Graduate Education in Brazil

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Introduction

The development of scientific and technological infrastructure and the formation and expansion of the academic community in Brazil has been focused on three different strategies over three periods (Marcuschi 1996).

1. During the 1950s and 1960s, research activities began to be formally organized and received great incentives from the Federal Government. In this period, the most important scientific and technological funding institutions were established in the country, among them the National Council for Scientific and Technological Development (CNPq, linked to the Ministry of Science and Technology) and the Coordination for the Improvement of Higher Education Personnel (CAPES, linked to the Ministry of Education). In other words, during these 2 decades, Brazil invested in building up an infrastructure for science and technology.

2. In the 1970s and 1980s, public policies focused on the expansion of graduate programs. During this period, CNPq and CAPES gave significant financial support to master's and Ph.D. programs and offered fellowships for graduate students. The focus was on the training of human resources for science and technology.

3. At the beginning of the 1990s, Brazil recognized the importance of addressing the scientific education of undergraduate students in order to improve their later performance in graduate schools. In this context, CNPq moved to reinforce the Initiation in Science (IC)[1] Fellowship Program, which consists of stimulating the involvement of university students in research being carried out by faculty members.

In this report, we analyze national policies for science and technology and their effects on graduate programs in Brazil. The discussion examines the accomplishments and failures of the federal government as it has attempted to train capable human resources for science and technology. It points out some of the difficulties Brazil still faces regarding the return on investments in personnel for scientific and technological activities. In addition, we discuss the sources and scope of investments in research and development (R&D), which present a great challenge for the country.

Brazilian Graduate Programs: Origin and Main Features

In the period between 1950 and 1980, Brazil experienced great changes, shifting from an agrarian to an industrial economy. A large part of the population migrated from small towns to urban centers, generating serious local and regional imbalances.

Since 1951, CAPES and CNPq have assumed the responsibility for training both scientists and technologists for R&D activities and academic personnel to teach in institutions of higher education. The importance of both agencies in the support of graduate studies was discussed in a recent report by Guimarães and Humann (1995). According to the authors, in 1992-93, these two agencies granted 96.6 percent of all national fellowships;[2] the remaining 3.4 percent was granted by the state agency of São Paulo (FAPESP).

During the 1960s, the industrial complex expanded under the protection of policies that favored domestic, multinational, and state-owned companies resident in Brazil, insulating them from foreign competition (Schwartzman 1995). The policy of protecting internal industry was accompanied by an important public commitment to the development of an infrastructure for scientific and technological activities. Brazil, at this point ruled by a military government, invested in science and technology and created the Second National Development Plan, which protected nascent industries, invested significantly in research, and established the National Program for Graduate Studies (PNPG). According to Guimarães and Humann (1995), "the PNPG was designed as a route for accelerating the training of human resources suitable to supply the urgent need for qualified personnel capable of improving the quality

[1] "IC" from the Portuguese Iniciação Científica.

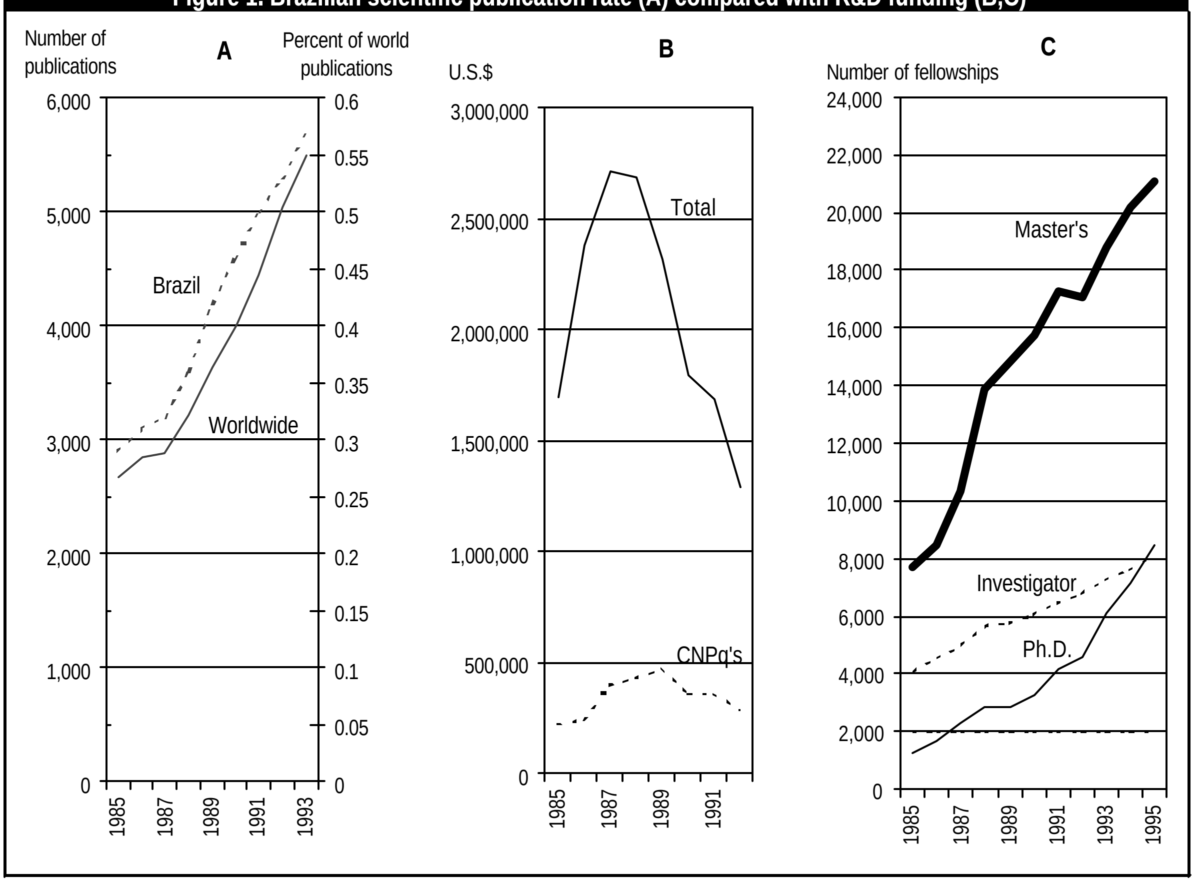
[2] This includes fellowships for specialization and master's, Ph.D., and postdoctoral programs abroad and within Brazil.

of teaching and strengthening the research activity at universities and other institutions." As a result, graduate programs were launched in public universities, and a dynamic fellowship program was established by CNPq and CAPES. Unlike in other countries, to be enrolled in a Brazilian graduate program, students must hold a degree from any of the 922 institutions of higher education established in the country. These students may require first a 2.5-year fellowship to attain a master's degree; after graduating, a 4.5-year fellowship may be required by the student to attain the Ph.D. degree. These are the maximum durations of the fellowships granted by CAPES and CNPq for graduate students.

Having received strong support from the military governments during the 1970s and 1980s, R&D faced a significant drop in federal funds in the early 1990s (figure 1B). Government policy concern is now directed toward developing and strengthening the links between academic research (at universities and research institutions) and private companies.[3]

In spite of problems with funding and the lack of investments from the productive sector, Brazil has succeeded in setting up a significant infrastructure for scientific and technological development. Today, the country has the largest R&D system in Latin America, with 4,402

Figure 1. Brazilian scientific publication rate (A) compared with R&D funding (B,C)



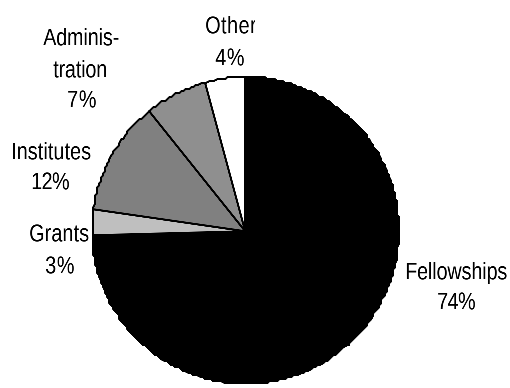
KEY: (A) Annual rate of Brazilian scientific publications from 1985 to1993, either worldwide or by Brazilian share of world's publications.
(B) Total Brazilian resources allocated to R&D and National Council for Scientific and Technological Development (CNPq)'s.
(C) Fellowships granted annually by CNPq and Coordination for the Improvement of Higher Education Personnel (CAPES) for master's students Ph.D. students, and investigators.

SOURCES: Institute for Scientific Information (1993); (CNPq), Relatório Estatístico 1993 Brasilia, 1994; *CNPq O CNPq e a ormação de recursos humanos de C&T para o Brasil, estatísticas de bolsas no pais e no exterior, 1980-95.* Brasília:MCT/CNPq, 1995, and Leta, J., D. lLannes, and L. de Meis. A formação de recursos humanos e a produção científica no Brasil. In M. Palatnik, et al., *A Pos-Graduação no Brasil.* ISBN 85-900550-2-7. Rio de Janeiro, 1998.

[3]Jose I. Vargas, in a speech given during the meeting with state ministers on the announcement of a new economic plan coordinated by Fernando Henrique Cardoso, minister of Finance, June 14, 1993; cited in Schwartzman (1995).

research groups and about 15,000 active scientists and researchers (Schwartzman 1995). The number of publications appearing annually in international journals has increased steadily (figure 1A). In the last few years, the bulk of CNPq's expenditures, which represent approximately 10 percent of total federal investments (compare table 5 with appendix table 1), has been allocated to fellowship programs rather than to grants in aid (which pay for infrastructure and equipment) (figure 2 and appendix table 1). Leta, Lannes, and de Meis (1998b) point out a correlation between support for training human resources (figure 1C) and the annual increase in the number of Brazilian publications (figure 1A). They conclude that investment in the education of qualified personnel is a key variable in determining level of scientific production.

Figure 2. Budget distribution (percent) for the Brazilian agency CNPq, 1992



NOTE: For details, see appendix table 1.

SOURCE: National Council for Scientific and Technological Development (CNPq), Brazil, 1993.

Reforms in Graduate Education

Current reforms in Brazilian education are mostly focused on the elementary and secondary levels. With respect to higher education, some important reforms are (1) the creation of shorter courses in which a student attains a degree in only 2 years, (2) annual evaluation of all institutions of higher education, and (3) a more accurate evaluation of graduate programs every 2 years.

The present system of graduate programs in Brazil dates back to the 1960s when the PNPG was established. Although Brazil has been able to expand its scientific and technological activities, the sector still faces significant problems. One of the difficulties concerns the efficiency of graduate programs, which have been evaluated by CAPES every 2 years. The evaluation process takes into account a series of indicators, among them the curriculum vitae of each faculty member and the average time students enrolled in the program take to graduate. Until 1997, CAPES rated graduate programs in five categories from A to E, with A being the best. In the 1998 evaluation, this scale changed from 1 to 7—the higher the number, the better the program. With this new evaluation, programs rated 2 or below are not allowed to register new enrollments until they achieve a better performance. Among the almost 1,800 programs established in the country, only 23 achieved a rating of 7; of these, 21 were in public universities, 1 was in a federal research institution, and the remaining 1 was in a private university. A national average time required for students to graduate is not available, either using the old or the new qualification scales.

We here present data on the best-rated graduate programs, according to the 1994-95 national evaluation, at the Federal University of Rio de Janeiro (UFRJ), the largest Brazilian federal university in the country. Tables 1A and 1B show how long it took students graduating in 1995, 1996, and 1997 to conclude their master's or Ph.D. coursework. In 1995, none of the "A"-rated master's courses had reached an average of 30 months (2.5 years); in contrast, in 1996 and 1997, the number of master's programs that attained this average increased to 4 and 6, respectively (table 1A).

The performance of the Ph.D. programs was similar. In 1995, only two of the best-rated Ph.D. programs had an average of 54 months for completion (i.e., students in these concluded their studies in 54 months or less—4.5 years). In 1996 and 1997, a larger number of Ph.D. programs achieved this average (table 1B). (For more details about UFRJ's A-rated graduate programs, see appendix tables 2 and 3.) In spite of the improvement in time students spend in UFRJ's A-rated graduate programs, one additional point has to be considered: these courses represent only 33 percent and 23 percent of the total number of master's and Ph.D. programs, respectively.[4]

To improve student performance in graduate programs, during the 1990s, CNPq greatly expanded its IC Fellowship Program. This program allocates to each investigator a number of scholarships to be awarded to un-

[4]At present, UFRJ offers 86 master's programs and 67 Ph.D. programs.

Table 1. Months to obtain a degree in the "A"-rated graduate programs at the Federal University of Rio de Janeiro

A. Master's programs

Months (average)	Number of programs 1995	1996	1997
up to 30	0	4	6
31 to 40	8	13	12
41 to 50	17	8	10
more than 50	4	4	1

SOURCE: Sub-Reitoria de Ensino para Graduados e Pesquisa (SR-2), Universidade Federal do Rio de Janeiro, Rio de Janeiro.

B. Ph.D. programs

Months (average)	Number of programs 1995	1996	1997
up to 54	2	5	7
55 to 65	6	8	5
66 to 75	4	2	3
more than 75	4	0	1

SOURCE: Ministry of Education, Coordination for the Improvement of Higher Education Personnel (CAPES) indicators for 1995, 1996, and 1996 for "A"-rated master's programs, which were the best qualified programs in the 1994-1995 evaluation.

dergraduate students who are engaged in research projects for 20 hours a week. The main goals of the IC program are to:

- attract a greater number of talented students to academic careers,
- prepare students for graduate work in order to decrease the time they will spend in master's and Ph.D. programs,
- reduce the average age of Ph.D. candidates, and
- improve the quality of future researchers.

The number of IC fellowships increased greatly after 1992, rising from 7,548 in 1990 to 11,440 in 1992 and 18,789 in 1995 (CNPq 1995). This significant expansion in the number of IC fellowships made this program one of the most important initiatives undertaken by the Brazilian government in an attempt to improve the training of scientists. During the last 2 years, CNPq has granted more fellowships to Ph.D. students than to master's. As a result, CAPES is now the main federal agency to grant master's programs.

Trends in Graduate Education

Enrollment and Degrees

Research and technological development in Brazil is carried out at 136 universities (of which 72 are public and 64 private) (INEP 1997); federal research institutions;[5] research institutes linked to state-owned companies; research institutes linked to state governments; and a few private enterprises (mainly in the fields of paper and pulp, computers, automobile suppliers, and steel).

In spite of this apparently diverse group of research establishments, most research in Brazil is concentrated in the public universities. Out of the total 922 institutions of higher education, only 10 public universities (0.01 percent) were responsible for 52.5 percent of all Brazilian publications indexed in the Institute for Scientific Information database during the 1981-93 period (Leta and de Meis 1996). Further evidence of the predominant role of the public universities is the distribution of graduate programs. In 1996, 91.3 percent of graduate programs were offered by public universities; the great majority of graduate students were later hired by these institutions. The growth in the number of graduate courses from 1987 to 1996 is shown in table 2. In this period, the number of master's and Ph.D. programs in the country increased by 37 percent and 63 percent, respectively. As a result of this increase, the total enrollment and the number of graduate degrees awarded annually have also grown (figures 3A and 3B), as has the number of scholarships allocated by CNPq and CAPES within the country (figure 1C).

Although the number of students enrolled in and graduated from master's programs is higher than for the Ph.D., there is a trend toward a decrease. This is suggested by the decreasing ratio of enrollment in master's versus Ph.D. programs (inset, figure 3A). The same is true for degrees awarded (inset, figure 3B). It is important to note that Ph.D. enrollment increased over the 10-year period by 176 percent (from 7,960 to 22,004), while Ph.D. degrees rose by 240 percent (from 872 to 2,972);

[5]Institutions linked to the Ministry of Science and Technology are: the National Institute for Space Research, the National Institute for Research on the Amazon, and the National Institute of Technology; those linked to CNPq: the Brazilian Center for Physics Research, the Center for Mineral Technology, the Institute of Applied and Pure Mathematics, the National Observatory, the National Laboratory of Synchrotron Light; those linked to the Ministry of Agriculture: the Brazilian Corporation for Agricultural Research; and those linked to the Ministry of Health: the Oswaldo Cruz Foundation.

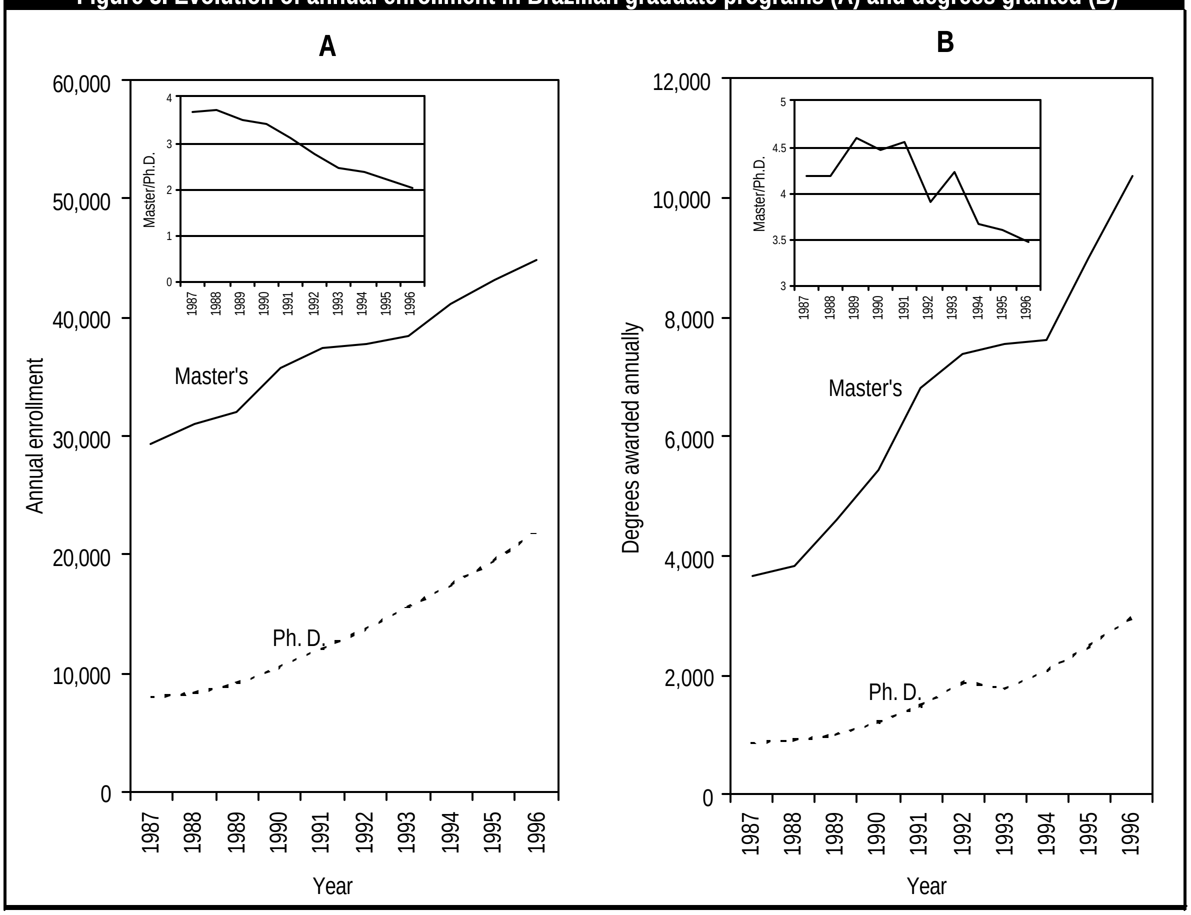
Table 2. Growth in the number of graduate programs in Brazil		
Year	Master's	Ph.D.
1987	861	385
1988	899	402
1989	936	430
1990	964	450
1991	982	468
1992	1,018	502
1993	1,039	524
1994	1,139	594
1995	1,159	616
1996	1,181	627

SOURCE: Ministry of Education, Coordination for the Improvement of Higher Education Personnel (CAPES), July 1998.

this indicates an improvement in national capacity for training new Ph.D.s. This tendency is seen across various fields, as shown in appendix tables 5 and 7.

Despite efforts on the part of the Brazilian government to develop a diversified R&D system, the percentage of the population that receives a graduate degree is still very low compared to some other developed countries. In 1996, Brazil's population was 157,070,163 (IBGE 1996)—larger than that of either Germany or the United Kingdom. However, the total numbers of Ph.D. degrees awarded in these latter countries were, respectively, 7.5 and 2.7 times higher than the number awarded in Brazil. Compared with the United States, the difference is even higher: 7.8 times (figure 4A). If we compare the ratio of

Figure 3. Evolution of annual enrollment in Brazilian graduate programs (A) and degrees granted (B)



KEY: (A) Number of students enrolled annually in Master's and Ph.D. courses from 1987-99. Insert: ratio between Master's and Ph.D. enrollments.
(B) Number of degrees conferred annually to master's and Ph.D. students in the same period. Insert: ratio between master's and Ph.D. degrees.

SOURCE: Ministry of Education, Coordination for the Improvement of Higher Education Personnel (CAPES), July 1998.

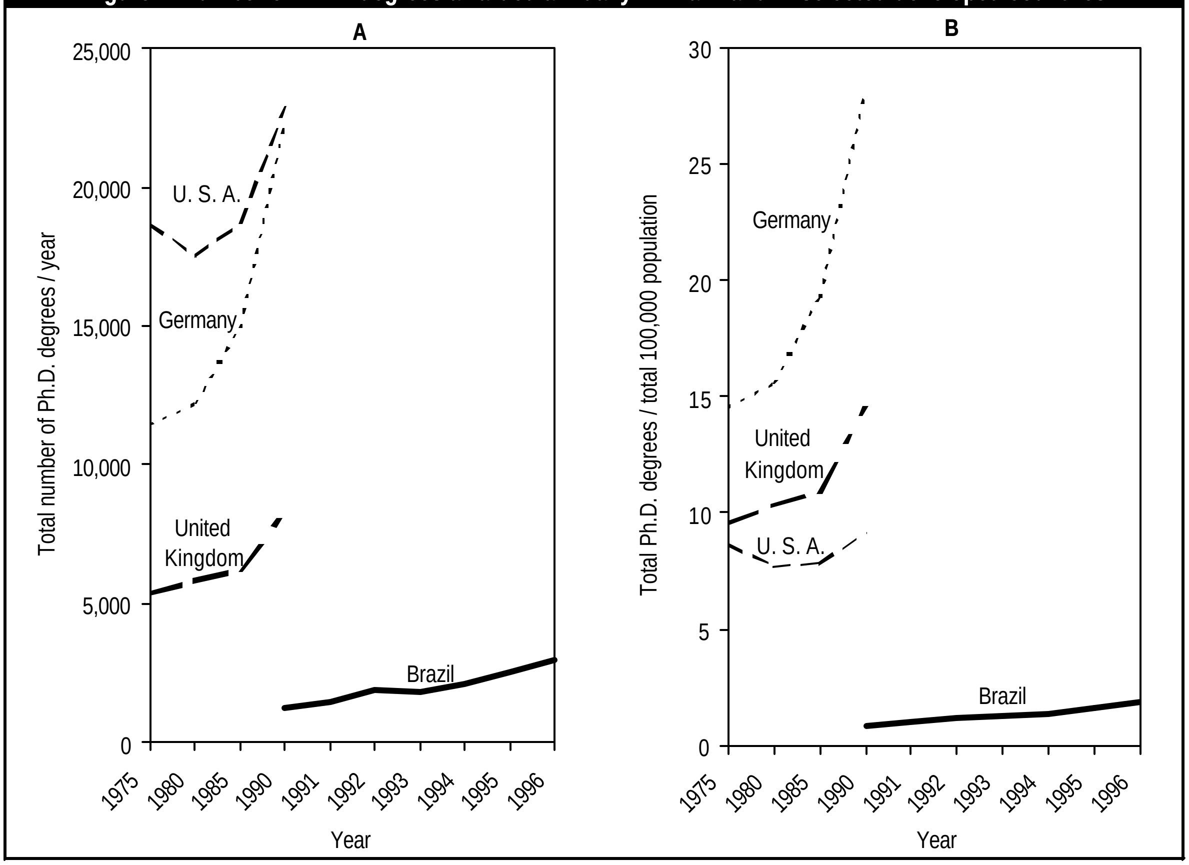
Ph.D.s awarded annually to the total population, Germany stands out among the other countries, with almost 30 Ph.D. degrees per 100,000 inhabitants in 1992 (figure 4B). Although this ratio is increasing in Brazil, it is still far below the ideal for a competitive R&D system. It is worth mentioning that, unlike in most developed countries, 41.4 percent of the Brazilian population consists of young people aged 5 to 24 (IBGE 1996). This fact reveals a great challenge for the country's modern education: a small scientific community is responsible for promoting science education to a very large young population (de Meis and Leta 1997). This challenge is a common feature among most developing countries. An effective science education would provide youngsters with the sophisticated scientific and technological skills required to enter the workforce today.

The Overseas Fellowship Graduate Program

Throughout the last decades, CNPq and CAPES have allocated scholarships for students to pursue their studies outside the country as well as within it. Table 3 shows the growth in both types of fellowships awarded by these agencies in 1990-95. It is worth noting that, while the number of fellowships for study within Brazil increased over that time, the number of fellowships for study abroad remained constant.

The master's and Ph.D. students awarded scholarships to study within Brazil receive monthly stipends of about US$600 and US$900, respectively. Students enrolled in public institutions are not charged tuition or labo-

Figure 4. Number of Ph.D. degrees awarded annually in Brazil and in selected developed countries



KEY: (A) Total Ph.D. degrees per year in Brazil, Germay, United Kingdom and United States.
(B) Ratio of number of Ph. D. degrees and total 100,000 population for each country.

SOURCES: For Brazilian data: Ministry of Education, Coordination for the Improvement of Higher Education Personnel (CAPES), July 1998, and IBGE, *Anuário Estatístico do Brasil.* Rio de Janeiro: Fundação Instituto Braileiro de Geografia e Estatística, 1996; for foreign data: National Science Foundation, Division of Science Resources Studies (NSF). *Human Resources for Science & Technology: The Asian Region.* NFS 93-303. Arlington, VA, 1993, and *Human Resources for Science & Technology: The European Region.* NSF 96-316. Arlington, VA, 1996.

Table 3. Scholarships for study at home and abroad awarded by CNPq and CAPES						
Agency and destination	1990	1991	1992	1993	1994	1995
CNPq total	28,696	33,041	37,834	40,955	44,420	52,041
Home	26,542	30,586	34,991	38,218	42,002	49,909
Abroad	2,154	2,455	2,843	2,737	2,418	2,132
CAPES total	14,518	15,611	15,377	21,511	23,124	25,523
Home	12,319	13,557	13,406	19,309	20,922	23,578
Abroad	2,199	2,054	1,971	2,202	2,202	1,945
Total	43,214	48,652	53,211	62,466	67,544	77,564
Home	38,861	44,143	48,397	57,527	62,924	73,487
Abroad	4,353	4,509	4,814	4,939	4,620	4,077

NOTE: Home scholarships include science technician, specialization, master's, Ph.D., postdoctorate, investigator, technician, and industrial science technician. Scholarships abroad include specialization, master's, Ph.D., postdoctorate, "sandwich," and sabbatical leave.

SOURCES: National Council for Scientific and Technological Development. (CNPq), *Indicadores Nacionais de Ciência e Tecnologica 1990-1995.* Brasília: MCT/CNPq, 1995 and Ministry of Education, Coordination for the Improvement of Higher Education Personnel (CAPES), July 1998.

ratory fees. However, in recent years (1993-97), CNPq and CAPES allocated an additional sum—equivalent to a third of the value of each student's stipend—to the graduate program. These resources are called "bench fees." Considering both stipends and bench fees, the total expenditure for a Ph.D. student enrolled in a graduate program within the country in that period amounted to approximately US$58,000 for a 4-year course.

A Brazilian graduate student who pursues a degree in a foreign institution receives a monthly stipend of US$1,100 and has his or her tuition and other fees paid by one of the two Brazilian agencies (an average of US$10,000 per year). The scholarship can be renewed for a maximum of 4 years. Therefore, at the end of the course, the total cost of educating these students amounts to approximately US$93,000. In addition to the higher costs of studying abroad, the Brazilian government is concerned about the risk of a "brain drain." As noted before, Brazil is still struggling to increase the number of investigators within the country; hence the importance of having the young Ph.D.s return to Brazil after they graduate. Moreover, de Meis and Longo (1990) observed that Ph.D. students studying abroad or within Brazil present similar profiles in terms of number of publications and citations during their thesis work and in their professional life after degree award. This suggests that training in Brazil is not very different from that received abroad.

To minimize the emigration of talent and, at the same time, offer Brazilian graduate students the opportunity to work in important research centers abroad, CAPES and CNPq have developed a special program called the "sandwich" Ph.D. Graduate students engaged in this program begin their training in a Brazilian institution and then spend 1 to 2 years doing research abroad. After this period, they return to the Brazilian university in which they are enrolled to conclude their work. The degree is conferred by the Brazilian institution. In this program, the chances of losing the student to a foreign research center are diminished. From 1992-95, enrollment in CNPq's sandwich program doubled, rising from 158 to 305 (table 4). In spite of this new program, however, almost 70 percent of CNPq

Table 4. Number of scholarships granted for study abroad in different programs: CNPq, 1988-95								
Graduate students	1988	1989	1990	1991	1992	1993	1994	1995
Total	1,611	1,979	2,154	2,455	2,843	2,737	2,418	2,132
Master's	172	234	225	192	148	69	17	5
Full Ph.D	956	1,243	1,508	1,821	1,977	1,912	1,726	1,475
Sandwich	-	-	-	-	158	255	302	305
Postdoctorate	330	335	285	306	346	301	248	293
Specialization	153	167	136	136	196	172	91	33
Sabbatical leave	-	-	-	-	18	28	34	21

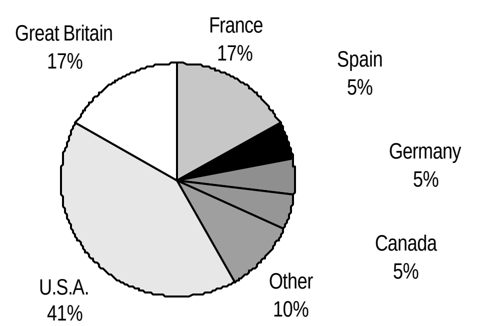
KEY: (-) = not applicable

SOURCE: National Council for Scientific and Technological Development. (CNPq), Indicadores Nacionais de Ciência e Tecnologica 1990-1995. Brasília: MCT/CNPq, 1995.

scholarships abroad are still allocated to Brazilian Ph.D. students enrolled for a full 4-year program in a foreign university.

The majority of students abroad are pursuing their degrees in American institutions (figure 5). This share is almost the same as that observed by Meneghini (1996) for international collaboration in Brazilian scientific publications. In this study, the author reports that the United States, France, the United Kingdom, Germany, and Canada were the countries that tended to collaborate with Brazil on international publications, with shares of 37.9 percent, 13.3 percent, 10.9 percent, 8.9 percent, and 6.6 percent, respectively. The data suggest that the choice of students for the foreign institution reflects the collaboration established by the Brazilian research group in which the students are engaged.

Figure 5. Countries in which Brazilian recipients of scholarships from the National Council for Scientific and Technological Development (CNPq) studied abroad in 1995 (percentage)



NOTE: "Other" includes 23 countries.

SOURCES: National Council for Scientific and Technological Development. (CNPq), Indicadores Nacionais de Ciência e Tecnologica 1990-1995. Brasília: MCT/CNPq, 1995.

There are no official data available regarding foreign graduate students enrolled in Brazilian programs. Most probably, however, the majority of these students come from other Latin American countries.

The Role of Government, Industry, and Academic Institutions in Supporting Science and Technology and in Employing Graduates

Despite the fiscal incentives established to encourage the private sector to invest in R&D during the 1960s, most of the resources for this activity come from the public sector (state and federal governments). There is, however, some evidence that industry's contribution to total R&D costs may be increasing. In 1959, only two Brazilian companies invested in R&D. By 1988, this number had risen to 81 (de Meis et al. 1991). According to Schwartzman (1995), only 6 percent of the investment in science and technology came from private sources during the period 1981-89. More recently, however, data compiled by the Ministry of Science and Technology indicate that Brazilian firms increased their participation to 22 percent of the total amount allocated to this activity (table 5).

From 1990 until 1996, the number of Ph.D. degrees conferred annually in Brazil grew from 1,222 to 2,972 (appendix table 4). Subsequently, there has been an increasing demand for academic positions in research institutions for these recent graduates. In this context, CNPq and CAPES created and have been supporting a Program for Recent Graduates. In 1995, the program awarded 561 recent Ph.D.s a 3-year assistantship to work on a research project under the aegis of some established group in a high-quality research center. These 3 years are meant to help the postdoctoral fellows maintain their academic research activity, keeping them in an academic environment while at the same time allowing them time to look for a permanent position.

As noted before, the bulk of Brazilian scientific activity takes place in public universities. As a result, they are the primary source of jobs for new graduates. In a preliminary study, it was found that, out of a group of 519

Table 5. Annual investments in science and technology by source (percent)						
Source	1990	1991	1992	1993	1994	1995
Total (US$ million)	3,081.5	3,034.4	2,442.5	4,703.0	4,995.0	5,957.0
Federal government [a]	83.9	79	74.8	54.9	51.8	47.1
State government [b]	16.1	21	25.2	18.4	15.2	21.8
Public enterprises [c]	NA	NA	NA	8.3	9.1	9.3
Private enterprises [c]	NA	NA	NA	18.2	23.9	21.8

[a] 1995 value includes an estimate of US$350,000 for wages of investigators who are faculty members at federal university. The current data collection procedure apparently fails to capture most of these payments. Preceding years do not include this estimate.

[b] The number of states included from 1990 to 1994 was 23, 21, 20, 23, and 27, respectively. Value for 1995 was estimated by the Ministry of Science and Technology.

[c] Estimate based on preliminary results from the first 500 firms responding to ANPEI's latest survey.

KEY: NA = not available

NOTES: Values were updated based on the gross domestic product implicit price deflator and translated to dollars using the average exchange rate for 1995 provided by the Brazilian Central Bank (US$1,00 = R$0,918). Totals for 1990-92 totals show only federal and state government expenditures.

SOURCES: Public sector data: Ministério da Ciência e Tecnologia/Coordenação de Estatísticas e Indicadores de C&T, Brasília, 1996; private sector data: Associação Nacional de Pesquisas e Desenvolvimento das Empresas Industriais (ANPEI), 1996.

alumni in the life sciences (Ph.D. students graduated from UFRJ whose employment could be identified), 64.4 percent have an academic position at UFRJ and another 16 percent are teaching at other public universities (table 6). In contrast, only four alumni from this group are employed in private universities and only one in industry.

Table 6. Employment of Ph.D.s graduated in the life sciences: an example from the UFRJ		
Position	Number	Percent
Total	519	100.0
Faculty at UFRJ	334	64.4
Faculty at other public universities	83	16.0
Faculty public universty retired or deceaser	36	6.9
Postdoctorate or Program for Recent Graduate	29	5.6
Investigator at a public research institute	27	5.2
Other[a]	10	1.9

[a] Includes five highschool teachers, four private university professors, and one industrial researcher.

SOURCE: Sub-Reitoria de Ensino para Graduados e Pesquisa (SR-2), Universidade Federal do Rio de Janeiro, Rio de Janeiro, March 1998

The contrast in distribution between public and private schools is also observed among professors employed at institutions of higher education. In 1996, a total of 148,320 faculty members were almost equally distributed among public and private institutions (table 7). However, teachers employed at public institutions are better qualified than those at private universities: the percentage of faculty members holding a master's or Ph.D. degree is two times higher at public institutions. The discrepancy is still greater if we take into account only faculty with a Ph.D. degree: they comprise 24.8 percent of the total at public institutions, as opposed to 7.4 percent at private institutions. From these data, it appears likely that a majority of new Ph.D.s begin their careers in public universities.

Table 7. Faculty members in Brazilian institutions of higher education by their credentials, 1996				
	Public		Private	
Credentials	Number	Percent	Number	Percent
Total	74,666		73,654	
Undergraduate degree	14,905	20.0	18,465	25.1
Specialization	19,261	25.8	34,729	47.2
Master	21,974	29.4	14,980	20.3
Ph.D.	18,526	24.8	5,480	7.4

NOTE: Data include faculty members of the 136 universities (public plus private) and 786 colleges and upperlevel technical schools (139 public and 647 private).

SOURCE: INEP, Censo Educacional: Evolução das Estatísticas do Ensino Superior no Brasil 1980/1996. Brasília: MEC/INEP/SEEC, 1997.

The growth in the number of graduate degrees among university faculty is also an indicator of employment trends for new graduates. From 1990 to 1996, this number rose by 33.2 percent for master's degrees and 41.7 percent for Ph.D.s (table 8). This increment is in accordance with a strong governmental policy of stimulating university faculty to obtain a Ph.D. degree. Faculty academic credentials are a major component in the current evaluation of Brazilian universities and graduate courses.

Credentials	1990 Number	1990 Percent	1996 Number	1996 Percent	Percentage change 1990-96
Total	131,641	100	148,320	100	
Undergraduate degree	45,352	34.5	33,370	22.5	-26.4
Specialization	41,597	31.6	53,990	36.4	29.8
Master's	27,753	21.1	36,954	24.9	33.2
Ph.D.	16,939	12.9	24,006	16.2	41.7

Table 8. Shifts in faculty credentials in Brazilian universities, 1990-96

SOURCE: INEP, Censo Educacional: Evolução das Estatísticas do Ensino Superior no Brasil 1980/1996. Brasília: MEC/INEP/SEEC, 1997.

CONCLUSION

During the last 3 decades, the Brazilian scientific and technological system has experienced significant changes. In the 1960s, the National Program for Graduate Studies was established, representing an important step toward structuring a national academic community. In the 1970s and 1980s, graduate programs were established throughout the country. A significant increase in the quality and quantity of human resources engaged in scientific and technological activities has facilitated the consolidation of a national infrastructure for research. However, there are still many challenges to be faced. These include:

- improving the efficiency of graduate programs (decreasing the time taken to train a Ph.D.),
- increasing the proportion of the population with graduate degrees,
- increasing the participation of private universities in R&D activities,
- decreasing the risk of brain drain, and
- expanding the job market for scientific and technological activities.

Policies that respond adequately to these challenges will depend on the engagement not only of the federal government, but also of the state and municipal governments as well as the private sector. Improvements in quality and expansion of graduate programs will require an increase in the number of academic positions offered by research centers throughout the country. The performance of graduate students may be improved if more undergraduates are given the opportunity of working under the IC Fellowship Program. By working on research projects at an early stage of their education, more talented students will be attracted to pursue careers in science and will also enroll in graduate programs with skills already acquired, allowing them to conclude their studies more rapidly. Another important issue to be considered is the role of master's programs. Today, students are required to complete a master's degree in order to enroll in most of the Brazilian Ph.D. programs. This requirement extends the amount of time and money spent on their education.

Recent advances in science and technology, together with a trend toward a globalized market, have reinforced the relationship between knowledge and economic gains. Knowledge and creativity are highly valued by different sectors, and science is increasingly significant to industrial production. As a result, scientists in developed and developing countries are positioned as central actors in the struggle for economic growth (Schwartzman 1995, Perez 1983, and Fransman and King 1984). In this context, widespread public debate has reinforced the importance of training scientists for the challenges presented by the new "information age." Brazil has engaged in this debate, focusing on the implementation of effective policies for educating scientists capable of responding to the dynamic challenge of the global market.

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APPENDIX

Appendix table 1. CNPq: allocation of resources, 1980-92 (US$000)

Year	Fellowships	Grants [a]	Institutes	Administration	Other [b]	Total
1980....................	42,252.3	23,166.3	26,233.9	40,598.9	4,243.2	136,494.6
1981....................	46,567.7	21,815.5	29,557.7	41,837.5	2,420.1	142,198.5
1982....................	72,396.3	37,793.5	34,489.4	35,032.4	2,265.8	181,977.4
1983....................	68,137.6	28,106.6	26,949.6	28,769.8	3,194.6	155,158.2
1984....................	61,400.8	21,521.1	23,092.8	37,682.4	5,034.5	148,731.6
1985....................	88,153.1	41,517.0	33,141.5	33,631.7	5,212.8	201,656.1
1986....................	94,630.1	50,996.2	35,497.9	27,931.3	7,552.3	216,607.8
1987....................	184,069.4	48,886.4	57,739.4	63,729.7	4,416.3	358,841.2
1988....................	238,004.4	46,552.1	49,322.2	47,281.9	4,415.3	385,575.9
1989....................	236,143.1	33,570.1	85,569.2	48,693.0	22,732.4	426,707.8
1990....................	178,339.5	41,672.8	50,529.1	36,513.3	14,684.5	321,739.2
1991....................	232,440.4	19,884.0	30,838.3	26,361.2	14,907.9	324,431.8
1992....................	193,820.4	7,635.8	30,655.5	17,362.2	10,603.2	260,077.1

[a] Includes special projects.

[b] Includes debt service payments; fringe benefits to employees (for food, child care and, transportation); and salaries of personnel temporarily allocated to other government agencies.

NOTE: Figures were adjusted for inflation according to the General Price Index of Fundação Getúlio Vargas, and converted to dollars according to the mean exchange rate for 1992.

SOURCE: Schwartzman, S. 1995. Science and Technology in Brazil: A New Policy for a Global World. IN S. Schwartzman er al., *Science and Technology in Brazil: A New Policy for a Global World.* Rio de Janeiro: Fundação Getúlio Vargas.

Appendix table 2. Months to obtain a degree in UFRJ "A"-rated master's programs

Program	1995	1996	1997
Administration	48	46	49
Biological chemistry	32	30	28
Biomedical engineering	40	39	38
Biophysics	42	41	35
Chemical engineering	40	33	31
Civil engineering	37	40	32
Computer science	40	36	41
Dentistry - Orthodontics	33	32	30
Dermatology	37	45	44
Electrical engineering	42	30	29
Engineering (Production management)	46	42	33
Geography	46	43	43
History	59	51	42
Information studies	47	35	40
Linguistic	50	54	50
Literature	47	43	49
Mathematics	45	37	30
Mechanical engineering	44	35	35
Metallurgy and material engineering	45	36	35
Microbiology	41	37	35
Nuclear engineering	45	33	33
Nursing	32	25	21
Organic chemistry	45	39	39
Parasitology and infectious diseases	65	29	54
Philosophy	44	51	43
Physics	53	35	34
Regional and urban planning	49	58	50
Social anthropology	43	45	28
Social welfare	54	49	41

NOTE: Ministry of Education, Coordination for the Improvement of Higher Education Personnel (CAPES) indicators for 1995, 1996, and 1996 for "A"-rated master's programs, which were the best qualified programs in the 1994-1995 evaluation.

SOURCE: Sub-Reitoria de Ensino para Graduados e Pesquisa (SR-2), Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Appendix table 3. Months to obtain a degree in UFRJ "A"-rated Ph.D. programs

Program	1995	1996	1997
Biological chemistry	43	44	43
Biophysics	71	61	63
Chemical engineering	80	66	58
Civil engineering	78	57	67
Dermatology	63	49	54
Electrical engineering	63	64	90
Linguistic	66	58	53
Literature	70	59	73
Metallurgy and material engineering	72	73	64
Microbiology	55	37	66
Nuclear engineering	118	58	58
Nursing	38	37	33
Orthodontics	83	-	40
Parasitology and infectious diseases	65	62	43
Philosophy	65	52	45
Social anthropology	64	65	43

KEY: (-) = not applicable

NOTE: Ministry of Education, Coordination for the Improvement of Higher Education Personnel (CAPES) indicators for 1995, 1996, and 1997 for "A"-rated master's programs, which were the best qualified programs in the 1994-1995 evaluation.

SOURCE: Sub-Reitoria de Ensino para Graduados e Pesquisa (SR-2), Universidade Federal do Rio de Janeiro, Rio de Janeiro.

Appendix table 4. Annual enrollment in master's programs in Brazil by field

Field	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total	29,273	30,990	31,992	35,727	37,428	37,813	38,414	41,084	43,121	44,925
Natural sciences	3,432	3,577	3,634	3,956	4,175	3,847	4,015	4,223	4,487	4,492
Biological sciences	2,078	2,255	2,103	2,426	2,516	2,772	2,780	3,153	3,286	3,445
Engineering	3,921	5,005	5,109	5,657	5,998	6,618	6,278	6,779	7,197	7,335
Health sciences	3,684	3,913	3,715	4,501	4,797	4,963	5,195	5,417	6,155	6,248
Agricultural sciences	2,475	2,893	3,107	3,302	3,437	3,532	3,685	4,102	3,936	4,099
Applied social sciences	5,720	4,778	5,562	6,054	6,044	5,895	6,086	6,255	6,451	7,033
Humanities	6,070	6,704	6,597	7,497	7,651	7,557	7,651	7,974	8,146	8,500
Language & linguistic	1,616	1,708	1,823	1,921	2,103	2,022	2,150	2,467	2,607	2,655
Arts	270	141	318	358	657	449	403	485	464	459
Multidisciplinary	7	16	24	55	50	158	171	229	392	659

NOTE: Natural sciences include mathematics, statistics and probability, computer sciences, astronomy, physics, chemistry, earth sciences, and oceanography; biological sciences include genetics, botany, zoology, ecology, morphology, physiology, biochemistry, biophysics, pharmacology, immunology, microbiology, and parasitology; engineering include all fields of engineering; health sciences include medicine, dentistry, pharmacy, nursing, nutrition, public health, phonoaudiology, physiotherapy, and physical education; agricultural sciences include agronomy, forestry, agricultural engineering, zootechnology, veterinary medicine, fisheries, and food science and technology; applied social sciences include law, economy, architecture and urban studies, urban and regional management, demography, information science, museum, communications, social services, home economics, industrial design, and tourism; humanities include philosophy, sociology, anthropology, archeology, history, geography, psychology, education, political science, and theology; and language & linguistics include linguistics, language, and arts.

SOURCE: Ministry of Education, Coordination for the Improvement of Higher Education Personnel (CAPES), July 1998.

Appendix table 5. Annual enrollment in Ph.D. programs in Brazil by field

Field	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total	7,960	8,345	9,148	10,496	12,095	13,764	15,556	17,464	19,492	22,004
Natural sciences	1,452	1,309	1,562	1,804	2,053	2,249	2,632	2,828	3,162	3,290
Biological sciences	1,094	1,215	1,108	1,346	1,504	1,755	1,891	2,161	2,371	2,721
Engineering	1,074	1,159	1,242	1,435	1,758	2,400	2,512	2,739	3,278	3,550
Health sciences	1,236	1,370	1,287	1,689	1,846	2,097	2,455	2,977	3,042	3,338
Agricultural sciences	577	545	730	858	820	1,211	1,307	1,730	1,829	2,012
Applied social sciences	984	797	1,048	1,170	1,285	1,174	1,330	1,285	1,519	1,857
Humanities	955	1,356	1,404	1,468	1,915	2,038	2,445	2,672	3,136	3,819
Language & linguistic	516	594	659	648	727	796	957	928	964	1,175
Arts	72	0	108	78	187	44	15	46	20	59
Multidisciplinary	0	0	0	0	0	0	12	98	171	183

NOTE: Fields are defined as in appendix table 4.

SOURCE: Ministry of Education, Coordination for the Improvement of Higher Education Personnel (CAPES), July 1998.

Appendix table 6. Master's degrees awarded annually in Brazil, by field

Field	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total	3,653	3,845	4,597	5,452	6,799	7,380	7,554	7,627	8,982	10,356
Natural sciences	655	557	669	829	1,022	950	972	1,007	1,122	1,233
Biological sciences	346	372	432	440	607	644	673	678	808	947
Engineering	527	554	739	934	1,205	1,153	1,231	1,209	1,383	1,541
Health sciences	491	562	547	696	803	991	1,013	1,081	1,233	1,417
Agricultural sciences	492	526	674	707	937	882	953	922	1,154	1,300
Applied social sciences	427	389	494	586	698	890	874	823	934	1,090
Humanities	547	679	799	957	1,180	1,448	1,353	1,469	1,792	2,048
Language and linguistic	146	196	200	250	304	341	387	338	440	582
Arts	22	10	43	51	40	65	75	70	89	106
Multidisciplinary	0	0	0	2	3	16	23	30	27	92

NOTE: Fields are defined as in appendix table 4.
SOURCE: Ministry of Education, Coordination for the Improvement of Higher Education Personnel (CAPES), July 1998.

Appendix table 7. Ph.D. degrees awarded annually in Brazil, by field

Field	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total	1,005	990	1,139	1,410	1,750	1,759	1,875	2,081	2,497	2,972
Natural sciences	151	149	179	209	307	303	322	328	420	455
Biological sciences	168	180	183	193	262	322	252	271	365	407
Engineering	111	81	116	138	205	171	244	254	304	417
Health sciences	166	239	220	335	385	324	352	380	489	612
Agricultural sciences	81	102	113	131	127	145	169	197	244	311
Applied social sciences	71	55	92	111	152	129	145	188	192	185
Humanities	124	118	154	186	233	266	279	262	341	435
Language and linguistic	55	66	69	74	74	84	95	138	128	143
Arts	5	0	13	11	5	15	16	7	9	4
Multidisciplinary	0	0	0	0	0	0	1	2	5	3

NOTE: Fields are defined as in appendix table 4.
SOURCE: Ministry of Education, Coordination for the Improvement of Higher Education Personnel (CAPES), July 1998.