on behalf of academic research:

> The liberal tradition of university autonomy became an instrument of resisting political pressures. In its dual role as a site of contention and a barrier against external intervention, the university came under suspicion and criticism from the power-holders. It was a place for a kind of research guided only by its own goals, without much contact with concerns emerging from its economic and social environment.[5]

This was the attitude in Europe where universities had a tradition and reputation for high achievement. It was different in Latin America. There, the values of academic autonomy had not been linked with pure research; rather, they were often linked with intense social and political activity.[6] This

and Technology Policies of UNESCO, which provided its main questionnaires and research methodology. The work in Brazil was supported by the Financiadora de Estudos e Projetos (financing agency for studies and projects). "Research units" are defined here as the minimum working team in a research institution, formed usually by a research leader, other scientists and engineers and technicians. For a full description of the project and some of its early results, see Andrews, Frank A. *et al.*, *Scientific Productivity* (Cambridge: Cambridge University Press, 1979).

[4] The best Latin American example of an academic institution outside the universities is probably the Instituto Venezolano de Investigaciones Científicas. See Vessuri, Hebe, "El Papel Cambiante de la Investigación Científica Académica en un País Periférico", in Díaz, Helena, Texera, Yolanda and Vessuri, Hebe, *La Ciencia Periférica* (Caracas: Monte Avila Editores, 1983), pp. 37–72; and Vessuri, Hebe, "The Search for a Scientific Community in Venezuela: From Isolation to Applied Research", *Minerva*, XXII (Summer 1984), pp. 196–235. Examples for Brazil are the Centro Brasileiro de Pesquisas Físicas (Brazilian centre for physics research) and the Instituto de Matemática Pura e Aplicada (institute of pure and applied mathematics), both in Rio de Janeiro and now associated with the Conselho Nacional de Desenvolvimento Científico e Technológico (national council for scientific and technological development); and the Instituto de Física Teórica (institute of theoretical physics) in São Paulo.

[5] Salomon, J.-J., *op. cit.*, p. 42.

[6] See Schwartzman, Simon, "The Focus on Scientific Activity", in Clark, Burton, E. (ed.), *Perspectives in Higher Education: Eight Disciplinary and Comparative Views* (Berkeley: University of California Press, 1984); Schwartzman, Simon, "The Quest for University Research: Policies and Research Organization in Latin America", in Wittrock, Bjorn and Elzinga, Aant (eds), *The University Research System: The Public Policies of the Home of Scientists* (Stockholm: Almqvist & Wikesell International, 1985), pp. 101–116.

activity demanded among other things that scientific research aim at changing social and economic conditions. In its most recent form, this view dates at least from the Second World War and has close affinities with the views popularised by Fréderic Joliot-Curie in France and J. D. Bernal in England in the years before the war. Science was regarded as a tool for economic development and planning. Scientists began to argue that their social responsibility should not be limited to scientific discoveries in universities—they wanted to participate in all decisions affecting society. Political participation was looked upon as necessary for the influence they sought; the creation of politically powerful planning institutions for the guidance of scientific research was considered the obvious path to follow.

There is an inherent tension between the values of academic freedom and planning—but scientists think that this tension would not exist if they were in charge. However, the politicisation of scientists and their entanglement in administrative matters created new difficulties. For one thing, it reduced the legitimacy of the more academic research undertaken primarily out of intellectual interest. It is certainly true that large expenditures by poor countries on scientific and technological research should be mindful of local, social and economic problems. It is also true that much strictly academic research is based on stereotyped views about what is "really scientific", derived from random experiences of residence in foreign countries while working for the doctorate. Nevertheless, these views can easily turn into attacks on intellectual quality and into attempts to control scientific research in all its aspects. "This is a luxury the country cannot afford" becomes a standard way of condemning even inexpensive forms of scientific research which make no claim to have an immediate practical application. At the same time, belief in the necessity of planning leads to the creation of cumbersome, costly and usually ineffective planning agencies;[7] it leads to the precipitation of naïve and crude decisions about what is most urgent. It is also associated with attacks on the very notion of freedom in research—attacks which are often made with the support of members of the scientific community itself. Finally, it frequently leads to large expenditures in fields which are thought to be of great practical importance, although the path from research to practical social and economic benefits is not clearly envisaged.

As the idea of the planning of science came to be accepted, scientists were frequently excluded from the deliberations. One possible reason for this exclusion is that planning is often adopted by military and conservative regimes which wish to keep scientists, who may be progressivists or radicals, at a distance. An additional explanation is that, in highly bureaucratic planning agencies, an unavoidable tension exists between bureaucrats and managers, on the one hand, and scientists and technological research

[7] Antonoci, M. and Avalos, I., *La Planificación Ilusória* (Caracas: Cendes/Ateneo, 1980). Their criticisms of the Venezuelan plans for science and technology could be easily applied to Brazil.

workers on the other. The consequence on numerous occasions has been the alienation of scientists from the very planning bureaucracies they helped to create and legitimate.

A further consequence of the alleged planning of science has been the enfeeblement of traditional arrangements for assessing the quality of scientific research. Academic research has traditionally been subjected to assessment by some variant of a review by peers; this has been the case in the selection of papers for publication in academic journals, in the distribution of grants for research, in the appointment of scientists, and in all the other processes by which what is considered scientifically superior is given precedence over what is scientifically inferior.

In the small and isolated settings of scientific work characteristic of countries with little scientific tradition, it is important that the standards applied should be those of the international scientific community. Otherwise parochialism and nepotism are very likely. Applied research is supposed to be controlled by considerations of cost-effectiveness, imposed by the mechanisms of the market or by political decision. When research is under the control of planning agencies, which allege that they are guided by long-term perspectives, neither strict academic standards nor market mechanisms operate. This can confer some advantages. With evaluation based only on peer review, financial support tends to be concentrated on well-established institutions and research topics, and new research institutions and new and risky projects may have little chance to get under way. Also, short-term considerations of market costs may hinder technological research projects with long periods of maturation and uncertain profitability. This is why some planning and estimates of future possibilities are certainly necessary; but attempts at comprehensive and long-term planning can easily lead to disregard of stringent assessment, and to incompetence in institutions.

If neither entirely competitive nor planned science seem to work satisfactorily, what about profit-oriented research and development? One feature of modern high technology seems to be the large amount of research and development carried on in their own laboratories by private corporations in the richer countries. This fact has encouraged the idea that research in poor countries should also be placed under profit-making firms—this is very much at the centre of the current debate in Brazil about the country's computer industry. At one extreme, it has been argued that all the existing arrangements for research in universities and for the planning of research and development should be dismantled and replaced by the free market, including the active presence of multinational corporations, which are supposedly the seed-bed of advanced technology. Opponents of this last position advocate the protection of research and development of domestic firms from international competition; they also call for the establishment of links between university centres of research, governmental research institutes and private industry. The current Brazilian policy follows the

second line in the expectation that domestic firms will do their own research. Neither side seems to expect anything from governmentally supported research and development carried on in universities. The universities have in fact been the neglected part of the Brazilian "informatics" policy of the last few years.[8]

A superficial interpretation of the technological achievements of some countries in Asia which have recently become industrialised, seems to confirm that this should indeed be the next step for all poor countries. However, it is clear that market forces by themselves do not seem to stimulate the development of research at the periphery.[9] On the contrary, a freely operating market helps to concentrate scientific research in regions with better external conditions for advanced technological research, such as congenial universities, skilled manpower, and suppliers of sophisticated and reliable instruments and materials. If these conditions exist, the market can help to assure the quality of the research and development done by private firms which bear the risks of enterprise. Protected companies, whether privately or publicly owned, enjoying monopolies and benefiting from governmental subsidies, are likely to conduct expensive and quite useless research and development of poor quality, which continues because there is no controlling assessment for scientific quality or cost-effectiveness. It drags on out of sheer bureaucratic inertia.

To convert oneself to the "Asian model"—which, on closer scrutiny, turns out to be less oriented to the free market than is often said—might destroy much of what has already been achieved, without providing any assurances about the future. Yet to disregard the "Asian model" risks the perpetuation of expensive, demanding and often obsolete research establishments. The real difficulty may consist in attempting to solve the problems of scientific and technological development through policies based on sweeping generalisations and ideologies, without any proper understanding of the realities involved.

University and Non-University Research in Brazil

As in many other countries, scientific research in Brazil is concentrated in universities or is linked in other ways to the higher educational system. Brazilian higher educational institutions have not provided the best possible environment for scientific research.[10] Today, research is concentrated in a

[8] Schwartzman, Simon, "High Technology and Self Reliance: Brazil Enters the Computer Age", in Botelho, A. and Smith, P. H. (eds), *The Computer Question in Brazil: High Technology in a Developing Society* (Cambridge, Mass.: Center for International Studies, Massachussetts Institute of Technology, July 1985), pp. 1–40.

[9] Dugger, William M., "The Nature of Capital Accumulation and Technological Progress in Modern Economy", *Journal of Economic Issues*, XVIII (September 1984), pp. 799–823.

[10] On the relations between scientific research and universities in Western societies see Ben-David, Joseph, *The Scientist's Role in Society* (Englewood Cliffs: Prentice Hall, 1971). For Brazil, see Schwartzman, Simon, *Formação da Comunidade Científica no Brasil* (Rio de Janeiro and São Paulo: Cia. Editora Nacional/FINEP, 1979); and "Struggling to be Born: The Scientific Community in Brazil", *Minerva*, XVI (Winter 1978), pp. 545–580.

few major universities, while most of the country's higher educational institutions do little research worth mentioning. The sample of "research units" which was drawn for my investigation was probably biased against university research, since it excluded individual scientists not working as members of groups. Nevertheless, it showed a remarkable concentration of units in universities or other higher educational institutions. (The term "universities" will be used hereafter in this larger sense.) A smaller number of units were found in non-academic, non-teaching research institutions, linked directly to state or federal governmental "institutes". There was a still smaller number in firms, public or private, with provision for research within the firm[11] (Tables I and II).

TABLE I

Research Units, Scientists and Financial Resources by Type of Institution

	Institutional Location			
	Universities	Research Institutes	Firms	Total
Estimated number of research units in selected regions and fields of knowledge[a]	2,928	1,568	278	4,774
Number of units in sample	172	84	32	288
Average number of research workers per unit	6.3	4.7		5.6
Estimated number of research workers per sector	18,446	7,369	1,142	26,957
Estimated Budget for Research and Development for 1982 (US$)[b]				
US$ per research unit:	90,846	300,102	596,852	217,461
US$ per research worker:	14,414	80,872	135,679	38,837

[a] The selected regions are the states of Rio de Janeiro, São Paulo, Rio Grande do Sul, Minas Gerais, Pernambuco, Bahia and the Federal District (Brasília). The fields of knowledge are biological, medical, exact and earth sciences, technology and agricultural research. A probabilistic, two-state sampling was adopted for the selection of the research units. The final sampling ratio was 1/16 for units in universities and research institutes, and 1/8 for units in firms. There was a 10 per cent loss of units in the sample during field-work. Estimates are extrapolations from the sample to the universe. For a full description of sampling procedures, see Iuperj, Projeto ICSOPRU, Documento de Trabalho 1, *O Projeto ICSOPRU no Brasil: A Amostra Brasileira* (Rio de Janeiro: IUPERJ, 1984), mimeograph.

[b] Dollar estimates in this table were produced on the assumption that half of the FNDCT, half of the Conselho Nacional de Pesquisas' funds for research and development and all the research budget of the Ministério da Educacão were allocated to the universities. This results in a total figure of US$266 million for 1982, a third of the federal budget for science and technology, or a fourth if expenditures of state-owned companies are included in that total.

[11] Preliminary research at the sampling stage showed very few established research units within privately owned firms in Brazil. It was impossible to get even preliminary information

TABLE II

Expenditures of the Brazilian Federal Government on Science and Technology, 1980 and 1982 (in US$ millions)

	1980	1982
A. General Expenditures under the Presidency or the Secretaria de Planejamento (planning secretariat)		
FNDCT (national fund for scientific and technological development)	114.423	94.775
CNPq (national council for scientific and technological development)	42.445	111.906
FNDE (national fund for economic development)	36.781	—
Other direct expenditures	2.200	98.814
B. Expenditures by Ministry		
Agricultura (agriculture, including Embrapa)	47.086	265.235
Educação (education, culture and sports)	26.703	106.071
Minas e Energia (mines and energy)	33.611	96.641
Indústria e Comercio (industry and trade, including STI, the secretariat for industrial technology)	21.040	51.646
Saúde (health and sanitation)	8.559	14.346
Transportes (transportation)	13.209	7.937
Aeronáutica (air force)	—	4.626
Exército (army)	1.878	4.104
Marinha (navy)	2.163	2.381
Interior (interior)	0.702	0.361
Justiça (justice)	—	0.313
Relações Exteriores (foreign affairs)	0.208	0.130
Previdência Social (social security)	0.607	0.025
Total	351.641	862.066
Research and Development (% of total expenditures)	2.1	3.6

SOURCE: Brazil, Conselho Nacional de Desenvolvimento Cientifico e Tecnológico, *1982: Orçamento da União para Ciência e Tecnologia: Anotações e Destaques* (Brasilia: CNPq, Coordenação Editorial, 1982) Adopted exchange rates (for the month of June): for 1980, US$ 1.00 = Cr$ 52.69; for 1982, US$ 1.00 = Cr$ 168.82.

The figures in Table II are only approximate. The inclusion of a given expenditure under the heading "science and technology" does not necessarily mean that research was in fact performed; also, an indeterminable part of the budgetary increase for science and technology between 1980 and 1982 is attributable to changes in accounting procedures. Finally, there are other sources of funds besides the federal government and the large public corporations. The state of São Paulo provides more

about research and development in firms in arms production; this work was done before the recent expansion of Brazil's computer industry. Large multinational firms operating in Brazil usually do their research and development in their countries of origin. In consequence, most of the "firms" referred to in this study are in fact state-owned, production-oriented corporations.

resources for research and development in that region than does the federal government, and the inclusion of its contribution would certainly improve the picture of university research.

Universities receive support only from the Fundo Nacional de Desenvolvimento Científico e Tecnológico (FNDCT, the national fund for scientific and technological development), which is administered by FINEP (Financiadora de Estudos e Projectos, the financing agency for studies and projects), the Conselho Nacional de Desenvolvimento Científico e Tecnológico and the Ministéro da Educacão. The Empresa Brasileira de Pesquisa Agropecuária (Embrapa, the Brazilian company for agricultural research, an agency of the ministry of agriculture), can also enter into contracts with universities for the performance of research. The Conselho Nacional de Desenvolvimento Científico e Tecnológico, however, has usually spent more than half its resources on the maintenance of its own institutes and on activities other than on research. In 1982, the percentage it spent on research or study grants (*fomento*) was 47.1 per cent; in 1981 it was 27.3 per cent. The Ministério da Educacão pays the salaries of research workers in the federal universities system; this does not appear under the heading of "science and technology". It does not support research directly. Only part of the FNDCT goes to research in universities, since it is also used to support military and other types of technological research done by different branches of the federal government. Finally, of Embrapa's US$142 million in the budget of 1982, 30 million went to "administration and co-ordination", 47 million for "strengthening agricultural research" and 65 million for research and development. Most of Embrapa's research is carried on through its own institutes and research centres.

The combined budget for research and development of the largest state corporations in Brazil is equivalent to the sum of resources available to the Conselho Nacional de Desenvolvimento Científico e Technológico and the FNDCT (Table III). These funds were affected by the economic recession in Brazil from 1982 to 1984, except for Petrobrás—the state oil monopoly—where the sum remained stable, and in the Companhia Vale do Rio Doce—mining—where it expanded rapidly.

Although it is difficult to obtain precise information about expenditures, it is quite evident that while most research in Brazil takes place in universities, most financial resources are allocated to research in other kinds of research institutions, which are presumably more amenable to considerations of policy.[12]

The discrepancy between the amount of activity and the size of expenditure is matched by the difference in qualifications of the scientists in universities and those in other types of research. Doctorates are almost a prerequisite for leadership of a research unit in universities, but this is not so

[12] Dagnino, Renato P., "A Universidade e a Pesquisa Científica e Tecnológica", *Revista de Administração* (São Paulo), CXIX (1984), pp. 60–77.

TABLE III

Expenditure on Research and Development by the Six Largest State Companies in Brazil, 1982, and Growth Rate between 1979 and 1982 (in US$ millions)

	Expenditures[a]	Growth[b]
Petrobrás (oil)	48.997	0.0
Telebrás (communications)	37.258	−7.2
Vale do Rio Doce (mining)	16.348	35.5
Electrobrás (electricity)	15.519	−28.1
Siderbrás (steel)	13.623	−9.9
Nuclebrás (atomic energy)	27.603	−22.8
Total	155.076	−8.4

[a] Exchange rate: US$1.00 = Cr$ 168.82.
[b] Average yearly increase.

SOURCE: Brazil, Conselho Nacional de Desenvolvimento Científico e Tecnológico, *Setor Produtivo Estatal: Dispêndios em Ciência e Tecnologia, 1979–82* (Brasília: CNPq, Coordenação Editorial, 1982), table 3.

elsewhere (Table IV). The difference in formal qualifications is not related, however, to difference in remuneration. In 1983, when the data were collected, salaries in firms tended to be consistently higher than in other institutions, and were not related to formal education. Research units in universities were more poorly provided with auxiliary staff such as technicians; they had less equipment and they tended to decline in size. Members of research units in universities were also less satisfied with the services and equipment provided (Table V).

Driving Forces

University and non-university research are sharply contrasted, not only in terms of the support they receive, but in the way resources are obtained. While most research within firms is supported by the firms themselves, research in universities is almost wholly dependent on external support (Table VI). In fact, almost 40 per cent of all university units would be unable to do any research at all without support from outside the university. External sources are also quite different: university research gets support from grant-awarding bodies, mostly governmental. Research units in firms obtain external financial support from the sale of their research services by contract. Units in research institutes are less able than university units to get support from grant-awarding bodies, and less well endowed by their parent-institutions than the ones in firms.

These differences in modes and sources of financial support do not correspond with differences in the extent to which the research done is applied or basic research (Table VII). The differences in preference for experimental development and pure research correspond to the terms of reference of the different types of institution. Each type of institution, by

TABLE IV

Education and Salaries of Scientists and Engineers, by Type of Institution[a]

	Institutional Location			
	Universities	Research Institutes	Firms	Total
Education:				
Unit leaders[b] with doctoral degrees (%)	78	30	6	56
Non-leaders with doctoral degrees (%)	25	14	1	10
Leaders with studies abroad (%)	57	34	37	48
Non-leaders with studies abroad (%)	20	19	8	17
Salary:				
Those earning more than 25 times the minimum wage (%)[c]				
with doctoral degrees:	62	74	—	64
without:	12	24	6	12
Coefficients of correlation between salary and years of education:				
leaders	0.25	0.30	0.14	0.10
non-leaders	0.52	0.59	0.23	0.37
Those doing outside consulting (%):				
leaders	41	20	9	31
non-leaders	28	12	9	21

[a] "Scientists and engineers" refers to research workers with university education.
[b] "Leaders" refers to persons formally or informally in charge of research units.
[c] The Brazilian minimum wage at the time was about US$60.00 per month. Salaries of middle-class sectors and wage differentials decreased dramatically in the years after the survey as a result of high inflation, recessive policies and wage controls.

tradition or by the kind of task which it accepts, cultivates particular fields of science, and this in turn partly determines whether it will use experimental methods or some other method. Thus, firms work in technology and some branches of earth sciences, while universities deal mainly with basic aspects of biology and physics, among others. (It is important to notice, however that basic research makes up only 30 per cent of all university research.) Many university scientists are interested in doing applied research, and do not lag far behind the other types of institution in their interest in doing it.

Scientists in the universities, and more specially the leaders of research units, display a high degree of initiative which is not visible in other types of

TABLE V

Working Conditions in Research Units

	Institutional Location			
	Universities	Research Institutes	Firms	Total
Number of technicians per research worker	0.39	0.58	0.89	0.50
Growth in number of research workers per unit, last three years (%)	−1.9	0.9	22.4	1.3
Units with access to computerised information systems (%)	52	54	78	56
Units with access to computerised data-processing (%)	80	75	96	80

TABLE VI

Percentage of Resources for Research Units Originating from Different Sources[a]

	Institutional Location			
	Universities	Research Institutes	Firms	Total
		(Percentage)		
Resources from units' parent institution	42	52	65	50
Support from grant-awarding bodies in Brazil[b]	45	24	4	35
Research contracts	4	9	30	9
Other sources within Brazil	3	5	1	3
Foreign sources	5	1	9	3
Units wholly dependent on non-institutional sources for research and development	38	7	12	26

[a] Figures are averages of percentage estimated by each unit leader about his own unit; thus, they do not necessarily add up to 100 per cent when taken together. All resources were taken into account, including salaries.

[b] These bodies were the Conselho Nacional de Desenvolvimento Científico e Technológico, FINEP, Fundação de Amparo à Pesquisa de São Paulo (São Paulo foundation for research support), etc.

TABLE VII

Kinds of Research Preferred by Leaders of Research Units

	Institutional Location			
	Universities	Research Institutes	Firms	Total
	(Percentage)			
Mainly experimental development	9	20	31	15
Mainly applied research	44	54	50	48
Mainly pure research	30	7	3	21
All types of work	16	18	16	17
Total	100	100	100	100

institutions (Tables VIII, IX and X). They decide on the problems they will investigate, take the initiative in seeking the resources without which their units could not survive, and make the decisions about how to disseminate the results of their research. This contradicts the usual assumption that

TABLE VIII

Modes of Arriving at Decisions about Research

	Institutional Location			
	Universities	Research Institutes	Firms	Total
	(Percentage)			
Through influence of financing institutions	15	24	3	16
By institutions which control research unit	9	24	78	21
By members of research unit, according to practical or scientific considerations	70	48	16	58
Other influences	6	4	3	5
Total	100	100	100	100

universities in Brazil are so permeated by bureaucracy at the top, and apathy and indolence in the middle ranks, that there is no stimulation or chance for an individual to exert himself. In spite of their well-known deficiencies, the best Brazilian universities do apparently provide, for those of their academic staffs who seek them, the opportunities for initiative which are lacking in other types of Brazilian scientific institutions. Of course, these opportunities are made possible by the existence of grant-awarding bodies which are external to the universities; such bodies can give their support directly to scientists, thereby enabling them to avoid the bureaucracy of the university. Certain institutional arrangements also protect research units from most of the routine controls imposed by the universities. Among these are the

TABLE IX

External Influences and Secrecy in the Dissemination of Results
(Scale: 1 = minimum, 5 = maximum)

	Institutional Location			
	Universities	Research Institutes	Firms	Total
External determination	2.7	3.6	4.0	3.1
Individual responsibility of unit members for dissemination of results	3.9	3.5	3.2	3.7
Secrecy required about results of research	1.7	2.4	3.8	2.2

TABLE X

Initiative in the Procurement of Support for Research

	Institutional Location			
	Universities	Research Institutes	Firms	Total
		(Percentage)		
Leader of unit	52	33	16	42
Scientists, engineers and technicians in unit	33	13	3	24
Other members of institution in non-administrative positions	2	6	6	6
Administrative officers in institution	10	47	75	28
Others	3	1	—	2
Total	100	100	100	100

non-profit "foundations" controlled by a given public university or one of its departments or institutes. The "foundations" arrange contracts with external institutions to appoint additional scientists who are not on regular academic appointment and supplement the salaries of the scientists.

Finally, scientists often enjoy a high place in public esteem, which gives them a position of authority within the university structure, and increases their sense of independence and self-confidence.[13]

The freedom scientists enjoy within the university is not without problems. Scientists often come into conflict with the central administrative authorities of their universities about managing research money, the

[13] On this aspect of research in universities in the United States see Cameron, Kim K., "Domains of Organizational Effectiveness in Colleges and Universities", *Academy of Management Journal*, XXIV (1981) pp. 25–47; and Clark, Burton C., *The Higher Education System: Academic Organization in Cross-National Perspective* (Berkeley: University of California Press, 1983). See also Geiger, Roger L., "The Home of Scientists: A Perspective on University Research", in Wittrock, B. and Elzinga, A. (eds), *op. cit.*, pp. 53–72.

appointment of members of their research staffs and responsibility for teaching. The flexibility of the "foundations" is sometimes abused; it certainly is contrary to the principle of centralised control and accountability. Scientists may become entangled in conflicts with their colleagues about the teaching of undergraduates and about activities outside research; colleagues who do not do research enjoy much less independence and tend to regard scientists who do research as snobs who condescend to them. These strains are aggravated when research workers obtain salaries above the standard at their university, either through research fellowships or by payments received for participation in specific investigations. The higher incomes of the scientists who do research explain why they tend to avoid participation in the very active teachers' unions or other associations which Brazilian teachers join, and why they are relatively undifferent to the demands to which Brazilian university teachers give so much energy.[14]

Research workers in research institutes or in the laboratories of firms enjoy much less freedom than their academic counterparts. In research institutes, scientists are far more subject to guidance or even prescription from the institutions which supply their financial support. In firms, they are almost entirely controlled by the institutions where they work. They are subject to more stringent control over the dissemination of their results; secrecy is frequently enjoined on them. On the other hand their salaries are higher and they do not need to seek funds to maintain their research units.

The bodies providing financial support have little influence on the decisions of research units about the themes they will investigate. It is, of course, possible that the leaders of research units have exaggerated their independence when responding to our questionnaire. Grant-awarding bodies might well influence the direction of research by allocating resources for the study of some topics rather than others, through bargaining with research institutes, or simply by announcing programmes that affect a research unit's selection of the topics on which it will do its research. Scientists may adjust their projects to the grant-awarding bodies while thinking in all good conscience that the decisions on research themes remain with them. Yet grant-awarding bodies are not completely free either to influence the activities of scientists according to their own desire. For one thing, these bodies often allocate resources incrementally, i.e., they are constrained by what they have done in the past. Furthermore, they solicit advice from the scientists, and may make their decisions in the light of the advice they receive. While these bodies can establish very general criteria of importance of various fields of research, they will usually follow the advice of influential scientists when deciding whether to support particular projects. In short, while the power of grant-awarding bodies is probably

[14] For a discussion of tensions within Brazilian universities, see Schwartzman, Simon and Oliveira, João Batista de Araujo e, "Relações Centro–Periferia: O Caso da Autonomia Universitária", in *Estudos e Debates* (Brasília, Conselho de Reitores do Brasil), III (1980), pp. 86–94.

greater than it appears on our data, it is certainly lower than is usually assumed.

Almost half the scientists interviewed in our survey receive income for activities related to work outside their main institutions. We call this "external consultation". It includes a wide variety of things, from private medical practice to individual technical assistance to private firms or public corporations. The fact that scientists in universities do more external consultation than those in other institutions can be variously interpreted. However, one thing which is quite sure is that scientists are not isolated in their academic institutions but have links with the outside world. One of our most reliable findings is that science as a career can and does coexist with a wide variety of activities outside scientific research. In Brazil the greatest intensity of concentration is in the region of São Paulo, which is the most advanced part of the country; it is found also in Pernambuco and Bahia, which are at the other extreme in terms of development; about 40 per cent of the research workers in these states report doing some kind of consultation. We should interpret these findings in a differentiated manner. External consultation in well-established research institutions can mean healthy links between universities and society. In poorer regions, it can mean that their research institutions are too weak economically to be able to provide full-time employment and sufficient salaries for their members. In regions with intermediate levels of development, such as Minas Gerais, Brasilia and Rio Grande do Sul, an average of only 21 per cent of scientists engage in external work. Rio de Janeiro with 32 per cent, is closer to São Paulo and to Bahia.

Progress in a scientific career within the universities depends on the initiative of the individuals of a group in defining a research project, finding the financial resources to pay for it, and looking after its diffusion. In research institutes, and especially in large firms, there seems little opportunity for these kinds of initiative. In these non-academic situations, professional advancement is probably less related to intellectual achievement than to the capacity to deal with bureaucratic authority and its procedures and to produce benefits for the firm or the institute.

Effectiveness: The Roles of Institutions, Fields of Knowledge and Social Setting

By "effectiveness", I mean the attainment of objectives at reasonable costs. The objectives sought by scientific research are not confined to the advancement of knowledge. The Brazilian scientists whom we studied had a plurality of objectives simultaneously which they pursued with diverse emphases. The emphasis varied with respect to the institutional setting of the activity. Among academics, the chief obligation was to contribute to the stock of knowledge, and the best indicator of that was taken to be publication of the results of one's research in internationally recognised

journals. Scientists who worked in other kinds of institutions measured their achievements by the patents for which they were responsible and the experimental devices they had invented. Scientists employed in firms assessed their achievements by their authorship of internal reports describing original or routine work.

Tasks or "orientations" differ from one type of institutions to another; so do institutional traditions. Traditions and tasks are closely related but can also be independent of each other. A person who works on tasks which are ordinarily pursued in one type of institution, e.g. a firm, but who does so in another type of institution, e.g. a university, will tend to define his objectives in accordance with the traditions of the latter type of institution. Publication in the international literature is essentially an academic activity, carried on in university units; publication in local journals is typical of applied fields, agriculture and medicine; and the production of patents is also, obviously, a product of technological and physical sciences (Table XI).

TABLE XI

Productivity of Research Units over Three-year Period[a]

	Products		
	Papers in international scientific journals	Papers in Brazilian scientific journals	Patents
All research units	3.5	9.6	0.18
Research units in universities	4.9		
Universities in São Paulo	8.2		
Research units outside universities	1.6		
Medical and agricultural research units		15.8	
Medical and agricultural research units in São Paulo		19.9	
Research units in firms		2.2	
Technological and physical sciences			0.33
Technological and physical sciences in São Paulo			0.65

[a] Numbers represent the average number of items produced by the unit in the preceding three years.

Another factor influencing the effectiveness of a scientist is the geographical location of the institution in which he works. For example, to work in São Paulo has a positive influence on effectiveness, regardless of the type of institution.

A research unit in a firm may be extremely effective on behalf of its firm,

TABLE XII

Determinants of Individual Productivity[a]
(1,112 scientists)

	Papers in Brazilian scientific journals	Papers in international scientific journals	Internal routine reports	Patents	Experimental devices
Position as leader of unit	0.130+++	0.083+	0.125+++		
Full-time work in unit	−0.104++				
Work outside unit				0.074+	
Has doctorate	0.163+++	0.297+++	−0.063+		
Holds appointment in university	−0.067+	0.054+	−0.176+++	−0.154++	0.062+
Employed in firm	−0.148+++		0.121++		0.059+
Field of specialisation					0.235+++
Physical and earth sciences	0.061+		−0.074+		0.109+
Medical sciences	0.137+++			0.068+	
Agricultural sciences	0.172+++				
Has studied abroad		0.123+++		0.065+	0.059+
Current work related with training	0.086++	0.084++			−0.112++

[a] Entries are partial correlation coefficients. Data on products transformed by y = log (1 + X). Only significant coefficients listed:
+++ significant at 0.001 level;
++ significant at 0.01 level;
+ significant at 0.1 level.

and very secretive about its achievements in research. At the same time, one might suspect that research units which generate only internal reports, where academic qualifications are low, and which are not evaluated according to cost–benefit considerations, may become bureaucratised and ineffective.

Individual Effectiveness

There is a very close association between the publication of papers in internationally recognised journals and the possession of advanced academic degrees (Table XII). However, this kind of intellectual effectiveness is not influenced by the type of institution in which a scientist works—whether or not he is a leader of research—or by his field of specialisation. Papers published in Brazilian journals and in Portuguese follow quite a different pattern. They too are the works of persons holding the doctorate, but less frequently so than in the case of papers in journals of international repute. Papers in Brazilian journals are more often written by the leaders of research units than by their academic colleagues. If a scientist works in a research institute in the fields of agriculture or medical sciences, and unless he concentrates all his energy and interest on full-time research in his units, he is also more likely to be a contributor to Brazilian and Portuguese language journals. Papers in these journals are probably less academic in nature, and the journals that publish them are less specifically scientific or technical than are international journals. The authorship of routine internal reports is more commonly the work of the leader of a research unit, of a woman[15] who is employed in a firm and not in a university, who does not have a doctorate, and who does not work in basic science.

The production of technical devices has a pattern of its own. Patents, which are extremely rare in the units surveyed, are obtained by individuals who work outside the universities; they are produced by individuals who have studied abroad and have diversified activities. The impression is that the few patents acquired are very unusual events that depend on the work of a few imaginative individuals. Experimental devices, however, show a clearer pattern and their invention seems more dependent on institutional settings. Mostly, they depend on whether one works in the fields of technology or the physical sciences; in Brazil, these fields are occupied by males. They also require a shift from a previous specialisation, presumably more traditional, to a new one. Given these conditions, this type of product seems to follow naturally.

[15] "Everywhere female scientists are more often doing the routine aspects of the research process and are more isolated from external contacts than men. Women scientists are also more authority-oriented and have lower scientific productivity than male scientists. These can be interpreted as a consequence of their lower status." Stolte-Heiskanen, Veronica, "The Role and Status of Women Scientific Workers in Research Groups", in *Research in the Interweave of Social Roles: Jobs and Families*, Vol. III, p. 59.

Coming Full Circle

The emphasis in Brazil in the last few years placed on research institutes and research in firms, and the implicit criticisms of and handicaps imposed on research in universities, have been probably misplaced. These policies are in need of reappraisal. The situation is not unique to Brazil; it is typical of many other countries.

First, the organisation of research in universities, with all its known limitations and difficulties, seems to provide more room for intellectual initiative, capacities for leadership and hard work and readiness to accept risks. Research outside the universities does not seem to offer the same intellectual possibilities, and is therefore more likely to fall into the ruts of routine and bureaucratisation.

Research in universities is best at linking individual academic achievements with rewards. Its most valued outcomes, the production of a scientific paper and its publication in a journal of high standard and reputation, are the ones more directly related to personal achievements. Progress in one's career, salary and prestige depend on them to a large extent. In other words, there is more chance of arousing individual initiative in research done in universities; and initiative is more likely to be focused on there than in other institutional settings. These other settings are much more likely to arouse the skills of money-making, gaining patronage, pressing for the advancement of the interests of one's group, and of finding one's way in a bureaucratic labyrinth. The universities of Brazil, despite their deficiencies, offer conditions more conducive to "quality control" in scientific and technological research than any alternative arrangements for the conduct of research.

Furthermore, it is simply not true that scientists in universities are concerned only with academic or basic research and are insensitive to the potential social and economic applications of the results of their work. Most of them, in fact, work in applied fields. The image of the pure scientist, living in an "ivory tower" and utterly indifferent to everything except his own research, is quite unrealistic.

The universities of Brazil, with all their shortcomings, are the best depositary of scientific competence and traditions, which cannot easily be transposed or created under non-academic institutional conditions.

Research in universities is certainly not free of difficulties. It has difficulties within the higher educational system. The necessary intellectual and personal qualities are scarce and very unevenly distributed in the universities of Brazil. Scientific careers are hazardous.[16] Links between the universities and the outside world are difficult and complicated. Scarce resources are dispersed and there is much less "quality control" of research than is necessary to meet the high standards of the international scientific

[16] Oliveira, João Batista de Araujo e, *Ilhas de Competência: Carreiras Científicas no Brasil* (São Paulo: Editora Brasiliense, 1984).

community. With all these limitations, however, a case can be made that building up, consolidating and improving academic research, is a better policy for Brazil than trying to plan science or maintain research in specialised research institutions, or in state-owned firms which are much less congenial to intellectual initiative and imagination or to intellectual discipline. Standards of assessment—though far from perfect—are more stringent and effective in universities than in other research institutions in Brazil.

Of course, not all research should be concentrated in universities. It is also obvious that not all universities or higher educational institutions in Brazil should place the same emphasis on research.[17] However, both non-academic research institutions and teaching institutions which do no research need close links with universities if they are to avoid intellectual stagnation. The maintenance of research in universities under a fairly autonomous system, guided by academic traditions, engaged in education, and connected with the sphere of the practical application of research, should be given a central position in national science policy. This does not mean that all difficulties in the development of scientific and technological research and their beneficial application will be removed. It means only that, if there is to be any chance of overcoming these difficulties, a proper understanding of the nature and relevance of research in universities is indispensable. It is not just a matter of giving academic scientific research a central position in any national programme in order to improve the quality of scientific work and to foster its application to practical problems. It is no less necessary to look to the improvement of the conditions and quality of research in the universities themselves. Then, given the proper conditions, university scientists are likely to be the first to press for more relevance and involvement with activities outside the walls of the universities.

[17] On the variety of educational institutions in Latin America, see Levy, Daniel C., *Higher Education and the State in Latin America: Private Challenges to Public Dominance* (Chicago and London: The University of Chicago Press, 1986).