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Postgraduate Degrees and Researcher Training in Argentina

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Recent Transformations of Argentina's Higher Education System

The expansion of higher education systems that began after World War II is a phenomenon shared by practically every country, regardless of its unique modes and traditions. There are other features in common besides expansion: among others, the separation into various levels (including the rapid growth of higher nonuniversity education), the fostering of research, and the development of postgraduate education. Osvaldo Barsky (1997) states that three of the factors that contributed to this process were the following: (1) a certain causal relationship between higher education becoming *massified and segmented*; (2) the scientific and technological explosion, and the subsequent broadening of the *knowledge-based economy*; and (3) the political determination of national states to contribute to the expansion of higher education systems, emphasizing advanced studies.

Barsky cites another series of factors that specifically have a bearing on the development of postgraduate studies. These factors allow us to depict the differences in the models and specific characteristics that postgraduate training acquires in each country, regardless of the general trend. Some of these factors are exogenous and others endogenous as regards university institutions; Barsky specifies them as the following:

- the *centralized or decentralized nature* of the higher education system;
- the *size* of university institutions;
- the *unity of teaching and research* as derived from the Humboldtian conception of higher education;
- the *organizational logic* of research activities in the realm of the university; and
- the *concern for reducing costs* (as a result of the massification of higher education), added to research and development (R&D) policies that tend to concentrate research and the training of a critical mass of scientists working in certain key subjects.

Besides the above-listed factors, one should also take into account the scientific and academic tradition of a country, and, as a general context, its degree of economic development and industrialization.

Analysis of the development processes of postgraduate training using the criteria outlined above helps explain the different directions they have taken in countries that—to an untrained eye—have similar structural characteristics, such as Brazil and Argentina. Although both countries share many features and at present belong to a common market (the MERCOSUR), their degree of industrialization is different, as are the historical processes through which both societies acquired the features that may be termed "modernization"; among these the diversification of the social structure and the level of education of the population. In the 1960s, when Brazil reformed and expanded its system of higher education and postgraduate training, the prevailing feature was that of an accelerated and successful industrialization process, which exerted pressure on the social structure of incipient modernization.

Argentina carried out a reform of higher education during the first years of this century; its society was "modern"—in line with the most advanced in Europe—although its economy was based on revenues from farming and agriculture. Some of these reform features lingered until the 1960s, and the Argentine scientific system achieved a certain splendor. This infrastructure enabled some researchers to be awarded the Nobel Prize in the sciences. In those years, however, the delay in industrialization was beginning to be felt, and the economic crisis that was to come later was starting to take shape.[1] This had an influence on the higher education expansion process, which

[1] Development of a thesis on the asymmetries between modernization and industrialization can be found in Suárez (1972).

was basically geared toward traditional professional training rather than to the training of the high-level human resources industry demanded. In that context, postgraduate training in Argentina remained significantly backward vis-à-vis that in other countries, such as Brazil.

It is worth pointing out that the expression "new trends in higher education" is, to a large extent, a euphemism for "the spread of the U.S. model of higher education." In fact, many features of the new model are customary in that country: the segmented structure, the role of research, the training of scientists and engineers, and the fact that higher education is not free, combined with the availability of a variety of private sources for donations and fellowships. Also—unlike in other countries—private universities are a major feature of the system.

This model is in keeping with the basic U.S. political philosophy, in which education and science are not responsibilities delegated to the federal government; this implies that the government does not act directly upon the fields of education and science. During World War II and after, American society carried out very complex debates aimed at establishing the extent to which the federal government should play a role in fostering fields of science and technology. The spread on a worldwide scale of the U.S. model has to do with its success in the context of the American economy, and with the importance that the United States itself has ascribed to this issue, which has been expressed in periodical reports alerting Americans to the strategic value of knowledge ranging from the historical *Science, the Endless Frontier* (Bush 1945) to the most recent *Unlocking Our Future* (U.S. House of Representatives 1998).

The relevance of the process of reform in higher education, and the training that scientists and engineers are undergoing in almost every country in the world, is also in keeping with Daniel Bell's theory of the post-industrial society, according to which knowledge is the central characteristic of the transformations of a social structure (Bell 1974). Therefore, institutions concerned with knowledge (particularly universities) become all-important institutions in society, and, at the same time, they themselves go through great transformations. Bell warned, however, that his statements applied to a handful of countries and could not be applied to developing countries.

The development of competitive conditions and their ideological unfolding accelerated the process of reform in higher education during the 1980s and forced changes in countries that had originally resisted adopting this model. It is natural, however, that the model's spread turned out to be wider and swifter in countries that put active policies of industrial development into practice, such as Brazil; and that it should be faced with greater difficulties in countries with more traditional social structures, such as Argentina.

Higher Education in Argentina

The Argentine Tradition

Postgraduate studies have a short tradition in Argentina, as a result of the university model that was strongly established in the country since the beginning of this century and which has remained without structural changes for decades in a context of economic crisis and scarce industrialization. It was only in this last decade that a great expansion in postgraduate training has been taking place and that certain symptoms of reform and updating of the higher education system as a whole can be perceived.

The Argentine university system is very old and dates back to the early colonial period. The first university founded in present-day Argentine territory was what is today the Universidad Nacional de Córdoba, created in 1610. The Universidad de Buenos Aires was established in 1821 after Argentina became independent from Spain. In the last years of the last century, as of Sarmiento's presidency, successive governments put into practice policies supporting education and science as part of a project to build a modern state that would break away from the colonial tradition and unify the country after decades of civil war. During his term, President Sarmiento invited, in 1870, the American astronomer Benjamin Gould and a group of collaborators to live in Argentina; they created the Córdoba Astronomic Observatory. President Sarmiento's speech at the inauguration of the astronomic center is regarded as one of the founding documents of science policy in Argentina.

Development of the contemporary Argentine university system has been influenced by two strong traditions: the Napoleonic model, whereby the state takes on the responsibility of higher education and the regulation of professions with a rigid, compartmentalized bureaucratic structure; and the model of the German scientific university created by Wilhelm von Humboldt, which gives precedence to research. In 1891, the Universidad Nacional de La Plata was created; it was expressly informed by the Humboldtian model. In fact, it was not a mere adoption of the model, but rather involved cooperation with German scientists. This university was very active in some domains and paved the way for the first development of a modern school of physics in our country.

With varying force, both influences converged to underscore the responsibility of the state in matters of higher education. This became a lasting feature in the Argentine educational model, which has a strong public preeminence. In 1918, the University Reform movement established the autonomy of universities and the concept of “shared government”—i.e., participation of students and graduates in the government of the university. That tradition is ensconced in the present Law of Higher Education (Law #24.521, Ley de Educación Superior—LES), which legalizes autonomy and shared government as basic principles of the university system.

In spite of the fact that the Humboldtian tradition lies at the very foundation of the Argentine university model, the weight of the “professionalist” trend became dominant. It should be emphasized that in this area, the Argentine university was successful. It trained professionals at an internationally renowned level and responded to a growing demand for higher education. Nevertheless, the hegemony of the professionalist trend meant that teaching became a part-time dedication and a supplement to professional work outside the university, among other consequences.

Since the beginning of the century, one of the main conditions the Argentine scientists have laid claim to has been that of having full-time employment status for some university posts, with a salary that allowed them to devote themselves entirely to teaching and research. The resolution of this conflict was rather peculiar. Not many full-time posts were created, but in 1958, the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) was established. The CONICET was conceived of as a structure with paid staff, organized hierarchically and serving as “career researchers.” Originally, this “career” was supposed to be supplementary to teaching at the universities; the CONICET was intended as the means by which university researchers would be given full-time posts.

In the 1960s, the University of Buenos Aires, which is the biggest and most important institution in the Argentine university system, was able to organize several high-level research teams in almost all scientific fields, mainly in the biological and health sciences. The University of La Plata was also able to build a strong synergy with the CONICET and thus reinforced its Humboldtian roots. Other public universities achieved similar good results in the consolidation of their research capacities.

That golden age turned into a crisis in 1966 when military forces interrupted the democratic process. Police forces invaded university campuses, striking teachers, scientists, and students alike. As a result, several of the most renowned scientists and engineers left the country and went into political exile. A very long process of scientific migration for political reasons thus began; this process would be repeated time and again over subsequent years. Argentina’s resulting “brain drain” was far more serious than that of other Latin American countries.

From this point on—and especially during the dictatorial government inaugurated in 1976—the CONICET became detached from the university system. It created its own institutes, and the “career” gradually became an endogenous instrument of the scientific community, rather than a stimulus to university research. Thus the training of researchers became, for more than 30 years, a question that strictly pertained to the CONICET, alienated from the universities. Only in recent years has this trend begun to be reversed, with universities again having high-level researchers. The relationship between the CONICET and the universities has improved, and most CONICET researchers work at university centers. However, the structural malformation remains. Even today, only one-eighth of university teachers have full-time employment status. Low university budgets, resulting in low university salaries, make it difficult to reverse this process—and make full-time employment in academic work unattractive.

During the last 10 years, the Argentine university system has undergone a new process of reform; this is taking place in a rather disorderly fashion, and mainly under the auspices of the federal government, which tends to deprive it of legitimacy in the academic world. Resorting to several legal instruments (the LES and decrees issued according to regulations), specific university programs, and new funding mechanisms in the Argentine university system (FOMEC, for example, which is dealt with below), the government—via the Ministry of Culture and Education—intends to regulate and organize a transition toward a model that is closer to international contemporary tendencies.

The Argentine curricular model has continental European roots and is drawn more from the old French and German models than from Anglo-Saxon tradition. Undergraduate courses are long: theoretically, they take 5, 6, or even 7 years to be completed, depending on the university degree (the real duration of the entire course of study is often even longer). Given such length, curricular content is often equivalent to a 4-year university course plus a master's degree in the Anglo-Saxon model. This explains why development of postgraduate training is very recent; such development is related to the need for an internationally homologous structure rather than to demand for new forms of knowledge.

Until very recently, Ph.D. degrees were restricted to the physical and natural sciences, and only those who wished to take up a scientific career applied for a Ph.D. In the health sciences field, postgraduate studies took on the form of specialization courses. In all other fields, especially those related to professions, postgraduate studies were quite uncommon.

The System of Higher Education

Higher education in Argentina consists of a university system and a nonuniversity system (colleges for teacher training, or for humanities, social work, technical, professional, or artistic training). The university system includes the universities and university institutes; these are different from nonuniversity institutes because they are dedicated to a single field. Both types of institutions can be either public or private; in the latter case, however, certification by a public institution is required.

Within the higher education system, it is the exclusive prerogative of university institutions to grant undergraduate degrees (*licenciado* and other professional equivalents) as well as postgraduate master's or Ph.D. degrees. In keeping with the LES, an undergraduate degree is required in order to be admitted to postgraduate training.

As of May 1998, there were 88 university institutions: 36 national public universities, 22 private universities with permanent authorization, 20 private universities with provisional authorization, and 6 private university institutes. As shown in table 1, although most public universities had already been created at the beginning of this decade, there has been a strong growth in private universities and university institutes; this is a result of the government's 1989 higher education policy to encourage development of the private higher education system.

In 1996, the Argentine university system had 953,801 students. Eighty-five percent studied at public universities, and the rest attended private ones. The number of students in public universities increased by 3.6 percent in the 1993-96 period. The rate of annual growth of private university students is the highest, amounting to 6.5 percent in the 1985-94 period. Over the last decade, the private sector has grown enormously, especially in terms of number of institutions. The student population is still only 15 percent of the total, however. Private universities have a very low impact on the training of scientists and engineers, and are mostly devoted to training for professional careers in the social sciences.

The Postgraduate System Today

General Features

Academic postgraduate training is beginning to emerge in Argentina. However, it is highly regulated by laws, government decrees, and university resolutions. According to this series of regulations, there are three

Table 1. Growth of universities in Argentina, 1990-97

Institutions	1990	1991	1992	1993	1994	1995	1996	1997
Total	60	66	67	69	76	82	87	89
National universities	29	29	31	31	33	36	36	36
Private universities with permanent authorization	21	22	22	22	22	22	22	22
Private universities with provisional authorization	5	9	10	12	17	18	18	20
National university institutes	3	4	-	-	-	-	5[a]	5[a]
Private university institutes with permanent authorization	2	2	2	2	2	2	2	2
Private university institutes with provisional authorization	-	-	2	2	2	4	4	4

[a] The National University Institute of Art, created by Decree # 140 (Dec. 3, 1996) is not open at present.

KEY: (-) = not applicable

SOURCE: National Commission for University Evaluation and Certification (CONEAU).

types of postgraduate courses: specializations, master's, and doctorates. Each of these has its own profile and degree; institutional conditions for teaching the postgraduate courses; syllabus characteristics (including number of hours); academic body requirements; and prerequisites concerning equipment, library, document centers, and other related matters.

The LES put into force in 1995 requires that postgraduate degrees be certified. This task has been delegated to an organization created by the LES, the National Commission for University Evaluation and Certification (CONEAU). The LES states that the processes for certifying postgraduate courses must be carried out according to the Ministry of Culture and Education in consultation with the University Council.

In order to certify postgraduate courses, the CONEAU must make a public summons, via the university institutions themselves, and then report to the National Inter-University Council, which comprises the presidents of public universities, and the Council of Private University Presidents. The CONEAU certifies specializations, master's, and doctorates upon the recommendations of expert peer committees.

During the last months of 1997, the CONEAU made the first summons to certify specializations in the health sciences, which mainly comprise postgraduate courses and projects in the fields of medicine and dentistry. Two hundred and ninety-two recommendations have been presented and submitted for approval. In 1998, the rest of the university specialization courses were summoned (251 presentations were received) along with master's and doctorates (which are still open, although it is estimated that there will be 600 to 700 applications).

In law, medicine, dentistry, architecture, engineering, and—to a lesser degree—pharmacy and biochemistry, there are specializations; in agronomy as well as in economics and the administrative sciences, there are master's degrees. In the exact sciences, natural sciences, and humanities—and partly in pharmacy and biochemistry—there are doctorates.

As far as funding is concerned, only 18.8 percent of postgraduate activities receive funding from sources outside the university. This setup is not so different in private universities: few institutes receive funds from large corporations. In general, the financing of postgraduate courses comes from the student's registration fee.

Expansion of Postgraduate Courses: Means of Regulation

The supply of postgraduate degrees in Argentina increased to 1,071 in 1996. This is equivalent to a 35 percent growth in only 2 years. The main growth was in the postgraduate courses offered by public institutions, which amounted to 40 percent. By type of postgraduate course, the segment of greatest growth was the master's degree at almost 70 percent.

If we consider the last 15 years, the total supply of postgraduate courses grew by 234 percent. Besides the quantitative increase, the structure of the supply changed, since specialization and master's courses have multiplied, and the rate of expansion was much greater than that for doctorates. In 1982, there were 205 doctorate courses, master's courses hardly existed, and specialization courses amounted to 97. The present state of affairs is represented in table 2.

Table 2. Supply of postgraduate courses, 1994 and 1996

Level	1994			1996		
	Total	Public sector	Private sector	Total	Public sector	Private sector
Total	792	518	274	1,071	725	346
Specialization	303	216	87	420	290	130
Master's	245	151	94	415	290	125
Doctorate	244	151	93	236	145	91

SOURCE: Barshy, Osvaldo, *Los posgrados universitarios en la República Argentina* (University Postgraduate Courses in Argentina). Buenos Aires: Troquel, 1997 and National Commission for University Evaluation and Certification (CONEAU).

In comparing the years under consideration (1994 and 1996), the postgraduate system expanded by 38.6 percent in terms of specialization courses and by just under 70 percent for master's; the supply of doctorate courses, on the other hand, fell by 3.27 percent. Table 3 shows the breakdown by field in specialization courses; note the strong prevalence of the health sciences and, to a lesser extent, the law as courses of study.

Out of 681 doctorate and master's courses offered in 1998, only 26 percent (176) were certified by the CONEAU. Of those certified, 93 percent were offered by public institutions, 57 percent are master's courses, and the rest are doctorate courses. It is worth noting that of 145 doctorate courses offered by public institutions, 50 percent have been certified. In the private sector, this proportion amounts to only 3 percent (see table 4).

Table 3. Specialization courses by field, 1998		
Field	Number of courses	Percent
Total	434	100.0
Health sciences	249	57.4
Law sciences	46	10.6
Administration	37	8.5
Pharmacy and biochemistry	20	4.6
Engineering	14	3.2
Social sciences	14	3.2
Education sciences	13	3.0
Dentistry	11	2.5
Psychology	10	2.3
Architecture	8	1.8
Farming and agriculture	6	1.4
Basic sciences	3	0.7
Humanities	3	0.7
Total	434	100.0
Public institutions	377	86.9
Private institutions	57	13.1

SOURCE: National Commission for University Evaluation and Certification (CONEAU).

Of the certified postgraduate courses, 41 percent are in the basic sciences; 36 percent are in the technological sciences; and 23 percent are in the social, human, and health sciences (table 5). In both the basic and technological sciences, the largest proportion of certified postgraduate courses are categorized as "A," which means they are at the highest level; in the social, human, and health sciences, the largest proportions are rated as "B" and "C," which means their level is intermediate or incipient.

Table 4. Certified postgraduate courses - 1998			
Level	Total	Public institutions	Private institutions
Total	176	164	12
Master's	100	91	9
Doctorate	76	73	3

SOURCE: National Commission for University Evaluation and Certification (CONEAU).

Of the total number of postgraduate courses supplied, about a quarter are in the health sciences, another quarter is in the applied sciences and engineering, and a third quarter is accounted for by the social sciences. The rest of the supply is in the basic sciences and humanities, each of which accounts for about the same proportion (table 6). In the applied, social, and human sciences, there is a predominant supply of master's courses; in the basic sciences, doctorates; and in the health sciences, specialization courses of study.

Table 5. Certified postgraduate courses in the public system by field, 1998				
Field	Total	A	B	C
Total	164	63	64	37
Basic sciences	67	30	24	13
Technological sciences	59	28	23	8
Social, human, and health sciences	38	5	17	16

KEY: A= Postgraduate course categorized as highest level.
B= Postgraduate course categorized as intermediate level.
C= Postgraduate course categorized as incipient level.

SOURCE: National Commission for University Evaluation and Certification (CONEAU).

Registration and Graduation

Barsky has estimated the number of students registering for postgraduate courses to be 20,180 in 1994, of which 57 percent were master's and doctorate students and 43 percent were students attending specialization courses (table 7). The recent expansion in the supply of courses seems to have had a direct effect on demand, since the available figures now show a more than 50 percent increase. Note, however, that these data are from different sources, and that the 1994 data presented by Barsky come from the certification of postgraduate programs, while the 1997 data are from a census taken by the Ministry of Culture and Education. This would suggest that 1994 data are underestimated and that growth has been slower than that shown in table 7.

Table 6. A breakdown of the postgraduate course supply by field (percent)				
Field	Total	Specialization	Master's	Doctorate
Total	100	100	100	100
Basic sciences	13.1	1.9	13.3	29.8
Applied sciences and engineering	25	15.6	31.1	30.4
Health sciences	26.3	52.7	11	8.8
Social sciences	24.3	24.8	30.6	14
Human sciences	11.3	5	14.1	17

SOURCE: National Commission for University Evaluation and Certification (CONEAU).

During the 1950s and 1960s, Argentina turned out more than 5,000 Ph.D.s per decade; in the 1970s and 1980s, this figure dropped to 3,000. In the current decade, changes in field breakdown have made it difficult to ascertain changes in the number of Ph.D.s by area of study. However, as table 8 shows, the total remains practically constant.

Table 7. Postgraduate student registration

	1987	1994	1997
Total	-	20,180	31,914
Specialization	-	8,750	13,165
Master's and doctorates	9,006	11,430	18,749

KEY: (-) = not applicable

SOURCES: 1987 and 1994 data are from Barshy, Osvaldo, *Los posgrados universitarios en la República Argentina* (University Postgraduate Courses in Argentina). Buenos Aires: Troquel, 1997 and 1997 data are from the Ministry of Culture and Education.

The Universidad de Buenos Aires is the institution responsible for awarding the largest proportion of postgraduate degrees—41.2 percent.

By field of study, of the 1,129 Ph.D.s. trained in the 1989-93 period in the basic and technological sciences, 72 percent received their degrees in the exact and natural sciences, 4 percent in engineering, and 0.2 percent in farming and agricultural sciences (table 9).

By fine field within the basic and technological sciences, most (53 percent) Ph.D.s received their degrees in interdisciplinary areas, 14 percent in pharmacy, and less than 10 percent in chemistry and biology. There were between 4 and 5 graduates per year (2 to 4 percent) in geology, physics, civil engineering, math and computing, astronomy, and chemical engineering. There were also some Ph.D.s in the areas of electrical engineering, geophysics, agronomy, and veterinarian medicine; there were no Ph.D.s in architecture, communication engineering, industrial engineering, and mechanical and mining engineering during this period (table 10).

Fellowships for Postgraduate Studies and Researcher Training

The organization that has usually granted fellowships for training researchers and for postgraduate studies at home and abroad is the CONICET. When new programs, such as the Fund for the Improvement of University Quality (Fondo para el Mejoramiento de la Calidad Universitaria—FOMEC), were put into effect, CONICET participation decreased; it has, however, managed to keep up a high percentage of fellowships, especially for all postgraduate studies carried out in the country. Recently, the Ministry of Culture and Education created a program for postgraduate training (PROFOR), which also grants fellowships for postgraduate studies abroad and administers programs together with the Fulbright Foundation and the Ministry of Education/Coordination for the Improvement of Higher Education Personnel from Brazil. Other organizations have their own postgraduate training policy in their area of competence, such as the National Institute for Public Administration, the National Institute of Farming and Agricultural Technology, and the Universidad de Buenos Aires itself, among others.

The CONICET

The CONICET was created February 5, 1958, with the aim of orienting, fostering, and subsidizing scientific and technological research, as well as supporting activities in both the public and private sectors. It also aims to foster scientific cooperation and exchange at home and abroad.

Table 8. Graduates from doctorate courses

Field	1950-54	1955-59	1960-64	1965-69	1970-74	1975-79	1980-84	1985-88[a]	1989-93[b]	1996[c]
Total	2,578	2,603	2,462	2,745	1,983	1,391	1,534	1,146	1,402	347
Basic sciences and technology	764	583	542	504	750	650	684	676	1,129	228
Social sciences	471	449	279	508	341	181	145	79	111	61
Human sciences	44	26	32	33	66	46	77	41	101	27
Medical sciences	1,299	1,545	1,609	1,700	826	514	628	350	61	31

[a] Note that this is a 4-year period, rather than 5 as elsewhere.

[b] In this period, changes were made in the disciplinary breakdown.

[c] These are the last available data

SOURCES: Data for 1950-93 are from Barsky, Osvaldo, *Los posgrados universitarios en la República Argentina* (University Postgraduate Courses in Argentina). Buenos Aires: Troquel, 1997; 1996 data are from the Ministry of Culture and Education.

Table 9. Graduate degree recipients by field of study and type of degree, 1989-93				
Field of study	Total	Specialization	Master's	Doctorate
Total	6,500	3,847	1,251	1,402
Basic sciences and technology	2,594	1,202	263	1,129
Agricultural and farming sciences	197	0	195	2
Architecture	52	52	0	0
Engineering	1,233	1,147	37	49
Exact and natural sciences	835	-	19	816
Biochemistry, pharmacy, chemistry	277	3	12	262
Social sciences	2,456	1,404	941	111
Administration and economics	1,727	950	764	13
Law and political science	688	415	177	96
Other	41	39	0	2
Humanities	107	4	2	101
Philosophy and literature	65	-	1	64
Education	3	0	0	3
Other	39	4	1	34
Medical sciences	1,343	1,237	45	61
Medicine	1,237	1,163	45	29
Dentistry	82	50	0	32
Health sciences	24	24	0	0

SOURCE: Barsky, Osvaldo, *Los posgrados universitarios en la República Argentina* (University Postgraduate Courses in Argentina). Buenos Aires: Troquel, 1997.

Table 10. Ph.D.s in basic and technological sciences, by fine field, 1989-93		
Fine Field	Ph.D. graduates	Percent
Total	1,129	100
Astronomy	22	1.9
Biology	88	7.8
Physics	37	3.3
Geophysics	1	0.1
Geology	47	4.2
Math and computing	24	2.1
Chemistry	102	9.0
Agronomy	1	0.1
Veterinarian medicine	1	0.1
Civil engineering	26	2.3
Communication engineering	0	0.0
Electrical engineering	3	0.3
Industrial engineering	0	0.0
Mechanical engineering	0	0.0
Mining engineering	0	0.0
Chemical engineering	20	1.8
Architecture	0	0.0
Pharmacy	160	14.2
Interdisciplinary	597	52.9

SOURCE: Barsky, Osvaldo, *Los posgrados universitarios en la República Argentina* (University Postgraduate Courses in Argentina). Buenos Aires: Troquel, 1997.

To meet these objectives, the CONICET, like its counterpart science-promoting agencies around the world:

- sponsors Scientific and Technological Researcher Career and a Staff Support Career (R&D);
- provides assistantships and fellowships for the training of university graduates or for doing specific research work at home or abroad;
- subsidizes and fosters scientific technological research aimed at achieving scientific and technological progress, and supports activities for this kind of research, in both the public and private sectors;
- fosters scientific and technological exchange and cooperation at home and abroad; and
- provides organization and subsidies for institutes, laboratories, and research centers, which usually operate in universities and other private or public institutions, or even within the CONICET itself.

For a long time, the CONICET was the only entity that gave fellowships for the training of researchers and highly qualified human resources both at home and abroad.

However, the training of researchers did not necessarily involve acquiring a postgraduate degree. The reason for this was that there was a very limited tradition of doctorate studies in Argentine universities; and—on the other hand—a certain "patriarchal" or magisterial culture in Argentine science, according to which the training of new researchers was conceived of as the practice of researchers working with a master or being included in a research team. This process included a "beginner" level and an "updating" level. The fellowships granted by the CONICET were either of these two types. They did not necessarily require obtaining a Ph.D. degree, not even when they were granted to train researchers abroad.

The fellowships offered by the CONICET for the training of researchers were considered a practically indispensable prerequisite for entry into a "researcher career"; thus, the CONICET tried to regulate the number of fellowships to be given every year according to the vacancies available in the course of studies. In those years when entering this course was highly restricted, conflicts arose with the fellows whose aspirations were frustrated. The negative consequences of this situation ultimately have affected the researcher career itself, bringing about an overall aging of the researcher staff roster. This situation changed in 1997, when entry to the course was expanded; the course has since been enlarged by almost 20 percent.

The fact that the CONICET did not require a doctorate of its fellows complied with the policy of regulating the number of fellows according to registration, and limited the number of fellowships the organization offered. Since, in practice, the fellowships stretched out much farther than the previously established 4 years, it was quite usual for a CONICET fellow to remain for up to 7 years (and sometimes even longer) in the status of a researcher-trainee. Obviously, this reduced the organization's capacity to give other fellowships due to budget limitations.

The reordering of the higher education system and of the fellowship system are solutions that have been tried during the past years to put an end to this problem. At present, fellows must have a postgraduate degree, and a Ph.D. is now necessary to enter the researcher career. The CONICET has finally created fellowships for postgraduate studies that do not necessarily involve the training of a researcher, with a wider criterion of what is known as high-level human resources.

Among the innovations in the CONICET fellowship system are postdoctorate fellowships in corporations as a way of including trained researchers in the productive sector. Also, the CONICET has created a system of fellowships to strengthen the technological development of skills and the transfer of technology.

The FOMEC

The Fund for the Improvement of University Quality, created in 1995, was designed to provide financial support for reform processes and to improve the quality of national universities. Improving the level of postgraduate courses offered by Argentine universities is one of the central aspects of the FOMEC program; with this program, both the supply (through the support of certified courses) and the demand (through fellows for young teachers) are funded. Funding to strengthen supply only applies to state universities, since Argentina does not subsidize the private sector university system except in the research area.

Before the LES was given legal force, rules were established and practices developed to evaluate postgraduate courses, since the FOMEC needed a mechanism to assess and certify the supply of postgraduate courses in order to fund their development according to their level of certification. In 1995, the Commission for the Certification of Postgraduate Courses (Comisión de Acreditación de Posgrados) was created, which carried out the first process of certification. In this first experience, 27 percent of master's and doctorate courses offered in the country were certified, qualified, and classified into three ranks: A, B, and C. Postgraduate courses certified as A—and, exceptionally, those ranked as B—were authorized to admit fellows funded by the FOMEC program.

Table 11. Fellowships given by the FOMEC, 1995-97

Level of study	Total	At home	Abroad	Mixed
Total	1,780	1,007	705	68
Master's	805	501	304	
Doctorate	675	368	239	68
Postdoctorate	207	45	162	

SOURCE: Fondo para el Mejoramiento de la Calidad Universitaria (FOMEC).

Fellowships for Postgraduate Courses

In 1997, there were 3,824 fellows in Argentina attending postgraduate courses with fellowships provided by national organizations (table 12). One-third of the fellowships awarded (32 percent) were for studies abroad; the remaining 68 percent were for postgraduate studies pursued in the country.

Fifty-one percent of the fellowships (1,940) were given or administered by the Ministry of Culture and Education; 47 percent (1,783) were granted by science and technology organizations; and 2 percent were from other offices of the national administration, mainly for the training of the staff itself or for a diplomatic course of studies.

Contrary to the trend of increasing enrollment for postgraduate courses in Argentina, the CONICET fellowships, traditionally a major institution in this matter, decreased between 1993 and 1998 from 1,926 to 1,210—a 37 percent drop (table 13). The reasons for this decline are outlined above. The 1995 creation of the FOMEC as an entity that also provides grants greatly increased the supply of fellowships and seems to have compensated for this drop.

Table 12. Total active fellows, 1997

Total	3,824*
Ministry of Culture and Education	
FOMEC	1,687
International Co-operation	170
PROFOR	52
PROFOR/FULLBRIGHT	11
CAPES, Brazil	20
Science and Technology Organizations	
CONICET	1,210
INTA	120
CNEA	47
INTI	6
UBA CyT	400
Others, Public Administration	
ISEN	40
AFIP	40
ISEG	15
INAP	6

NOTE: *This figure must be interpreted as stock, since it stands for the number of postgraduate students whose fellowship was in force, regardless of the year it started.

SOURCE: National Council of Science and Technology Studies (CONICET).

Fellowships to Study Abroad

Most of the 1,210 fellows studying abroad in 1997 were funded by the FOMEC (64 percent); the next largest sources of fellowships were those provided as part of the international cooperation mechanisms sponsored by the Ministry of Culture and Education, and CONICET fellowships to study abroad.

Table 13. CONICET: number of fellows, as of last month of each year

Level	1993	1994	1995	1996	1997	1998
Total	1,926	1,970	1,764	1,705	1,503	1,210
Beginner	622	523	548	571	523	529
Updating	1,013	1,251	664	544	569	537
Postdoctoral	2	2	540	578	411	144
Others	289	194	12	12	0	0

SOURCE: National Council of Science and Technology Studies (CONICET).

Table 14. FOMEC: fellowships to study abroad and mixed fellowships, 1995-98

Level	Basic sciences and engineering	Social, human, and health sciences	Total
Total	508	265	773
Master's	145	159	304
Doctorate	213	94	307
Postdoctorate	150	12	162

SOURCE: Fondo para el Mejoramiento de la Calidad Universitaria (FOMEC).

FOMEC Fellowships

Out of the 773 FOMEC fellowships provided for study abroad, 40 percent are for doctorates, 39 percent for master's, and 21 percent for postdoctorates (table 14).

Two-thirds of the fellowships are for basic science and engineering courses (primarily in doctorate programs). One-third is allotted to the social, human, and health sciences (primarily in master's programs). Most postdoctorate fellowships are in the basic sciences and engineering.

CONICET Fellowships

Of the 94 CONICET fellowships to study abroad still in force, 38 percent are for fellows pursuing doctorates in the United States, 18 percent in Great Britain, and 15 percent in France; the remaining fellowships are for doctoral study in Spain, Holland, Germany, Australia, Canada, and Italy (table 15).

These figures can be correlated to a great extent to the proportion of publications coauthored by Argentine and foreign scientists. Of the publications produced in collaboration with other countries between 1991 and 1995 and recorded in the Science Citation Index, 38 percent had U.S. coauthors; 15 percent had Spanish coauthors; 13 percent each had French and Brazilian coauthors; and 12 percent were collaborations with German authors.

Table 15. CONICET: fellows studying abroad by country (as of August 31, 1998)

Country	Fellows	Percent
Total	94	100
Australia	2	2
Canada	2	2
France	14	15
Germany	4	4
Great Britain	17	18
Holland	8	9
Italy	2	2
Spain	9	10
United States	36	38

SOURCE: National Council of Science and Technology Studies (CONICET).

Fifty-nine percent of the CONICET fellowships abroad correspond to stipends for postdoctoral courses and 40 percent for doctorate courses. The postdoctoral courses are mostly in the natural and exact sciences. In the social sciences and humanities, there is a prevalence of doctorates.

Thirty-nine percent of the fellowships abroad are for the natural and exact sciences, followed by the technological sciences (19 percent), social sciences (15 percent), farming and agriculture (13 percent), humanities (10 percent), and medical sciences (4 percent).

Fellowships in the Country

There are a total of 2,614 fellows doing postgraduate work in Argentina with grants provided by public institutions; of these, 1,116 (43 percent) were granted by the CONICET and 914 (35 percent) by the FOMEC. A significant amount of fellowships was awarded by the Universidad de Buenos Aires, which contributes toward postgraduate studies; these awards do not necessarily imply course attendance (i.e., the recipients might be doing research only).

Table 16. CONICET fellowships abroad in force as of August 31, 1998

Field	Total	Master's	Doctorate	Post-doctorate
Total	94	1	38	55
Agricultural sciences	11	1	6	4
Biological sciences	11	-	-	11
Engineering and technology	10	-	6	4
Physical sciences	8	-	-	8
Chemical sciences	7	-	-	7
Chemical engineering	6	-	1	5
Earth sciences	6	-	-	6
Economics	5	-	5	-
Math and computing	5	-	2	3
Medical sciences	4	-	1	3
Sociology	4	-	4	-
Law	3	-	3	-
Philosophy	3	-	3	-
History	3	-	2	1
Architecture	2	-	2	-
Political sciences	2	-	1	1
Anthropology	1	-	-	1
Philology	1	-	1	-
Linguistics	1	-	1	-
Veterinarian sciences	1	-	-	1

KEY: (-) = not applicable

SOURCE: National Council of Science and Technology Studies (CONICET).

CONICET Fellowships

Of the CONICET's 1,210 active fellowships, 92 percent are local fellowships. Of these, 47 percent are beginner fellowships, which are mainly for master's courses; 45 percent are fellowships for advanced courses through doctorates; and 8 percent are fellowships to take postdoctorates (table 17).

By field, 49 percent of the CONICET fellowships (547) are in the exact and natural sciences, where updating fellowships prevail; 16 percent (175 fellowships) are in the technology area, where both beginner and updating fellowships prevail; 15 percent (171 fellowships) are in medical sciences, with an equal amount for beginner and updating courses; 9 percent are in the humanities with a net prevalence of beginner fellowships; 6 percent are in the social sciences, which are mostly for beginner fellow-

Table 17. CONICET, total fellowships as of May 1998				
Field	Total	Beginner	Updating	Post-doctorate
Total	1,210	529	537	144
Medicine	175	75	72	28
Biology	160	63	72	25
Chemistry	156	61	77	18
Physics	116	42	62	12
Earth	112	45	49	18
Chemical Engineering	100	33	54	13
Agronomy	66	33	30	3
History	60	36	21	3
Engineering	58	33	23	2
Sociology	45	27	16	2
Math	40	15	19	6
Architecture	35	18	12	5
Literature	24	13	10	1
Philosophy	23	12	5	6
Law	22	14	7	1
Economics	14	6	7	1
Others	4	3	1	0

SOURCE: National Council of Science and Technology Studies (CONICET).

ships; and 5 percent (55 fellowships) go to the agricultural sciences, with a slight predominance of beginner fellowships.

FOMEC Fellowships

Out of the FOMEC's total 1,687 fellowships, 914 (54 percent) are for local fellowships. Of these, 377 are open grants directly allocated to the postgraduate courses (table 18). Fifty-five percent of the local fellowships are for master's degrees, 40 percent for doctorates, and 5 percent for postdoctoral degrees. This same scheme, with some slight differences, applies to the basic sciences and engineering, and to the social, human, and health sciences.

Table 18. FOMEC local fellowships, 1995-98			
Level	Total	Basic sciences and engineering	Social, human, and health sciences
Total	914	695	219
Master's	501	358	143
Doctorate	368	298	70
Postdoctorate	45	39	6

SOURCE: Fondo para el Mejoramiento de la Calidad Universitaria (FOMEC).

Table 19. FOMEC fellowships granted by field, 1995-98	
Total	1,687
Subtotal, Basic Sciences and Engineering	1,140
Biology	83
Physics	113
Computing	89
Math	93
Chemistry	97
Engineering courses	251
Farming and agriculture sciences	301
Other basic sciences	113
Social, Human and Health Sciences	547

SOURCE: Fondo para el Mejoramiento de la Calidad Universitaria (FOMEC).

The exact and natural sciences account for 28 percent of the total FOMEC fellowships; farming and agricultural sciences, 18 percent; engineering, 15 percent; and the social, health, and human sciences, the remaining 32 percent (table 19).

Final Remarks

Postgraduate studies and the training of researchers in Argentina have traditionally been shaped on a peculiar model that is hard to compare with that of countries that have adjusted their higher education systems to the Anglo-Saxon tradition—more specifically, to the American model.

Having a curricular model that is long and grants degrees called *Licenciaturas* (similar to a bachelor's degree in Britain), postgraduate careers have not become widespread or properly rooted in the Argentine universities, except in the exact sciences and specializations in the field of medicine. The scientific system has been geared toward training researchers through apprentice-master relationships rather than via formal doctorate studies. Added to this is the country's relatively low level of industrialization, which is manifested in a low demand for highly trained engineers.

Recently, the situation has begun to change, more due to government pressure than to societal demands. The prevailing criterion in these recent changes is to adjust Argentina's educational and scientific systems to new international trends. This process is just beginning and has little legitimacy inside the academic world; moreover, under the present circumstances, it is very disorderly. However, it is possible to consider the expansion of graduate education as a trend to be strengthened in the future.

There are not enough data available to assess the international mobility of scientists and engineers in Argentina. Nevertheless, in examining co-publications, it can be noticed that only 23 percent of the articles by Argentine authors in the Science Citation Index in the period between 1991 and 1995 are done in collaboration with other countries (Fernández, Gómez, and Sebastián 1998). This figure is by far the lowest in Latin America. There are two main reasons for this fact. The first is that the Argentine scientific community is isolated from the rest of the world, mostly due to a lack of policy instruments facilitating international mobility. The second derives from the greater degree of autonomy and maturity of the Argentine scientific community, mainly because of its longer tradition as compared to other Latin American countries.

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Graduate Education in Brazil

Beatriz Santana, Marcos Palatnik, Jacqueline Leta, and Leopoldo de Meis

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.

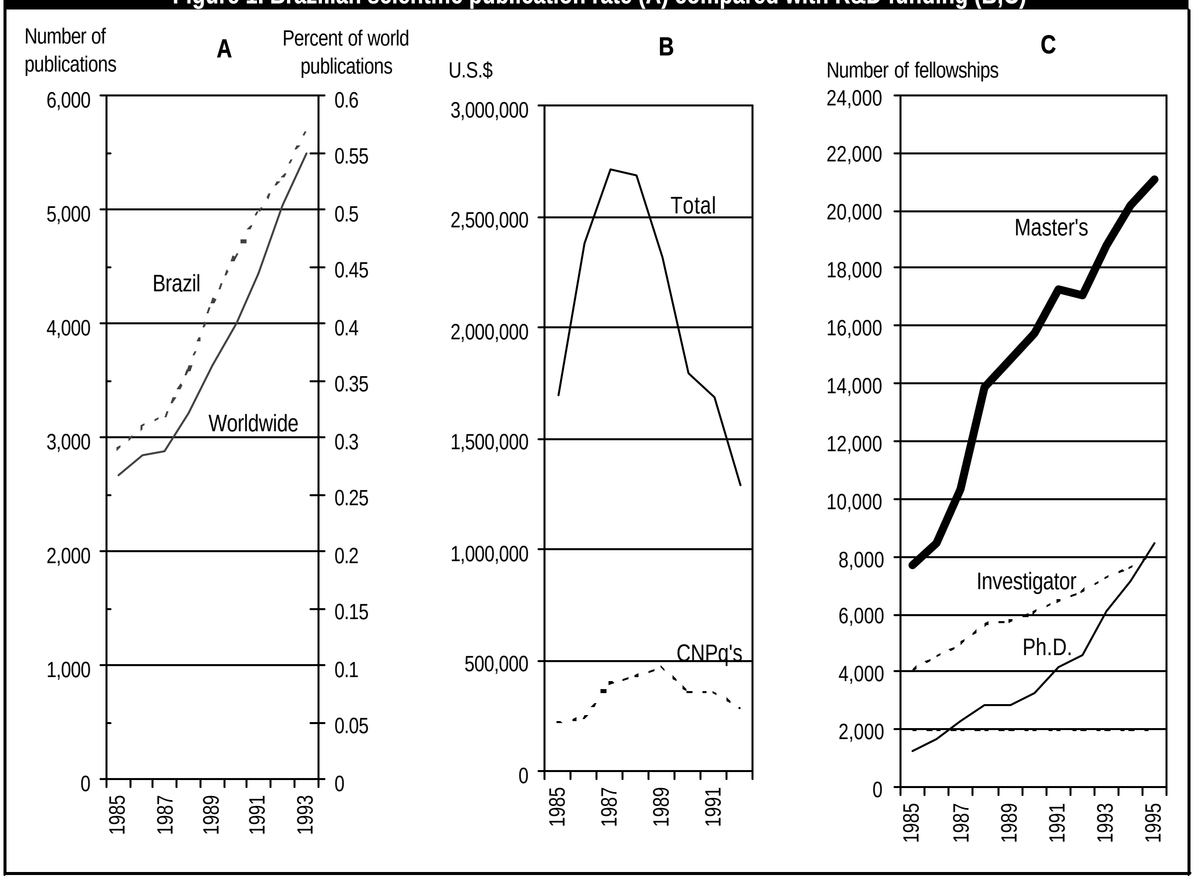
[2] This includes fellowships for specialization and master's, Ph.D., and postdoctoral programs abroad and within Brazil.

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)



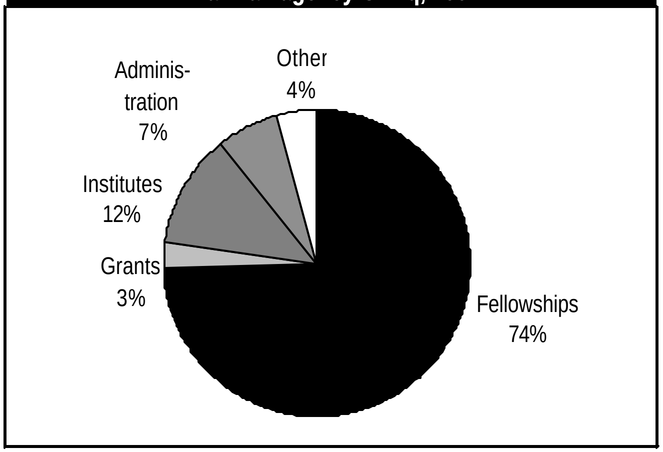
KEY: (A) Annual rate of Brazilian scientific publications from 1985 to1993, either worldwide or by Brazilian share of world's publications.
(B) Total Brazilian resources allocated to R&D and National Council for Scientific and Technological Development (CNPq)'s.
(C) Fellowships granted annually by CNPq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

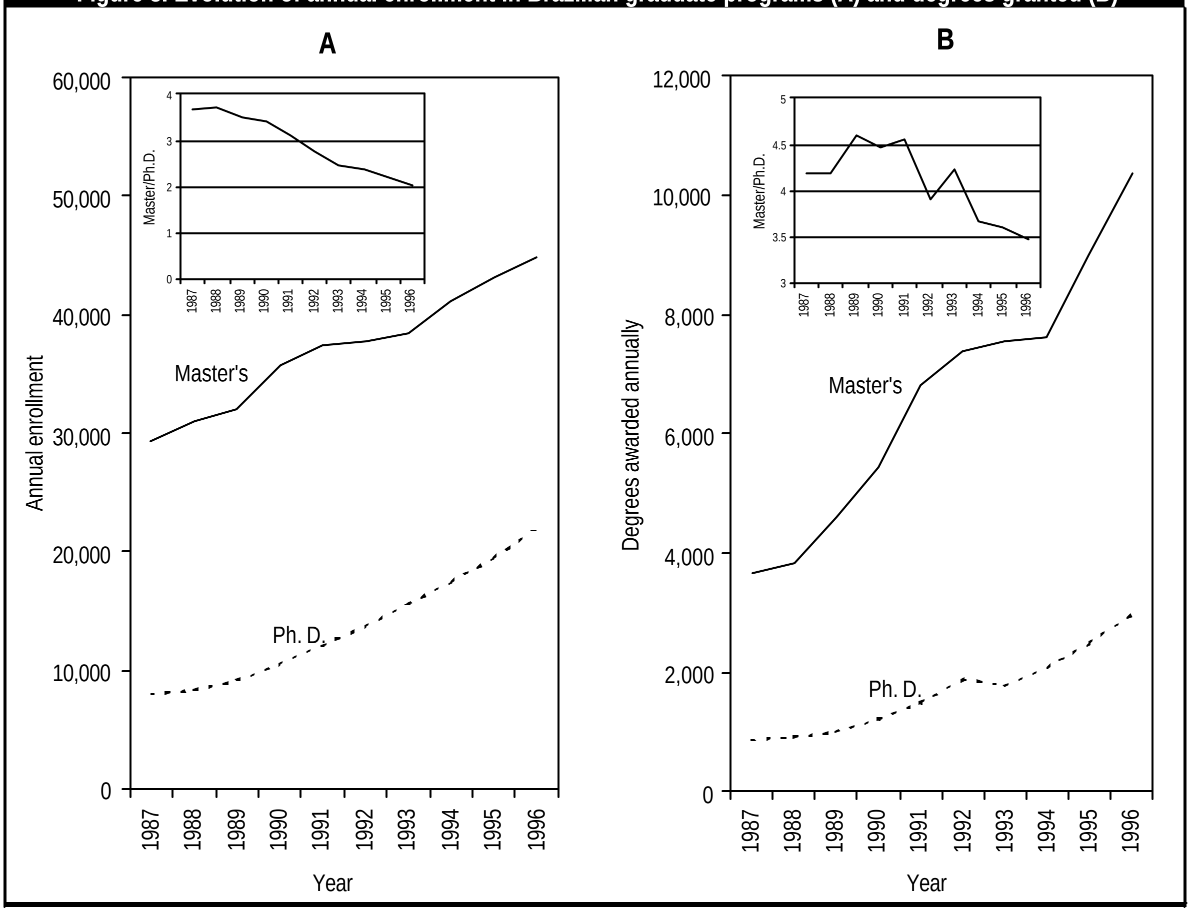
Year	Master's	Ph.D.
1987	861	385
1988	899	402
1989	936	430
1990	964	450
1991	982	468
1992	1,018	502
1993	1,039	524
1994	1,139	594
1995	1,159	616
1996	1,181	627

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.

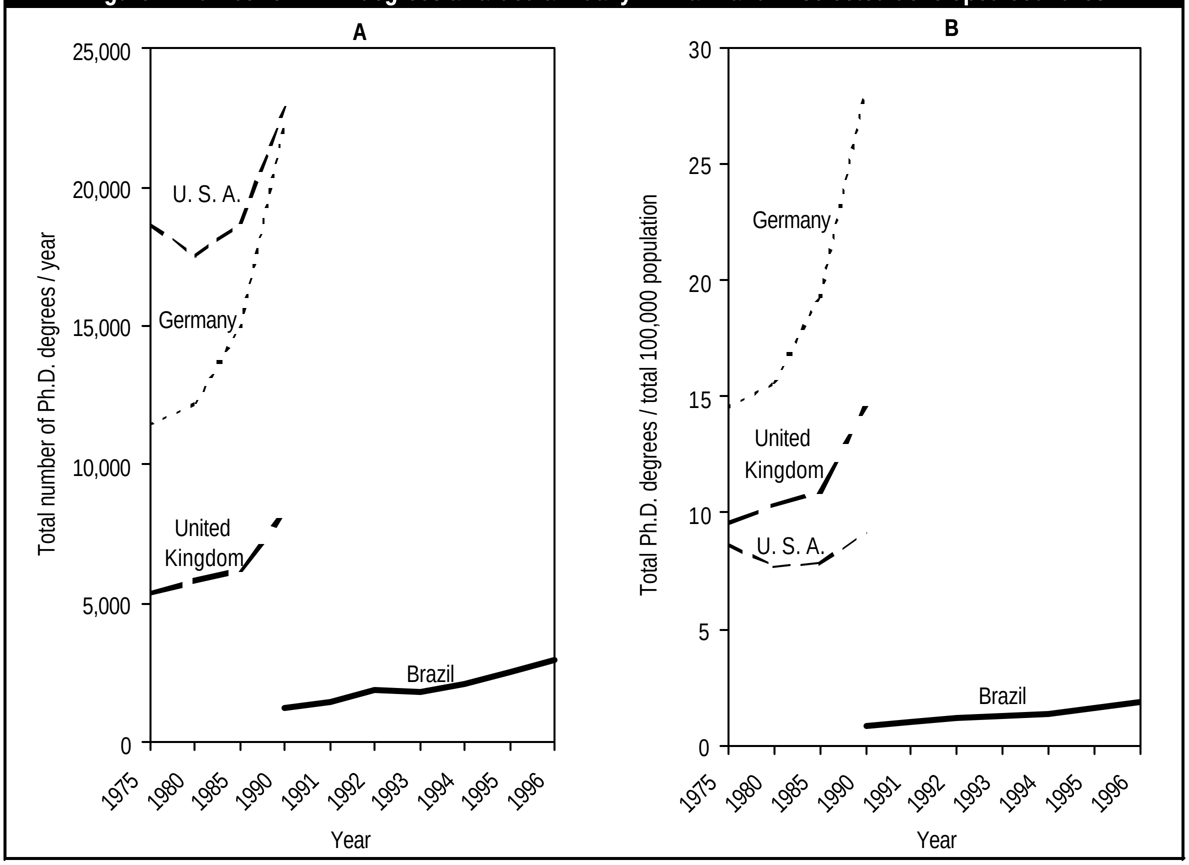
Ph.D.s awarded annually to the total population, Germany stands out among the other countries, with almost 30 Ph.D. degrees per 100,000 inhabitants in 1992 (figure 4B). Although this ratio is increasing in Brazil, it is still far below the ideal for a competitive R&D system. It is worth mentioning that, 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

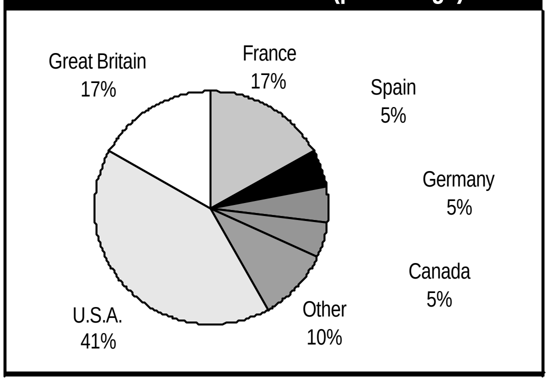
KEY: (-) = not applicable

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

Credentials	Public		Private	
	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.

Table 8. Shifts in faculty credentials in Brazilian universities, 1990-96					
	1990		1996		
Credentials	Number	Percent	Number	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

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.

Graduate Education in Traditional Chilean Universities: A Historical Analysis

Sergio H. Marshall

Summary

Important changes have occurred in higher education in Chile during the past 20 years. During this period, a variety of newly formed private universities have become strong competitors of state-funded traditional universities for undergraduate students. These newer institutions are quite different in quality, focus, and history from the traditional universities. In the early eighties, traditional universities were forced to look for self-financing, and therefore had to compete with private universities for incoming secondary education graduates. As a result, graduate education in the traditional universities has not been able to evolve as expected by taking advantage of the country's growing scientific research potential. Nevertheless, the integrity of traditional universities, and their unquestionable historical strength in basic and applied research, has allowed them to rapidly recover their place and use key strategies to slowly reposition graduate education as one of the main activities distinguishing the highly intellectual Chilean society.

Preliminary Remarks

In Chile, there are two educational options following completion of a university degree: *postgrado*, equivalent to graduate education in the United States, with a minimum requirement of a bachelor's-type degree (*licenciado*); and *postítulo*, which refers to professional education for jobs such as engineer, teacher, or lawyer. Only the former qualifies a student for research activities.

Introduction

Since the beginning of this century, due to its homogeneous population, a long-term sustained economic stability, a solid European-based cultural background, and a strong democratic upbringing, Chile has turned out to be a natural leader in Latin America. Among other institutions, its universities have had a crucial role in the structuring, shaping, and strengthening of a highly efficient society, maintained by qualified and competitive professionals. Many of these professionals are world-renowned for their accomplishments. Natural evolution and the need to internationalize academic activities in the early 1950s and 1960s led seven of the most traditional Chilean universities to establish graduate programs in selected competitive areas. These programs were mostly generated as a means of optimizing internal potential as well as to better serve an always-demanding society. Globalization strategies and international quality assessments also led universities to participate in ongoing mobility programs as well as to establish their own programs.

The abrupt disruption of democracy in Chile in 1973 severely fractured the academic community. Exile, combined with central and imposed government control, disrupted the freedom to speak openly and to organize academic activities within the universities. As a result, the previous harmony in academic activities was threatened, seriously hampering the dynamics of day-to-day academic life. Another consequence was that most academic leaders who remained in the country and in their universities ended up sheltered in their own intellectual environments, suffocated by stringent rules and nonparticipative policies. This situation led universities to become partially isolated from their social and natural environment, resulting in a diminished perception of the real needs of a fast-changing society. For 17 years, the country was forced to function under a defined set of general rules and principles wherein intellectual pursuits were not a priority. In the meantime, a well-organized economy created a new generation of youth who cared more for material things and were unmotivated by the more transcendental aspects of life. These historical developments had a clear impact on university life in Chile and especially on the evolution of graduate education.

From Traditional to Private Universities in Chile

Up to 1980, higher education in Chile was represented by eight traditional universities (table 1 and figure 1) with 118,000 students (for comparison, note that, in 1955, this number was 11,000). These students were mostly undergraduates, and a significant percentage of the university budgets were provided by the state. Under the military regime, a new law was established that restricted state funding for traditional universities. The new scenario created an almost immediate imbalance in the

Chilean higher education system, with an emphasis on undergraduate, rather than graduate, education. The logic behind this strategy was that universities should become self-sustaining from an economic point of view and therefore mainly focused on highly qualified undergraduate formation. As a result, an overwhelming number of new private institutions were created; these developed academic programs primarily oriented to the most attractive and competitive professional careers, and had a "blackboard and chalk" basis—i.e., oriented toward careers that did not require laboratories, special facilities, or any type of previous scientific research.

At present, there are around 250 institutions of higher education in Chile distributed as follows: 67 universities (25 traditional, 42 new private); 70 professional institutes; and over 118 technological centers. In all, these have a total of 370,000 officially registered students, of whom 266,000 are university undergraduates (Frei 1998). Almost all of the faculty members associated with these newborn organizations were, and still are, distinguished professors from classical traditional universities hired on a part-time basis for teaching purposes.

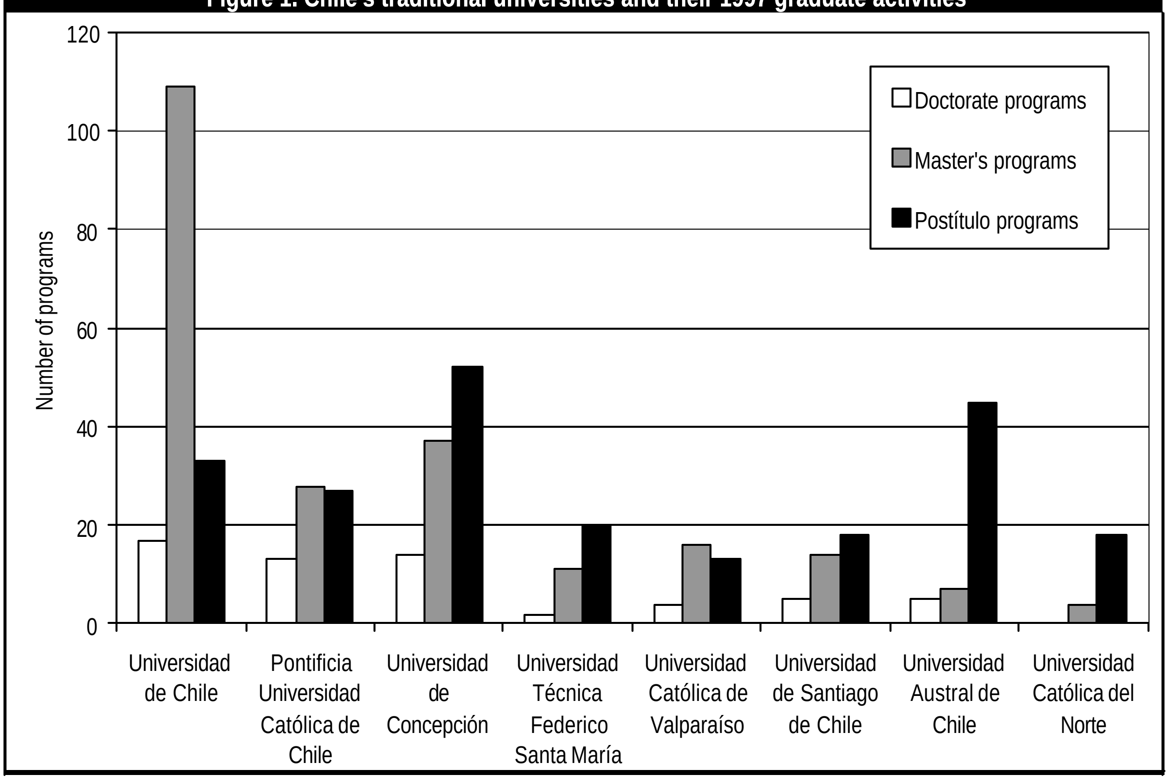
When democracy was reinstated in Chile in March 1990, traditional state-funded universities still maintained

Table 1. Chile's traditional universities and their 1997 graduate activities

University	Year of foundation	Doctorate programs	Master's programs	Postítulo programs
Total		60	226	226
Universidad de Chile	1622	17	109	33
Pontificia Universidad Católica de Chile	1888	13	28	27
Universidad de Concepción	1919	14	37	52
Universidad Técnica Federico Santa María	1926	2	11	20
Universidad Católica de Valparaíso	1928	4	16	13
Universidad de Santiago de Chile	1947	5	14	18
Universidad Austral de Chile	1954	5	7	45
Universidad Católica del Norte	1956	0	4	18

SOURCE: Information from individual university Internet (web sites).

Figure 1. Chile's traditional universities and their 1997 graduate activities



SOURCE: Information from individual university Internet (web sites).

their dignity and their standards although their structure was notoriously weakened. The latter was reflected in a less committed, over-middle-aged faculty, and the absolute absence of new faculty positions. Moreover, the new 1980 law stated that the best-ranked 27,500 students applying for university enrollment each year would receive a significant subsidy from the state. This situation occurred under a tight budget, and led traditional universities—besides competing among themselves—to design yearly changing, aggressive strategies for survival as a means of overcoming the uneven competition from private universities for incoming undergraduate students. Thus, the country was not prepared for significant development of graduate training since this simply could not be a priority for traditional universities outnumbered by their private counterparts.

Actual Structure and Organization of Traditional Universities in Chile

At present, there are 25 traditional universities in Chile, out of 68 universities in all; these are scattered over the 12 administrative regions of the country plus the metropolitan region that comprises the country's capital. Most of these universities are concentrated in Santiago, the capital city, and in Regions V and VIII (table 2). All traditional universities have in common—to a certain extent—some kind of state support; in contrast, private universities do not. The original eight traditional universities still exist, and all of them have active graduate programs (table 1). Due to the complexity of branch distributions across regions of some of the original universities and the new economic scenario faced by universities in the middle to late 1980s, most regional branches have become autonomous and have acquired new names; nonetheless, they continue to be state-funded just like their progenitors. Something similar happened in the early 1990s to regional branches of Universidad Catolica de Chile, the second most important university in the country. This university, although dependent on the Catholic Church (like Universidad Catolica de Valparaiso), still receives marginal funding from the state.

The 25 traditional universities are affiliated with the Consejo de Rectores (C.R.), or Council of Rectors, which comprises the rectors of these universities, which are officially recognized by the state; the council is headed by the minister of Education. Besides the rectors, the council has a general secretary who is nominated by the minister of Education and who administers the council's activities. The head of the Department of Higher Education of the Ministry of Education also attends the council sessions as a permanent guest. In the minister's absence, the council is headed by the rector of Universidad de Chile, the first established and strongest university in the country. Foreseeing the need to strengthen graduate activities, the council has, since 1991, had an advisory committee on graduate affairs comprised of all graduate program directors from the 25 member universities. Its objective is to keep this activity alive within these universities and to set quality standards for all programs so they might be recognized internationally. Within this committee, there is an executive commission, composed of all seven university members offering doctorate programs, most of which are accredited by international standards (table 3 and figure 2). At present, this commission is headed by the author of this paper.

Graduate Activities in Traditional Universities

Most C.R. university members offer some kind of graduate programs, although the great majority promote master's over doctorate degree programs. Nonetheless, as a way to promote and maintain regular graduate activities—by themselves expensive—most universities have developed *postítulos*, in which a certificate is granted after 1 to 2 years of advanced specialization courses. In a *postítulo*, no research or thesis work is required for graduation, and the program is mainly oriented to competitive professionals who need to be updated in specific areas of knowledge. Because of their orientation, these programs have a high tuition fee and have become an efficient way to relate to the national productive sector. They have also become an efficient alternative for traditional universities to provide financial support for other academic activities, among them graduate programs. Tables 4, 5, and 6 show the official registration for doctorate, master's, and *postítulo* programs, respectively.

It is clear that the seven leading universities in terms of granting doctorates are also the ones with solid master's and *postítulo* programs. With the exception of Universidad Catolica del Norte—one of the eight originals—and its *postítulo* programs (table 6), most activity is concentrated in Santiago and two or three other regions. No doctorate programs are available at any of the private universities, and only a few private universities have MBA-type master's programs—these number fewer than 10 at any one university.

Table 2. Total undergraduate and graduate enrollment in traditional universities, 1997

University/Region	Total	I	II	III	IV	V	VII	VIII	IX	X	XI	XII	RM
Total	184,282	7,418	12,553	3,432	6,974	23,181	7,338	27,703	9,475	13,057	0	2,343	70,808
Univ. de Chile	21,910	0	0	0	0	0	0	0	0	0	0	0	21,910
P.Univ. Católica de Chile	15,821	0	0	0	0	0	0	0	184	0	0	0	15,637
Univ. de Concepción	15,124	0	0	0	0	0	0	15,124	0	0	0	0	0
Univ.Católica Valparaíso	8,689	0	0	0	0	8,689	0	0	0	0	0	0	0
Univ. T.F. Santa María	8,218	0	0	0	0	6,028	0	1,708	0	0	0	0	482
Univ. Santiago de Chile	18,295	0	0	0	0	0	0	0	0	0	0	0	18,295
Univ. Austral de Chile	9,698	0	0	0	0	0	0	0	0	9,698	0	0	0
Univ. Católica del Norte	8,592	0	7,203	0	1,389	0	0	0	0	0	0	0	0
Univ. de Valparaíso	4,920	0	0	0	0	4,920	0	0	0	0	0	0	0
Univ. de Antofagasta	5,350	0	5,350	0	0	0	0	0	0	0	0	0	0
Univ. de la Serena	5,585	0	0	0	5,585	0	0	0	0	0	0	0	0
Univ. del Bio Bio	7,779	0	0	0	0	0	0	7,779	0	0	0	0	0
Univ. de la Frontera	6,892	0	0	0	0	0	0	0	6,892	0	0	0	0
Univ. de Magallanes	2,343	0	0	0	0	0	0	0	0	0	0	2,343	0
Univ. de Talca	0	0	0	0	0	0	0	0	0	0	0	0	0
Univ. de Atacama	7,204	0	0	3,432	0	0	3,772	0	0	0	0	0	0
Univ. de Tarapacá	5,098	5,098	0	0	0	0	0	0	0	0	0	0	0
Univ. Arturo Prat	2,350	2,320	0	0	0	0	0	0	30	0	0	0	0
Univ.Metrop.Cs.de la Ed	6,549	0	0	0	0	0	0	0	0	0	0	0	6,549
U.P.Ancha Cs. de la Ed	3,544	0	0	0	0	3,544	0	0	0	0	0	0	0
U. Tecnol. Metropolitana	7,935	0	0	0	0	0	0	0	0	0	0	0	7,935
Univ. de Los Lagos	3,359	0	0	0	0	0	0	0	0	3,359	0	0	0
Univ. Católica del Maule	3,566	0	0	0	0	0	3,566	0	0	0	0	0	0
Univ. Católica de Temuco	2,369	0	0	0	0	0	0	0	2,369	0	0	0	0
Univ. Catolica S.Concepc	3,092	0	0	0	0	0	0	3,092	0	0	0	0	0
Percentage distribution	100.0	4.03	6.81	1.86	3.78	12.58	3.98	15.03	5.14	7.09	0.00	1.27	38.42

KEY: RM = metropolitan region (Santiago)

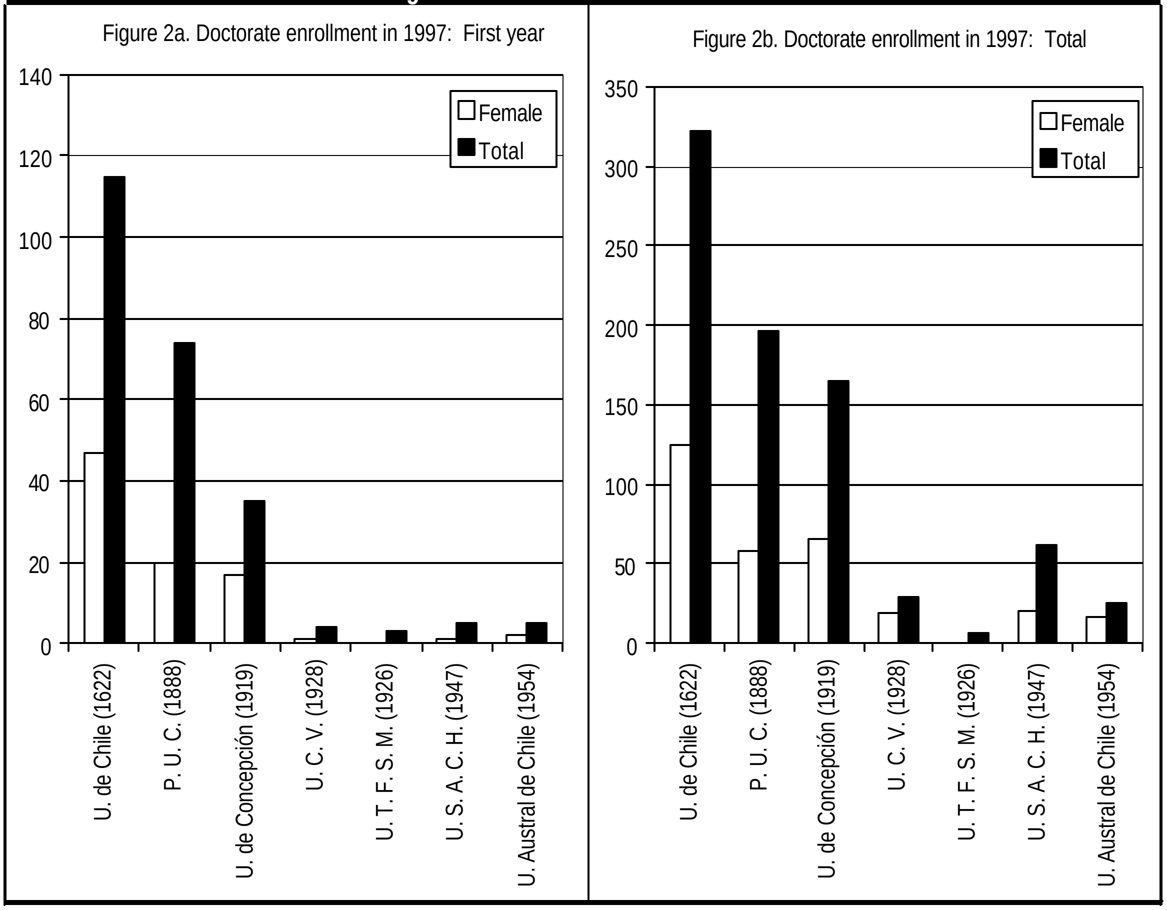
SOURCE: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1997).

Table 3. Doctorate enrollment in 1997

University	First year registration		Total registration	
	Total	Female	Total	Female
Total	241	88	807	305
Universidad de Chile	115	47	322	125
P. Universidad Católica de Chile	74	20	197	58
Universidad de Concepción	35	17	165	66
Universidad Católica de Valparaíso	4	1	29	19
Universidad T. F. Santa María	3	0	6	0
Universidad de Santiago de Chile	5	1	62	21
Universidad Austral de Chile	5	2	26	16

SOURCE: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1997).

Figure 2. Doctorate enrollment in 1997



SOURCE: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1997).

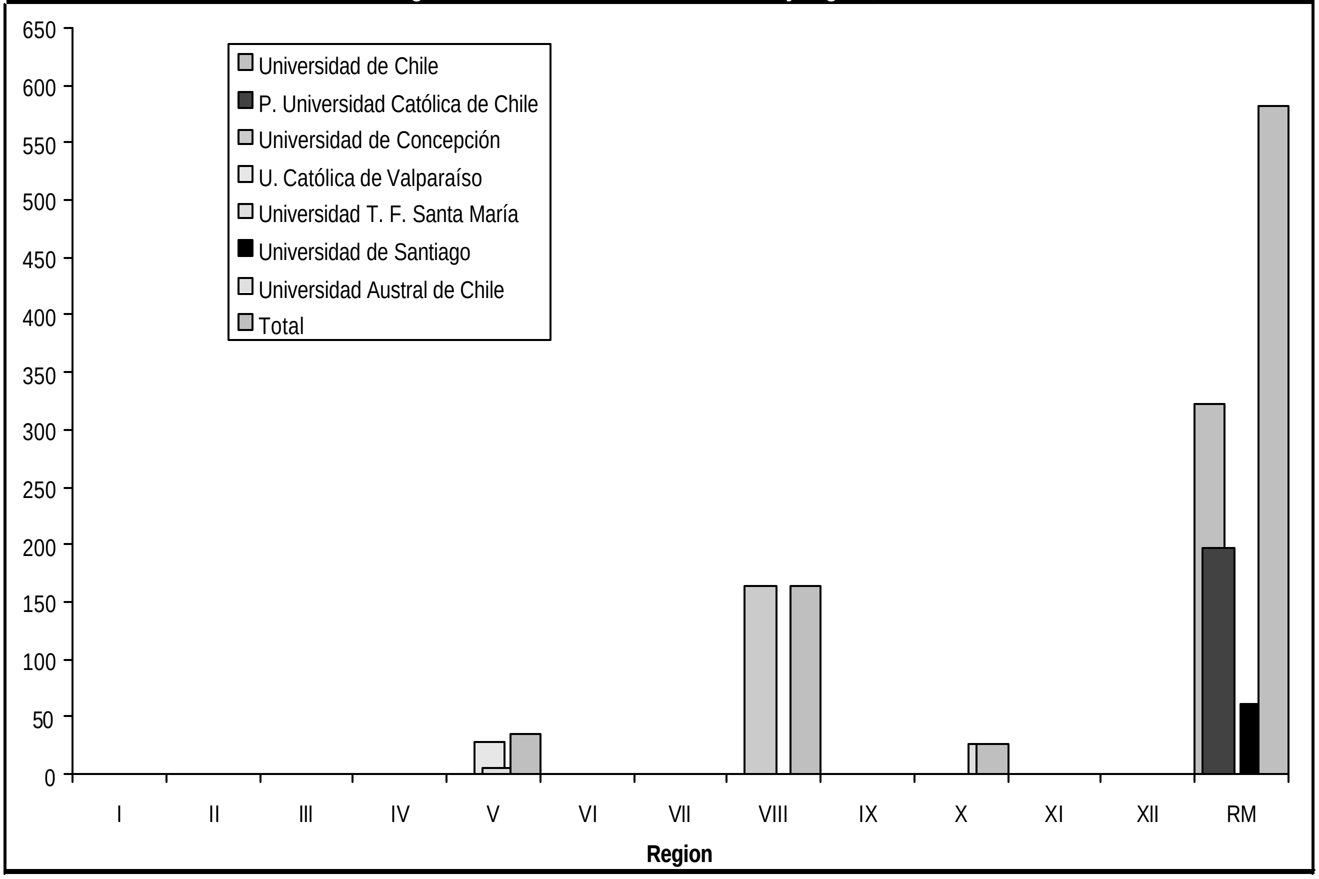
Table 4. Total doctorate enrollment by region, 1997

University/ Region	Total	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	RM
Total...	807	0	0	0	0	35	0	0	165	0	26	0	0	581
Univ. de Chile............................	322	0	0	0	0	0	0	0	0	0	0	0	0	322
P.Univ. Católica de Chile...........	197	0	0	0	0	0	0	0	0	0	0	0	0	197
Univ. de Concepción..................	165	0	0	0	0	0	0	0	165	0	0	0	0	0
Univ.Católica Valparaíso............	29	0	0	0	0	29	0	0	0	0	0	0	0	0
Univ. T.F. Santa María...............	6	0	0	0	0	6	0	0	0	0	0	0	0	0
Univ. Santiago de Chile.............	62	0	0	0	0	0	0	0	0	0	0	0	0	62
Univ. Austral de Chile.................	26	0	0	0	0	0	0	0	0	0	26	0	0	0
Percentage distribution..................	100.0	0.0	0.0	0.0	0.0	4.3	0.0	0.0	20.4	0.0	3.2	0.0	0.0	72.0

KEY: RM = metropolitan region (Santiago)

SOURCE: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1997).

Figure 3. Total doctorate enrollment by region, 1997



KEY: RM = metropolitan region (Santiago)

NOTE: No doctoral enrollment in regions I-IV,VI-VII, IX-X, and XI-XII.

SOURCE: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1997).

Table 5. Total master's enrollment by region, 1997

University/Region	Total	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	RM
Total	5,442	133	57	47	236	510	0	0	547	245	322	0	22	3,323
Universidad de Chile	1,578	0	0	0	0	0	0	0	0	0	0	0	0	1,578
P. Universidad Católica de Chile	841	0	0	0	0	0	0	0	0	0	0	0	0	841
Universidad de Concepción	547	0	0	0	0	0	0	0	547	0	0	0	0	0
Universidad Católica de Valparaíso	147	0	0	0	0	147	0	0	0	0	0	0	0	0
Universidad T. F. Santa María	91	0	0	0	0	91	0	0	0	0	0	0	0	0
Universidad de Santiago de Chile	312	0	0	0	0	0	0	0	0	0	0	0	0	312
Universidad Austral de Chile	316	0	0	0	0	0	0	0	0	0	316	0	0	0
Universidad Católica del Norte	75	0	57	0	18	0	0	0	0	0	0	0	0	0
Universidad de Valparaíso	73	0	0	0	0	73	0	0	0	0	0	0	0	0
Universidad de la Serena	218	0	0	0	218	0	0	0	0	0	0	0	0	0
Universidad de la Frontera	245	0	0	0	0	0	0	0	0	245	0	0	0	0
Universidad de Magallanes	22	0	0	0	0	0	0	0	0	0	0	0	22	0
Universidad de Atacama	47	0	0	47	0	0	0	0	0	0	0	0	0	0
Universidad de Tarapacá	133	133	0	0	0	0	0	0	0	0	0	0	0	0
U. Metropolitana de Cs. De la Ed.	592	0	0	0	0	0	0	0	0	0	0	0	0	592
U. De Playa Ancha Cs. De la Ed.	199	0	0	0	0	199	0	0	0	0	0	0	0	0
Universidad de los Lagos	6	0	0	0	0	0	0	0	0	0	6	0	0	0
Percentage distribution	100.0	2.4	1.0	0.9	4.3	9.4	0.0	0.0	10.1	4.5	5.9	0.0	0.4	61.1

KEY: RM = metropolitan region (Santiago)

SOURCE: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1997).

Table 6. Total *postítulo* enrollment by region, 1997

University/Region	Total	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	RM
Total	10,091	175	2,644	97	117	1,084	50	572	1,188	280	936	0	0	2,948
Universidad de Chile	1,019	0	0	0	0	0	0	0	0	0	0	0	0	1,019
P. Universidad Católica de Chile	871	0	0	0	0	0	0	0	0	70	0	0	0	801
Universidad de Concepción	511	0	0	0	0	0	0	0	511	0	0	0	0	0
Universidad Católica de Valparaíso	415	0	0	0	0	415	0	0	0	0	0	0	0	0
Universidad T. F. Santa María	1,127	0	0	0	0	459	50	0	159	0	0	0	0	459
Universidad de Santiago de Chile	365	0	0	0	0	0	0	0	0	0	0	0	0	365
Universidad Austral de Chile	745	0	0	0	0	0	0	0	0	0	745	0	0	0
Universidad Católica del Norte	2,687	0	2,644	0	43	0	0	0	0	0	0	0	0	0
Universidad de Valparaíso	136	0	0	0	0	136	0	0	0	0	0	0	0	0
Universidad de la Serena	74	0	0	0	74	0	0	0	0	0	0	0	0	0
Universidad de la Frontera	210	0	0	0	0	0	0	0	0	210	0	0	0	0
Universidad de Atacama	97	0	0	97	0	0	0	0	0	0	0	0	0	0
Universidad de Tarapacá	175	175	0	0	0	0	0	0	0	0	0	0	0	0
U. Metropolitana de Cs. De la Ed	304	0	0	0	0	0	0	0	0	0	0	0	0	304
U. De Playa Ancha Cs. De la Ed	74	0	0	0	0	74	0	0	0	0	0	0	0	0
Universidad de los Lagos	191	0	0	0	0	0	0	0	0	0	191	0	0	0
Universidad Católica del Maule	572	0	0	0	0	0	0	572	0	0	0	0	0	0
Universidad Católica S. Concepción	518	0	0	0	0	0	0	0	518	0	0	0	0	0
Percentage distribution	100.0	1.7	26.2	1.0	1.2	10.7	0.5	5.7	11.8	2.8	9.3	0.0	0.0	29.2

KEY: RM = metropolitan region (Santiago)

SOURCE: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1997).

There are significant differences among the 25 C.R. member universities in their experience in graduate education activities. Graduate activity in Chile constitutes a natural heritage of traditional universities. Out of the 25, 7 universities offer doctorate programs, 17 offer master's programs, and 18 offer *postítulo* programs (tables 1, 3, 4, 5, and 6). Most programs show a reasonable degree of efficiency, as measured by the number of graduates in each type of program. Table 7 shows the 1997 official data for graduation in doctorate programs. Table 8 does the same for master's programs. When comparing the number of candidates in doctorate programs (table 3) against the number of graduates (table 7), the yearly average graduation is 5 to 10 percent of all enrolled students. As expected, the average graduation frequency for master's programs (tables 5 and 8) is much higher, reaching levels up to 20 percent per year.

The core of qualified graduate programs lies in traditional universities, which are outnumbered by their private counterparts. Internationally competitive graduate programs occur almost exclusively at the doctorate level. Only 7 of Chile's 68 universities participate at this level, offering 60 different programs, most of which are fully accredited either nationally or—in a few cases—internationally. College-level activity in all traditional universities

Table 7. Total doctorate degrees granted, 1997

University/Area	Total	Agronomy	Art	Sciences/ mathematics	Social sciences	Law	Humanities	Education	Technology	Health
Total	57	0	0	45	0	0	1	3	0	8
Universidad de Chile	26	0	0	18	0	0	0	0	0	8
P. Universidad Católica de Chile	12	0	0	8	0	0	1	3	0	0
Universidad de Concepción	7	0	0	7	0	0	0	0	0	0
Universidad Católica de Valparaíso	4	0	0	4	0	0	0	0	0	0
Universidad de Santiago de Chile	2	0	0	2	0	0	0	0	0	0
Universidad Austral de Chile	6	0	0	6	0	0	0	0	0	0
Percentage distribution	100.0	0.0	0.0	78.9	0.0	0.0	1.8	5.3	0.0	14.0

SOURCE: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1997).

Table 8. Total master's degrees granted, 1997

University/Area	Total	Agronomy	Art	Sciences/ mathematics	Social sciences	Law	Humanities	Education	Technology	Health
Total	648	35	5	95	197	4	59	134	76	43
Universidad de Chile	201	14	3	29	67	0	20	4	24	40
P. Universidad Católica de Chile	173	14	2	9	98	4	10	8	28	0
Universidad de Concepción	53	1	0	19	6	0	8	8	8	3
Universidad Católica de Valparaíso	18	0	0	7	0	0	5	4	2	0
Universidad T. F. Santa María	13	0	0	2	0	0	0	0	11	0
Universidad de Santiago de Chile	31	0	0	2	14	0	11	1	3	0
Universidad Austral de Chile	36	5	0	22	7	0	2	0	0	0
Universidad Católica del Norte	5	0	0	5	0	0	0	0	0	0
Universidad de la Serena	51	1	0	0	0	0	0	50	0	0
Universidad de la Frontera	5	0	0	0	5	0	0	0	0	0
Universidad de Magallanes	2	0	0	0	0	0	0	2	0	0
Universidad de Tarapacá	22	0	0	0	0	0	0	22	0	0
U. Metropolitana de Cs. De la Ed	29	0	0	0	0	0	2	27	0	0
U. De Playa Ancha Cs. De la Ed	6	0	0	0	0	0	1	5	0	0
Universidad de Antofagasta	3	0	0	0	0		0	3	0	0
Percentage distribution	100.0	5.4	0.8	14.7	30.4	0.6	9.1	20.7	11.7	6.6

SOURCE: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1997).

has had to increase heavily in the last 10 years and has been forced to perform at a level of high efficiency in terms of graduates. This has not been the case for graduate education, which annually graduates 2 doctorate students per million inhabitants, not counting those graduating abroad. This is quite a low figure when compared to 10 in Brazil and 150 in the United States (Zumelzu 1997).

After this rather somber evaluation, one might question why such an evolution has occurred—and even wonder how graduate activity has survived. The main answer to both questions is that traditional universities in Chile know, and have known for a long time, that without graduate activity, a strong, complex university cannot survive. In addition, Chile is very much aware that a reduced scientific mass necessarily undermines the future of science and, to a lesser degree, technology; therefore, it is the responsibility of its universities to generate, maintain, and renew the scientific and technically trained personnel sustaining the country. Certainly, graduate education is one of the pivotal instruments required to achieve these objectives.

The Research Mission Supporting Graduate Education

Today, the organized body of knowledge that makes it possible to understand the causes of verifiable phenomena (science) and the application of knowledge to the production of goods and services (technology) permeates all sectors and activities of society (Mayorga 1997). There are many areas in which the spheres of science and technology and the socioeconomic development of any country overlap. Universities should act as interfaces to harmonize the process, providing not only knowledge, but also—and most importantly—the actors. In recent years, as discussed previously, significant changes in the university environment have affected the research-related missions of these institutions and, as a consequence, their approach to graduate education. In particular, universities are becoming more diverse in structure and more oriented toward economic and industrial needs, while coping with year-to-year higher college-level student enrollment. On the other hand, government budgets to support traditional universities, as well as those related to research and development (R&D), are increasing very slowly and at a percentage not comparable to those of developed countries. Table 9 shows the percentage of the gross domestic product (GDP) invested in R&D in Chile starting in 1965 and the estimated rate expected at the year 2000.

Table 9. Percentage of Chile's GDP invested in R&D, 1965-2000

Year	R&D expenditures (Mil. US Dollars)	Percent
1965	0.02	0.32
1966	0.02	0.35
1967	0.03	0.41
1968	0.03	0.42
1969	0.03	0.39
1970	0.03	0.39
1971	0.05	0.49
1972	0.06	0.51
1973	0.04	0.41
1974	0.04	0.33
1975	27.00	0.37
1976	39.29	0.40
1977	57.61	0.43
1978	76.21	0.49
1979	82.56	0.40
1980	107.59	0.39
1981	123.86	0.38
1982	108.91	0.45
1983	96.20	0.49
1984	99.30	0.52
1985	80.16	0.50
1986	81.02	0.48
1987	104.76	0.55
1988	108.35	0.45
1989	131.01	0.47
1990	161.95	0.53
1991	183.34	0.53
1992	248.58	0.58
1993	286.82	0.63
1994	340.49	0.65
1995	430.37	0.64
1996	454.98	0.66
1997	528.34	0.69
1998	678.28	0.84
1999	850.93	0.98
2000	1,005.04	1.09

SOURCE: Comisión Nacional de Investigación Científica y Tecnológica (CONICYT), Santiago, Chile.

These data suggest that, in the near future, sustainability of traditional universities will become more and more dependent upon the annual fees paid by undergraduate students and, to a lesser extent, upon any lateral activities they could perform in the areas of applied research, technical assistance, training courses or programs, and knowledge and technology transfer to the productive sectors of the economy. These trends undoubtedly raise serious questions about how to ensure that universities can continue to make their unique contribution to long-term basic research—a pivotal and unavoidable key component supporting graduate activities inside established universities. Unfortunately, these are considered unprofitable activities with high unit cost to achieve graduation for a small number of students, where external support is limited and scholarships scarce. Therefore, traditional Chilean universities, as elsewhere, must adapt to this reality in largely positive ways, evolving toward new roles and configurations to properly face the needs of the 21st century. One example of this trend is the fact that, with declining government support, there is an obvious need not only to seek new sources of funds but also to establish a new basis for that support. One appealing strategy applied in Europe (OECD 1998), and which could be applicable in Chile, would be to change the nature of government funding to make it mission-oriented, contract-based, and more dependent on output and performance criteria. If applied, this would lead universities to perform more short-term and market-oriented research.

Financing R&D Activities: Competitive Funds for Research

It has been already stated that research is essential in supporting qualified graduate programs, and vice versa. It is also well known that, in order to do that, external funding is a must. Therefore, an indirect way to examine the efficiency of graduate activity in a country is to analyze the economic resources invested in R&D as a percentage of GDP (UNESCO 1993) and identify where the research activity occurs. The low level of R&D funding helps explain the low level of graduate formation in the country. Chile used only 0.7 percent of its GDP in 1994 in this area, compared with 0.8 percent in Argentina, 0.9 percent in Brazil, and 2.77 percent in the United States (Zumelzu 1997). The main reason for this is that most of the research performed in Chile occurs in universities. Table 10 shows that, for the last 15 years, on average, almost 70 percent of all researchers work at universities; this might be interpreted as meaning that the productive sector is not involved or not interested in developing its own research potential. Table 11 further suggests that this might be the case. Over 70 percent of R&D done in the country is performed at universities, mostly—but not exclusively—by graduates. Table 10 also shows that the industrial sector has a negligible participation; in addition to universities, most market-oriented research is done at professional institutes supported by the state where graduate training is not at all considered.

Table 10. Total researchers at universities			
Year	Total in Chile	Researchers in universities	Percent at universities
1981...........	3,420	2,434	71.2
1982...........	3,547	2,561	72.2
1983...........	3,727	2,677	71.8
1984...........	3,886	2,789	71.8
1985...........	4,079	2,924	71.7
1986...........	4,251	3,056	71.9
1987...........	4,588	3,169	69.1
1988...........	4,803	3,279	68.3
1989...........	5,115	3,389	66.3
1990...........	5,421	3,609	66.6
1991...........	5,628	3,710	65.9
1992...........	5,860	3,942	67.3
1993...........	6,028	4,029	66.8
1994...........	6,223	4,168	67.0
1995...........	6,388	4,356	68.2
1996...........	6,619	4,583	69.2

SOURCES: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1981 a 1996). Information submitted directly by universities and institutes; Department of Information, Comisión Nacconal de Investigación Centifica y Tecnológica (CONICYT).

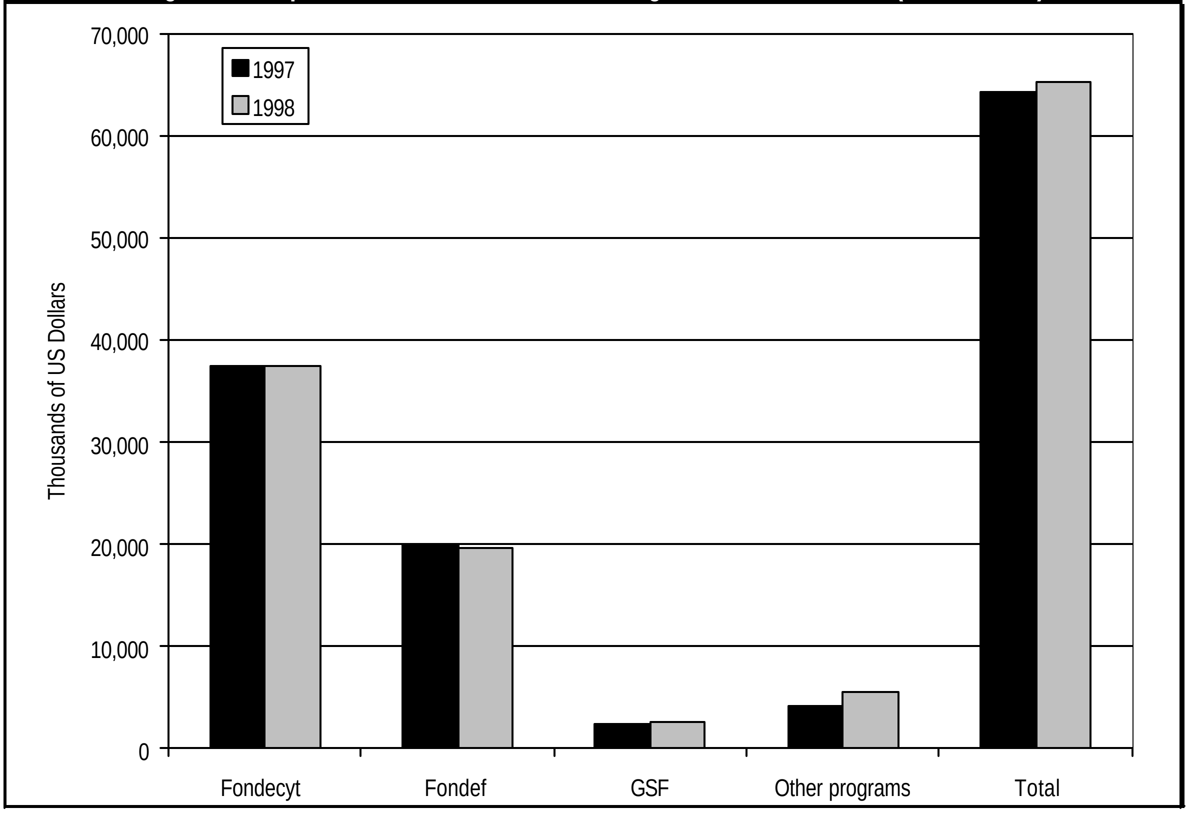
To do highly competitive and consistent research, funding is fundamental; to get this funding appears to be the sole responsibility of each researcher through state-provided competitive funds. Since graduate programs normally require an experimental thesis for graduation, it is also the responsibility of the research advisor to provide the required financial support. This is indeed the case, and can be inferred from figure 4, where the most relevant state-provided competitive funds are summarized. It can be clearly seen in the figure that the only direct support for the development of graduate education corresponds to graduate student fellowships, representing a low 4 percent of the total. This support is restricted to accredited programs. In the figure, Fondecyt is a research fund that supports single principal investigators; Fondef, an equivalent supporting institution, generally supports universities in association with industries. Thus, the only real sources of money to carry out graduate work are indirect and unstable, depending on researchers to provide them.

To understand these data in a more general context, a closer analysis of the steady-state annual national budget distribution in the field might help. As an example, in 1997 the national R&D expense reached US$480 million. From this lump sum, 70 percent (US$336 million) corresponded to state expenditure, and 23 percent (US$110 million) to enterprise expenditure. Of the state expenditure, 26 percent (US$87 million) was competitive funds,

Table 11. Graduate involvement in the national R&D system						
Year	Total researchers	Total graduates	Universities	Professional institutes	Industry	Percent of graduates
1981.................	3,420	2,314	2,239	75	none	67.6
1982.................	3,547	2,408	2,325	83	none	67.8
1983.................	3,727	2,718	2,633	85	none	72.9
1984.................	3,886	2,884	2,793	91	none	74.2
1985.................	4,079	3,213	3,111	102	none	78.8
1986.................	4,251	3,551	3,440	111	none	83.5
1987.................	4,588	3,667	3,541	126	none	79.9
1988.................	4,803	3,631	3,484	131	16	75.6
1989.................	5,115	3,833	3,677	137	19	74.9
1990.................	5,421	3,775	3,628	147	none	69.6
1991.................	5,628	3,815	3,661	154	none	67.8
1992.................	5,860	3,869	3,692	177	none	66.0
1993.................	6,028	3,884	3,692	192	none	64.4
1994.................	6,223	4,455	4,259	196	none	71.6
1995.................	6,388	4,926	4,730	196	none	77.7
1996.................	6,619	5,153	4,957	196	none	77.9

SOURCE: Comisión Nacional de Investigación Científica y Tecnológica (CONICYT), Santiago, Chile.

Figure 4. Competitive state funds available for higher education in Chile (via CONICYT)



SOURCE: Comisión Nacional de Investigación Científica y Tecnológica (CONICYT), Santiago, Chile.

31 percent (US$104 million) was the state direct allowance shared by the 25 traditional universities, and 17 percent (US$57 million) was the direct subsidy the state provides for its technological institutes (Frei 1998 and Santibañez 1998). It is appropriate to say, at this point, that the direct state allowance received by traditional universities is not evenly distributed; it varies widely based on a number of factors. Therefore, and as already mentioned, a minimum amount of this fund goes to graduate students—mainly as fellowships—and not in direct support of experimental research.

The Situation in Science and Engineering

Most graduate programs in traditional universities deal with basic sciences and mathematics rather than with engineering. This may be one of the factors underlying the weak relationship existing between universities and the productive sector. Engineering is an activity that builds on sciences, techniques, and arts to improve and diversify the production of good and services, contributing in this way to societal satisfaction. The relationship of empirical engineering with basic sciences to make up what is currently known as "engineering sciences" is a rather recent phenomenon; therefore, the development of graduate activities has naturally been delayed in relation to basic sciences. This is the situation in Chile, where the universe of people and organizations devoted to research in this field is not very large nationwide. Fewer than 15 percent of all graduate programs currently in progress in Chile correspond to engineering and related areas. Table 12 shows the distribution of scientists and engineers involved in research in Chile, where engineers represent about 30 percent of the total. The difference is even higher when the analysis is limited solely to universities. Table 13 shows that, in the last 15 years, the proportion of engineers among researchers at universities has declined from over 16 percent to less than 14 percent. This is an evident sign of the already discussed tendency of graduates to prefer the private sector to universities.

Table 14 shows that the number of scientists and engineers per 1,000 population has increased modestly from 0.9 in 1981 to 1.2 in 1996.

Although the representation of engineers in research—and, as a consequence, in graduate activities—is low, their efficiency might be high. To test this hypoth-

Table 12. Scientists and engineers involved in research in Chile					
Year	Total number of researchers	Scientists		Engineers	
		Number	Percent	Number	Percent
1981....................	3,420	2,369	64.3	1,051	30.7
1982....................	3,547	2,488	70.1	1,059	28.9
1983....................	3,727	2,632	10.6	1,095	29.4
1984....................	3,886	2,739	70.5	1,147	29.5
1985....................	4,079	2,873	70.4	1,206	29.6
1986....................	4,251	3,000	70.6	1,251	29.4
1987....................	4,588	3,174	69.2	1,414	30.8
1988....................	4,803	3,222	67.1	1,581	32.9
1989....................	5,115	3,427	67.0	1,688	33.0
1990....................	5,421	3,669	67.7	1,752	32.3
1991....................	5,628	3,784	67.2	1,844	32.8
1992....................	5,860	3,979	67.9	1,881	32.1
1993....................	6,028	4,055	67.9	1,973	32.8
1994....................	6,223	4,177	67.1	2,046	32.9
1995....................	6,388	4,350	68.1	2,038	31.9
1996....................	6,619	4,552	71.3	2,067	31.2

NOTE: The engineers included here are those who perform research.

SOURCES: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1981 a 1995); and Departamento de Información y Departamento de Estudios, CONICYT, Chile.

Table 13. Percentages of scientists and engineers at universities					
Year	Total number of researchers	Scientists		Engineers	
		Number	Percent	Number	Percent
1981....................	2,434	2,035	83.6	399	16.4
1982....................	2,561	2,153	84.0	408	16.0
1983....................	2,677	2,260	84.4	417	15.6
1984....................	2,789	2,363	84.7	426	15.3
1985....................	2,924	2,489	85.1	435	14.9
1986....................	3,056	2,612	85.5	444	14.5
1987....................	3,169	2,716	85.7	453	14.3
1988....................	3,279	2,817	85.9	462	14.1
1989....................	3,389	2,918	86.1	471	13.9
1990....................	3,609	3,117	86.4	493	13.7
1991....................	3,710	3,206	86.4	504	13.6
1992....................	3,942	3,406	86.4	536	13.6
1993....................	4,029	3,472	86.2	558	13.8
1994....................	4,168	3,589	86.1	580	13.9
1995....................	4,356	3,755	86.2	601	13.8
1996....................	4,583	3,960	86.4	623	13.6

SOURCES: Consejo de Rectores de las Universidades Chilenas, *Anuario Estadístico* (Santiago, Chile, 1981 a 1995); and Departamento de Información y Departamento de Estudios, CONICYT, Chile.

Table 14. Total scientists and engineers per 1,000 population

Year	Active population (Thousands)	Scientists and engineers	Per / 1,000
1981	3,815.1	3,420	0.90
1982	3,897.4	3,547	0.91
1983	4,127.3	3,727	0.90
1984	4,174.5	3,886	0.93
1985	4,239.3	4,079	0.96
1986	4,346.9	4,251	0.98
1987	4,392.3	4,588	1.04
1988	4,551.6	4,803	1.06
1989	4,674.6	5,115	1.09
1990	4,728.6	5,421	1.15
1991	4,794.1	5,628	1.17
1992	4,990.4	5,860	1.17
1993	5,219.3	6,028	1.16
1994	5,299.5	6,223	1.17
1995	5,538.2	6,388	1.15
1996	5,776.9	6,619	1.15

SOURCES: Instituto Nacional de Estadísticas, INE, *Anuarios Estadísticos,* años: 1984 a 1994, Santiago, Chile; Banco Central de Chile, Boletines Mensuales, años: 1984 a 1996 Santiago, Chile; Consejo de Rectores, *Anuarios Estadísticos,* años: 1982 a 1995; and Departamento de Información y Departamento de Estudios, CONICYT, Chile.

esis, one reasonable way to analyze the productivity level of engineering sciences and technology research in a developing country like Chile would be to look into indexed mainstream articles at the Institute of Scientific Information (ISI) over a defined period of time (Zumelzu 1997).

Such an analysis allows one to quantify and evaluate research activities in a given field, which indirectly may be a basic reflection of graduate activities performed in a given country. According to ISI data, the contribution of Latin American countries to indexed scientific publications accounts for only 1.3 to 1.8 percent of the world's total; of this, Brazil, Argentina, Mexico, and Chile represent a solid 85 percent of Latin America's contribution (Appenzeller 1995). When considering the number of publications per million inhabitants, Chile occupies the first place, followed by Argentina (Ayala 1995). In contrast, Latin American engineering publications, when compared to other disciplines, do not exceed 5 percent of the total, of which Chile has the lowest impact (Krauskopf et al. 1995).

Final Remarks

This presentation updates as well as summarizes the most relevant issues that have defined the state of development of graduate education in Chile. Although its standards remain high, graduate education has a low representation in university life in Chile. To increase its prominence as a key instrument for social and technical development, stronger support from the state is required, in close association with traditional universities and—hopefully—the private sector as well. A 5-year state program supported by the World Bank oriented to graduate education is in the process of being implemented in Chile, thus providing new reason for optimism.

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Mexico, Colombia, and Venezuela

Hebe Vessuri

Mexico

Recent Reforms and Trends

In 1987, the National Council for Science and Technology (CONACYT) started a support program in Mexico for graduate courses that required all graduate programs to provide data about their current state, curricula, enrollment, graduates, teaching staff, etc. In addition, members of an ad hoc evaluation committee visited each program. Although only a limited number of programs responded to this initiative at first, public universities, together with educational authorities, did make an effort to increase the number of responding graduate programs; 8 years later, CONACYT had accredited 614 graduate programs. By 1996, however, this number had dropped substantially from 614 to 478 accredited graduate programs. This drop may be explained in terms of a change in the evaluation criteria recently applied by CONACYT and to the disappearance of the "others" category. With some ups and downs, a group of 160 doctoral programs (33.5 percent of the accredited graduate programs) has been established that competes with some high-level doctorates abroad. However, only a small number of domestic doctoral programs have achieved such a level of quality. Among the doctoral programs, 18.8 percent are in the basic sciences, and 16.9 percent are in engineering.

Table 1. Mexican graduate population by field of study, 1991-96

Field	1991	1992	1993	1994	1995	1996
Total	425	453	461	574	614	478
Basic sciences	46	52	55	64	74	68
Natural sciences	32	36	31	36	36	29
Health	34	41	43	51	52	35
Earth sciences	20	19	17	18	20	18
Social sciences	52	59	70	95	107	103
Human & behavioral sciences	51	52	48	67	69	45
Applied & engineering sciences	109	103	102	131	135	97
Biological applied sciences	81	91	95	112	121	83

SOURCE: National Council for Science and Technology (CONACYT) <<http://www.main.conacyt.mx1/>>, 1998.

In the Government Program of Science and Technology (Programa de Gobierno de Ciencia y Tecnología 1995-2000), the training of human resource professionals was given priority, due to the insufficient quantity and quality of those already in the workforce. It was agreed to support more strongly high-quality doctoral programs offered by Mexican institutions through evaluation by groups of prestigious academics and better fellowships to the students enrolled in these programs, and by establishing a postdoctoral fellowship program for those graduating from such programs. As a result of continuous effort, graduate enrollment grew 129.48 percent between 1987 and 1997, to a total of 87,696 students. Adding to this figure those who were abroad (data available for 1995-96 indicate that there were 3,360 Mexican graduate students abroad) yields a total global graduate population of over 91,000. It is estimated that postgraduates represent slightly over 1 percent of those new employees who join the workforce each year.

Many a graduate program, even within the same institution, tends more to disintegration than to union, collaboration, and collective effort; moreover, they are often centered in groups that are not highly productive, as reflected in times to degree completion. Perhaps the most disturbing feature is the scant number of students with few instructors in some fields. The small number of graduates produced in the different fields therefore comes as no surprise; this in turn results in very low growth of research scientists and engineers.

A frequent complaint is the lack of connection between *licenciatura* and graduate programs, and between teaching and research programs. Often, an institution hires researchers with the aim of strengthening its teaching through lecture-giving, rather than making it a requisite part of the program that students spend a work period in a research group. The old system of laboratory practices is frequently preferred, although some universities have very well-furbished research labs, and excellent students could undoubtedly be oriented toward the graduate level and research.

Table 2. Number of graduate programs accredited by field of knowledge in Mexico, 1991-97						
Field	1991	1992	1993	1994	1995	1996-97
Total	425	453	463	574	614	NA
Doctorate	118	120	129	172	195	160
Basic sciences	25	30	30	35	41	38
Natural sciences	21	23	18	19	19	15
Health	21	26	28	33	31	21
Earth sciences	11	11	10	11	12	10
Social sciences	43	49	59	73	81	77
Human and behavioral sciences	32	37	32	45	46	29
Applied and engineering sciences	84	78	77	96	98	70
Biological applied sciences	60	69	70	82	84	58
Master's	297	323	324	394	412	318
Basic sciences	25	30	30	35	41	38
Natural sciences	21	23	18	19	19	15
Health	21	26	28	33	31	21
Earth sciences	11	11	10	11	12	10
Social sciences	43	49	59	73	81	77
Human and behavioral sciences	32	37	32	45	46	29
Applied and engineering sciences	84	78	77	96	98	70
Biological applied sciences	60	69	70	82	84	58
Others	10	10	10	8	7	NA
Basic sciences	3	3	2	2	2	NA
Natural sciences	0	1	1	1	0	NA
Health	0	0	0	0	0	NA
Earth sciences	1	0	0	0	0	NA
Social sciences	1	2	2	2	2	NA
Human and behavioral sciences	10	0	0	0	0	NA
Applied and engineering sciences	4	3	3	3	3	NA
Biological applied sciences	1	1	1	0	0	NA

SOURCE: National Council for Science and Technology (CONACYT) <<http://www.main.conacyt.mx1/>>, 1998.

The government's policy aims with regard to training high-level scientists and engineers include the following:

- to increase the number of fellowships for graduate studies in Mexico and abroad;
- to support training programs for the *licenciaturas* teaching staff;
- to foster increased offerings of good-quality *licenciaturas*;
- to accelerate improved quality in domestic graduate programs—particularly, to stimulate the establishment and accreditation of high-level doctoral degrees comparable to those available internationally in the coming years; and
- to promote improved professional training in the sciences and engineering.

Levels of Graduate Enrollment and Degrees in Mexico

Enrollment. The development of higher education in Mexico is necessary to support research and improve the training of teaching staff within higher education itself, as well as influencing the remaining levels and subsystems of education. At the present time, most higher education teachers (about 80 percent) have only a first degree (*licenciatura*), and the number of researchers in this country of 90 million is less than 10,000. If the figures of the National System of Researchers (SNI) are taken as a reliable indicator, the development of the scientific endeavor in Mexico—particularly in connection with training the future generation of scientists—rests upon a little over 5,000 people in SNI levels I, II, and III (1997).

As far as graduate education is concerned, enrollment is very low (87,696) relative to the *licenciatura* (1,310,229) and normal education[1] (188,353) programs; it represents only 5.85 percent of total higher education enrollment in Mexico—thus indicating the need to give priority to the growth of graduate education. Note, however, that graduate enrollment has more than doubled in the last 10 years, rising from about 38,200 in 1987 to about 87,700 in 1997. (See appendix table 1.)

Although the proportion of students seeking education in science and technology in Mexico is not significantly different from that of more industrialized countries, the schooling rate of the age group is lower, because the latter students have more extensive nonuniversity sectors that provide shorter training of a more practical and vocational nature—i.e., more students have a nonuniversity education adequate to meet the conditions of the employment market. Qualified observers of the Mexican educational system notice a weak enrollment in training for work and terminal secondary higher education,[2] which on the whole comprises barely 3 percent and has lost its attractiveness since the 1980s (OECD 1997, p. 38). The modalities of what in many countries is called post-obligatory secondary education and in Mexico is known as *formación media superior*, its content, and its structure help explain to a large extent the evolution of the demand for higher education. It is also at that level that many countries offer broad possibilities for technical and professional training. It is for this reason that Organisation for Economic Co-operation and Development (OECD) examiners called attention to the need for observing the extent to which these training programs coincide with those of higher education. In Mexico, this educational level has traditionally had a preparatory function: many educational institutions depend directly upon higher education institutions. It thus seems advisable, when trying to get an overview of higher education and the role of graduate education, not to disregard the complex structure and interlocking levels and subsystems.

Higher education in Mexico has a long history. It has managed to educate an internationally recognized intellectual and professional elite, but the mean level of education and professional qualification continues to be very modest. The organizational framework within which the Mexican system of higher education fulfills its function is through the following programs and levels of study: (1) the *licenciatura* level, traditionally associated with professional training; and (2) graduate studies, specifically specialization certificates and master's and doctoral degrees. To complete a *licenciatura* takes from 4 to 6 years; specializations take 1 year, except for medical options; master's programs, 2 years after *licenciatura*; and doctoral studies from 2 to 3 years after the master's degree or from 4 to 5 years after the *licenciatura*. However, the *licenciatura* or first degree often takes a considerably longer period to be completed.

As far as the public sector is concerned, these levels of study operate in a very complex political and administrative setting of institutions of higher education dependent on the federal and state governments. These, in some cases, have to deal with the Secretariat of Public Education (SEP); in others, with the Secretary of Finance and Public Credit; and in still others, with the presidency.

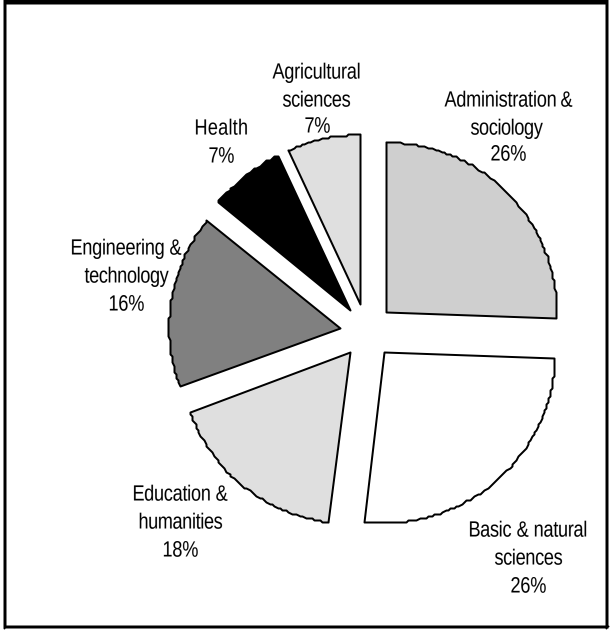
Enrollment in Doctoral Programs. Growth at the doctoral level has been remarkable in relative terms, with a 342.85 percent rise in the 10-year period under consideration. During that same time, the master's level grew 151.68 percent, and the specialist's degree level had an increase of 66.15 percent. But the participation of the population in doctoral programs continues to be minimal (rising only from 1,400 to 6,200 in 10 years) relative to that in master's programs, which still have the bulk of enrollment with 59,900 students, and specialist programs, with 21,600. At the doctoral level, the distribution of enrollment by field is relatively homogeneous: 26 percent corresponds to the basic and natural sciences, 7 percent to health and applied biological sciences, 26 percent to social and administrative sciences, 18 percent to education and humanities, and 16 percent to engineering and technology. But only two disciplines had more than 500 students enrolled: biology (522) and education (668) in

[1]Normal education, which involves the training of basic education teachers in normal schools, is included here with higher education, because the degree granted since 1984 is that of *licenciatura*. However, normal education has its own identity in terms of curriculum, organization, and ideology.

[2]Secondary education lasts 3 years and is offered to the 12- to 16-year-old population that has completed primary school. It is provided in the following modalities: (1) *general secondary*, which accounts for the largest proportion of enrollment; (2) *technical secondary*, which simultaneously provides general education and terminal training for productive activities in four fields: industry, agriculture, fishing, and forestry; (3) *secondary for workers*, which is given at special times and sometimes in the workplace; and (4) *telesecondary*, created to give opportunity to inhabitants of small and isolated communities.

1997; physics followed with 413, social science with 342, chemistry with 291, agronomy with 270, and anthropology and archaeology with 246. All other fields had meager populations of fewer than 100 students.

Figure 1. Doctorate student population by field of study in Mexico, 1997 (percent)

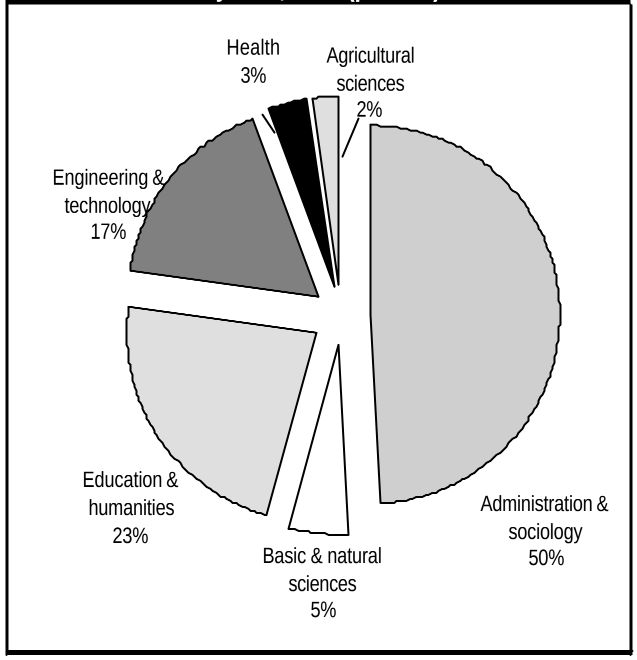


SOURCE: Asociacíon Nacional de Univeridades e Instituciones de Educación Superior (ANUIES). Anuario Estadístico, 1997.

Accepting the premise that the doctorate is the best means to train researchers and advanced teachers, the small number of Mexican doctoral students both in the country and abroad is clearly a limiting factor for the country. When looking at potential supply and demand given the number of researchers in the SNI (5,000, excluding candidates), with good planning, a greater number of graduate students could attend than is the case at the present time; this would raise the current figure by a factor of three. Also, there are enough candidates who could enroll in doctoral programs—i.e., students newly graduated from master's programs—as well as teaching staff who do not yet have a doctoral degree.

At the master's level, enrollment is dominated by the social and administrative sciences, keeping the same proportion as at the *licenciatura* level: i.e., approximately half the total enrollment. There follow in importance education and the humanities with 23 percent, engineering and technology with 17 percent, and the basic and natural sciences with 5 percent. The remaining fields (health and agricultural sciences and technologies) have marginal enrollments of 2 or 3 percent each. By far the most impressive concentration is in anthropology and archaeology, which had 16,923 students in 1997; followed by education (10,455) and law (2,851); taxes and finances (2,425); psychology (2,248); and economy and development (2,104).

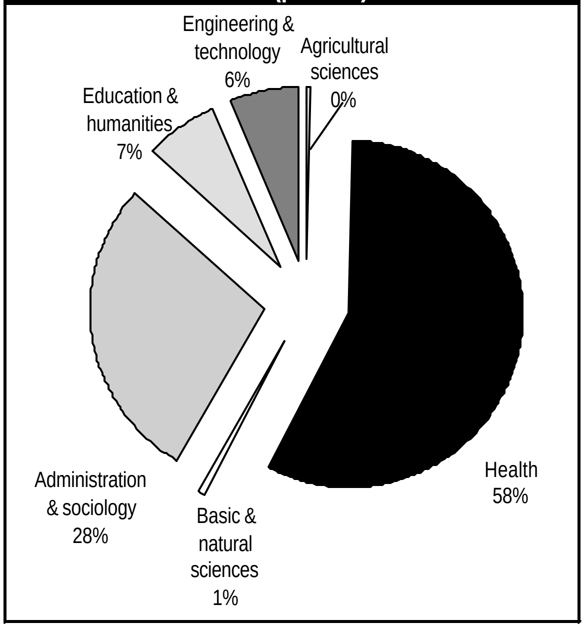
Figure 2. Master's student population in Mexico by field, 1997 (percent)



SOURCE: Asociacíon Nacional de Univeridades e Instituciones de Educación Superior (ANUIES). Anuario Estadístico, 1997.

Specialization studies are graduate studies carried out after the *licenciatura* which prepare students for work in a specific field of professional endeavor without constituting an academic degree. In 1997, 21,600 students were enrolled in specialization programs, or 24.62 percent of total graduate enrollment. At the specialist level, most of the enrollment has historically been concentrated in the health sciences, due to the fact that medicine and dentistry professional specializations are obtained through this means. However, the proportion of enrollment captured by the health sciences and technologies at this level has been decreasing. In 1985, it represented 80 percent of total enrollment, compared to less than 70 percent in 1992; by 1997, only 57.3 percent of the total population was at this level. This phenomenon may be explained by the proliferation of specialist programs (generally diploma courses) in the social and administrative sciences, in which absolute enrollment had a threefold increase during the period of reference; and, to a lesser extent, by the growth of certificates in education and in engineering and technology. In the remaining fields, enrollment has also shown an upward trend, although with less intensity.

Figure 3. National concentration of specialties: student population by field and program in Mexico, 1997 (percent)



SOURCE: Asociacíon Nacional de Univeridades e Instituciones de Educación Superior (ANUIES). Anuario Estadístico, 1997.

The SEP has made a real effort to decentralize higher education. Whereas in 1970, over half the enrollment in higher education was located in the Federal District (D.F.), today this zone has only a fifth of national enrollment. There continues, however, to be a significant concentration in the territorial distribution of graduate enrollment. In 1985, over half the enrollment was concentrated in the universities located in the capital city; by 1997, the D.F. continued to have over 41 percent of total graduate enrollment, although a significant effort at decentralization was also noticeable. In 1985, three states still lacked master's programs (Aguascalientes, Chiapas, and Quintana Roo); in 1992, only Quintana Roo was without programs at this level. In that year, however, more than 80 percent of doctorates were awarded to individuals in the D.F.

Along with the territorial distribution is an institutional concentration, which includes outstanding names such as UNAM, which alone has 23.7 percent of all graduate enrollment in the country, as well as the Autonomous Metropolitan University (UAM), the Iberoamerican University, and the National Polytechnic Institute (IPN). Some institutions outside the Metropolitan Zone also have large concentrations of graduate students, particularly at the master's level. Among these are the University of Guadalajara, the University of Nuevo León, and the Technology and Advanced Studies Institute of Monterrey. Finally, there is a concentration of graduate studies and research in the public sector, which accounts for over three-quarters of enrollment, and nearly 87 percent in specialist and doctoral programs.

Table 3. Main geographical concentrations of Mexican graduate student population, 1997

State	Number of enrollments	Number of graduates
Total	87,696	20,203
Specialization	21,625	8,305
Federal District	11,192	3,988
Mexico	1,438	777
Jalisco	1,873	673
Puebla	660	341
Master's	59,913	11,164
Federal District	15,669	3,050
Nuevo Leon	7,169	1,269
Puebla	4,425	815
Mexico	3,934	812
Doctorate	6,158	734
Federal District	3,665	503
Guanajuato	342	35
Mexico	338	36
Jalisco	139	46

SOURCE: Asociacíon Nacional de Univeridades e Instituciones de Educación Superior (ANUIES). *Anuario Estadístico. Poblacio escolar de posgrado.* México, D.F.

Female participation grew very considerably between 1984 and 1996, although males still dominate in some fields. Over this period, female enrollment went up 248.8 percent in master's programs and 325.7 percent in doctoral programs; male enrollment grew 116.1 percent at the master's level and 381.9 percent at the doctoral level—a clear reflection of the great expansion of studies at this level (see appendix tables 2, 3, and 4). In 1997, females accounted for 40 percent of enrollment in master's programs and in 34.42 percent in doctoral programs.

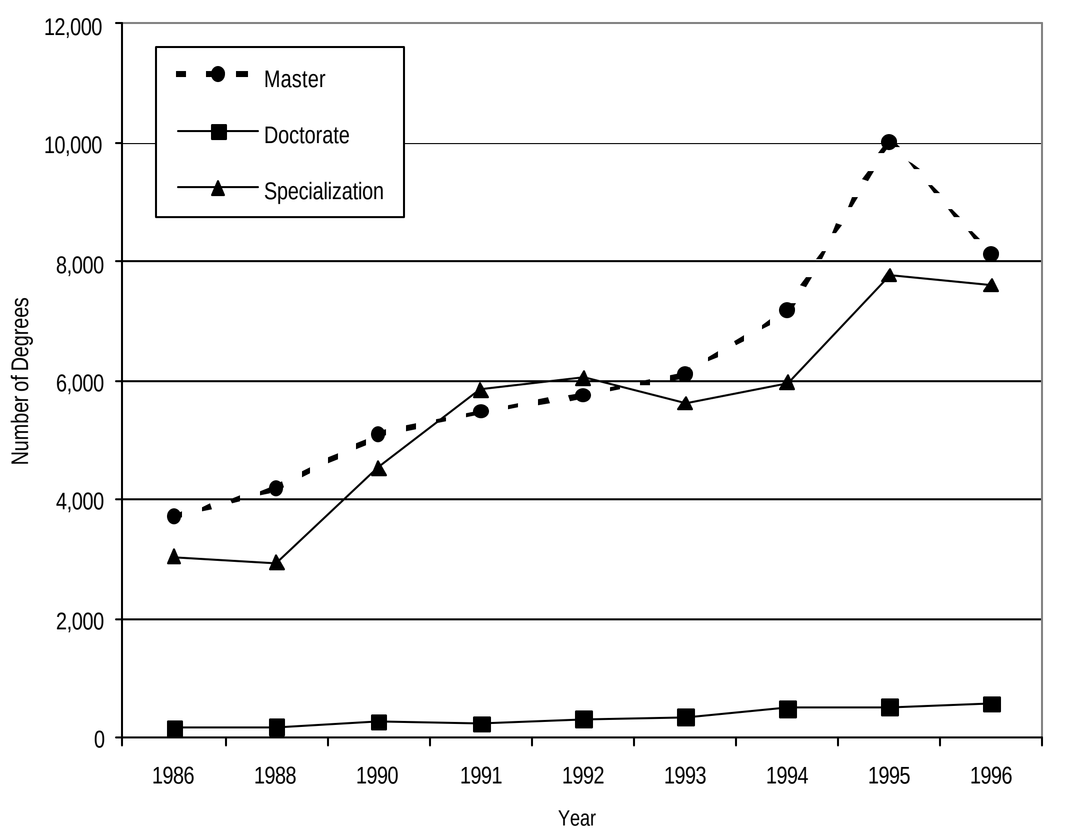
Doctoral Degrees. The number of graduates of doctoral programs has remained very low despite undeniable advances. In 1984, distribution by degree was 3.69 percent doctoral graduates (245 individuals), 54.86 percent master's graduates (3,640), and 41.43 percent graduates of specialist programs (2,749). In 1995, those proportions showed little variation: 2.83 percent doctoral graduates (519 individuals), 54.71 percent master's graduates (10,008), and 42.44 percent graduates of specialist programs (7,764). By 1996, there was a recovery in the proportion of doctorates relative to the total graduating population, increasing to 3.63 percent (734 doctorates); graduates of master's programs represented 55.25 percent (11,164 persons) and from specialist programs, 41.10 percent (8,305 individuals) (SEP-CONACYT 1997, p. 146, table II.27; and ANUIES 1995 and 1997).

The distribution of doctoral graduates by field in 1996 was as follows: over half (54 percent) corresponded to the social and human sciences combined, 17 percent to the basic and natural sciences, 14 percent to health, 8 percent to engineering and technology, and 7 percent to agricultural sciences and technologies. The most remarkable change is the increment of doctorates in the field of health, showing a 75 percent increase relative to 1995. The agricultural sciences also show a remarkable 140 percent increase in number of doctorate recipients, although the absolute figures are small (48 individuals in 1996).

As far as geographical distribution is concerned, the Federal District continues to show an increasing concentration in the number of graduates produced relative to the rest of the country. In specialist programs, the proportion rose from 19.60 percent of graduates in the D.F. in 1984 to 39.78 percent in 1995. At the doctoral level, compared to 59.59 percent of graduates in the D.F in 1984, there were 64.54 percent in 1995. A reduction is observed only at the master's level: graduates in the D.F. comprised 35.41 percent in 1984 and had decreased to 26.15 percent by 1995. At a university like UNAM, between 1989 and 1996, the granting of degrees at the doctoral level increased 69 percent (329 in 1997), with 31 percent for master's candidates (1,044) the same year. It is intriguing that the data collected for enrollment and degrees, if correct, indicate that those pursuing a doctorate degree in the D.F. are less likely to complete their degree than those pursuing a doctorate outside the D.F. We do not yet have an explanation for this.

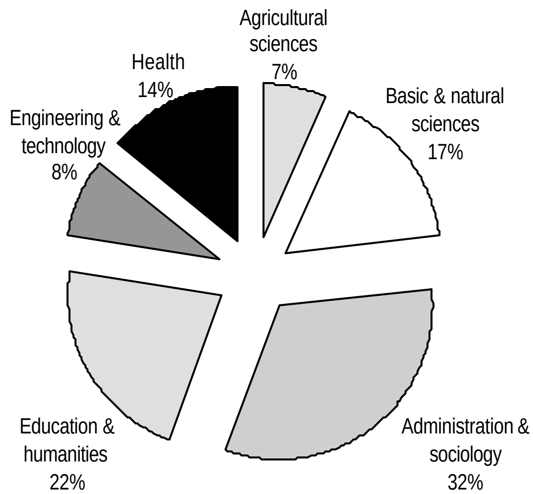
On a cursory level, the number of researchers in some disciplines—such as biology, medicine, and chemistry, with 973, 410, and 317 SNI researchers, respectively in 1997-98—does not seem so scant. Differentiating by subfield, however, reveals significant differences, with some areas showing a potential for improvement and

Figure 4. Graduate degrees earned by Mexican citizens by level of study, 1986-96



SOURCE: Asociacíon Nacional de Univeridades e Instituciones de Educación Superior ANUIES, Anuarios Estadísticos de Posgrado, 1985-96.

Figure 5. Doctoral graduates in Mexico by field of knowledge, 1996



SOURCE: Asociacíon Nacional de Univeridades e Instituciones de Educación Superior ANUIES, Anuarios Estadísticos de Posgrado, 1985-96.

growth (e.g., biochemistry and physiology); and others having only a small number of researchers in the local context and thus an apparently small potential for growth (e.g., biophysics among many others). These limitations may affect the future development of new sciences and technologies (Peña 1995, pp.15-18). The same author calls attention in another work (1994, pp. 23-27) to a lack of students, particularly at the doctoral level. He argues that science teaching is one of the weak points in the Mexican educational system, and that one of the mechanisms for attracting the young to research entails integrating them at an early stage in groups that carry out research. Peña urges increased promotion of graduate programs, although he admits that, in the biological fields, there are few places that offer adequate features conducive to fostering research.

Time to Degree. Terminal efficiency—or time to degree—has improved over time. The efficiency of the higher education system is calculated globally, correlating enrollment in a given year with graduation from the institutions 5 years later, which is the average official duration of undergraduate studies (*licenciatura*). Results obtained from the number of graduates in the 1990s give an average efficiency of slightly over 54 percent. This represents an improvement over values observed in the 1970s, when the efficiency proportion hardly reached 45 percent, and over the 1989-90 to 1993-94 period, when it was 49 percent and showed marked variations by course of study.

Improvements seem to have occurred especially at the doctoral level; this is basically attributed to the type of program and support given to graduate students during the period of thesis work. In a field like physics, which has been closely followed by analysts for the last 10 years, it is argued that the terminal efficiency of the graduate programs of the Center for Research and Advanced Studies (CINVESTAV) are the highest in the domestic context. Figures for graduates in physics doctoral programs in Mexico are given in table 4.

Among doctorate recipients from Mexico in the United States, the average time from baccalaureate to Ph.D. is 10.3 years, and the average registered time is 6.5 years; this latter varies between 5.4 years in the computer/information sciences to 6.8 years in the physical sciences and psychology/social sciences. (See appendix table 6.)

Table 4. Graduates from Mexican doctoral programs in physics, 1986-95

Institution	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	Average 1992-95 (1981-95)	TE* percent
Total......................	12	14	21	20	21	27	25	20	30	39	34	-
UNAM................	8	7	7	6	8	8	12	4	8	8	8 (8)	38
CINVESTAV.......	2	2	4	8	3	6	6	6	4	7	6 (5)	86
CICESE.............	-	2	3	1	4	3	2	3	6	6	4 (3)	
INAOE...............	-	1	-	-	-	1	1	1	1	4	2 (-)	40
Others................	2	2	7	5	6	9	4	6	6	14		

KEY: (-) = not applicable
TE* = Terminal efficiency for the last three generations.

NOTE: Average number of graduate students per institution in 1991-95 and 1986-95 (in parentheses), as well as average terminal efficiency (percentage) for the three more recent generations.

SOURCE: Pérez, A., and V.G. Torrees. La disica mexicana en perspectiva. Interciencia 23(3): 163-75, 1998.

Fellowships. A high-level staff training policy absorbs significant amounts of money (10 percent of the Mexican science and technology domestic expenditure). The growth in recent years of the number of graduate students is largely a consequence of the support given by the federal government to several fellowship programs. In 1990-95, the fellowships granted by these programs increased 190 percent; 24,845 fellowships were awarded in 1995. Several institutions have important fellowship programs, among them the SEP, CONACYT, UNAM, and IPN.

The CONACYT program is the broadest fellowship program in the country. It absorbs almost half the budget resources of the institution (46 percent in 1995) and comprises 65 percent of all fellowships supported by the federal government. In 1996, it supported 18,079 students. Of these, 21 percent were individuals who went abroad to study; the remaining 79 percent studied in Mexican institutions. Of all the fellowships, 12,479 (69 percent) were for master's courses; 5,269 (29 percent) were for doctoral degrees; and 331 (2 percent) supported other studies. This program has grown more than five times in the last 5 years. (See appendix tables 7 and 8).

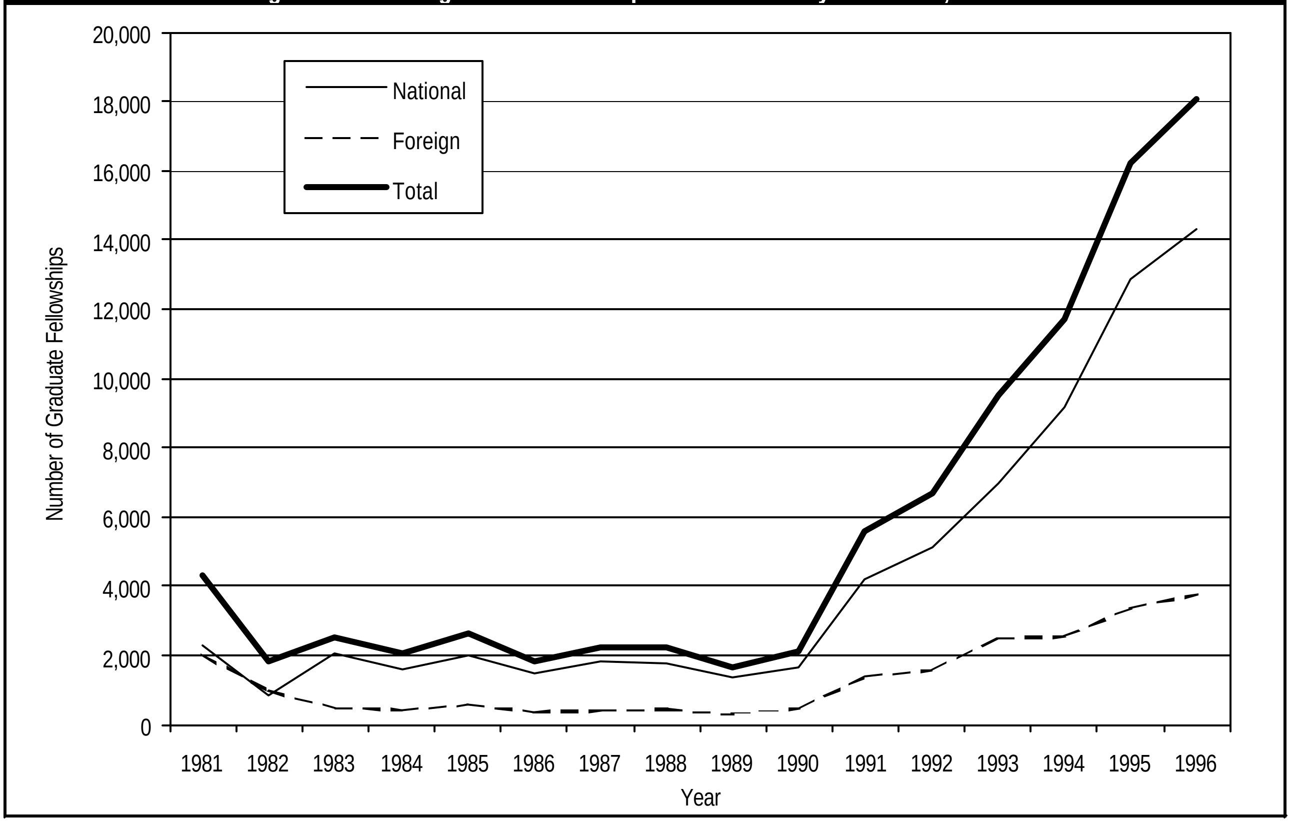
Table 5. Mexican graduate fellowships granted by administrative sector, 1989-95

Sector	1989	1990	1991	1992	1993	1994	1995/p
Total	7,548	8,572	11,900	13,426	16,451	19,057	24,845
SAGAR	-	-	-	-	-	800	1,240
SCT	30	99	159	268	118	6	8
IMT	30	93	155	264	114	0	0
IMC	0	6	4	4	4	6	8
Secofi	-	-	-	-	-	50	61
SEP	4,125	5,401	20,935	20,935	14,351	16,214	21,554
CONACYT 1/	1,677	2,135	5,570	6,665	9,492	11,703	16,200
UNAM	778	1,277	1,417	1,549	1,714	1,494	1,197
Sistema SEP-CONACYT	86	94	147	232	260	564	751
INAH	128	206	297	248	262	n.d	n.d
UAM	90	158	92	91	270	295	350
IPN	1,170	1,344	1,552	1,717	1,860	1,735	2,593
UPN	0	3	1	11	39	NA	NA
Cinvestav	-	-	-	-	-	107	147
DCIT	196	184	422	422	454	316	316
Salud y S.S.	-	-	-	-	-	613	760
Semernap	20	24	31	19	19	138	156
Energía	3,358	2,947	2,203	1,959	1,844	402	380
IIE	369	464	466	504	394	273	239
IMP	2,840	2,405	1,588	1,295	1,321	129	141
ININ	149	78	149	160	129	0	0
PGR	15	32	124	145	37	689	538
SHCP	-	69	84	100	82	145	148
Total amount (m.N.P)	41,332	54,106	89,795	155,050	248,098	406,659	676,759

KEY:
p/= preliminary figures
(-)= not applicable
NA= not available
SAGAR= Agriculture, Livestock & Water Resources Secretary
IMT= Mexican Transport Institute
Secofi= Commerce & Industrial Promotion
CONACYT= National Council for Science & Technology
Sistema SEP-CONACYT= SEP-CONACYT Research Centers
INAH= Anthropology & History National Institute
IPN= National Polytechnic Institute
Cinvestav= Research & Directorate of Technological Institutes
m.N.P.= thousands of new pesos
SCT= Transport & Communication
IMC= Mexican Communication Institute
SEP= Secretariat of Public Education
UNAM= National Autonomous University in Mexico
UNAM= Metropolitan Autonomus Univ.
UPN= National Pedagogic University
Salud y S.S.= Health & Social Security
Energía= Energy
IIE= Institute of Electrical Research
ININ= National Institute of Nuclear Research
SHCP= Finance & Public Credit
PGR= Office of the General Attorney of the Republic

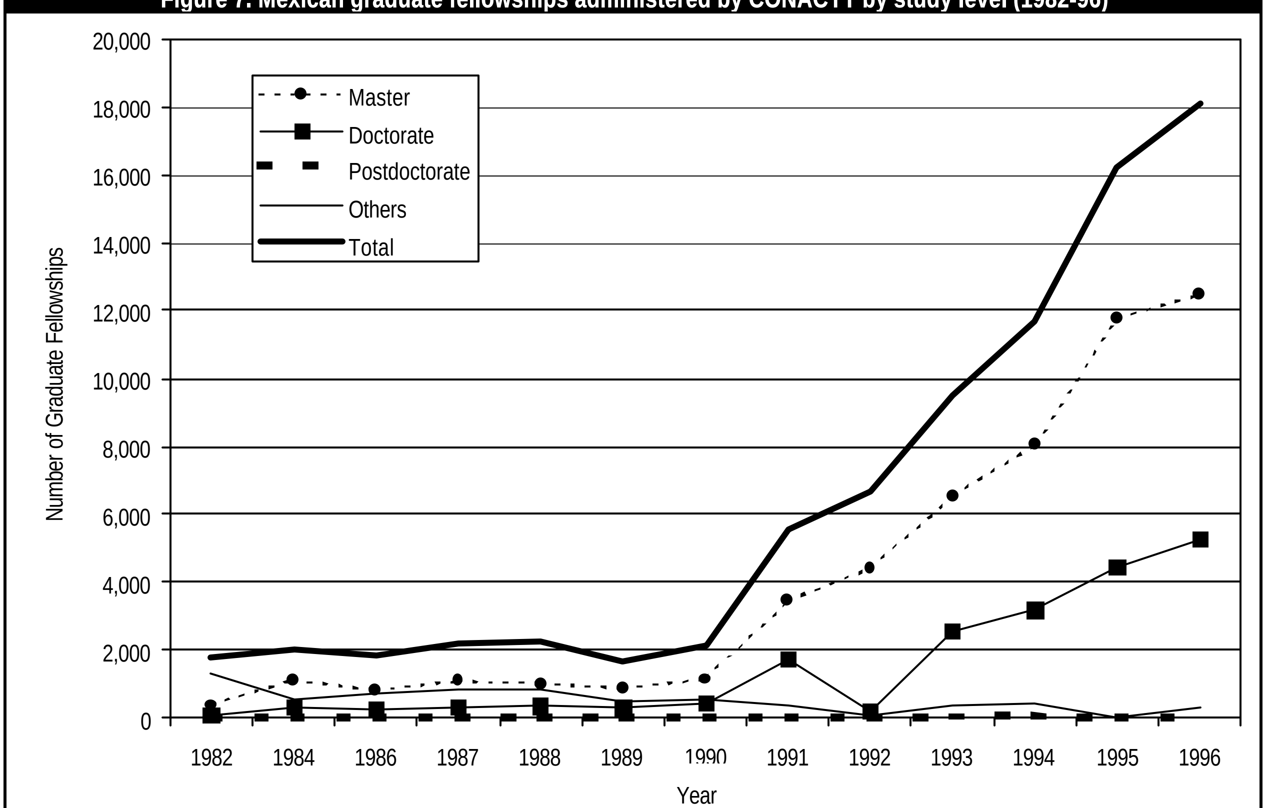
SOURCE: National Council for Science and Technology, (CONACYT) (n.d.).

Figure 6. Mexican graduate fellowships administered by CONACYT, 1981-96.



SOURCE: National Council of Science and Technology Studies (CONACYT), Mexico.

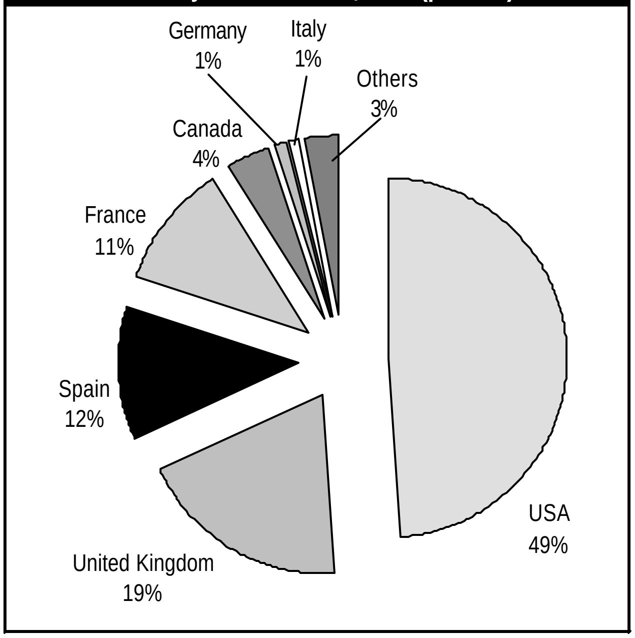
Figure 7. Mexican graduate fellowships administered by CONACYT by study level (1982-96)



SOURCE: National Council of Science and Technology Studies (CONACYT), Mexico.

Of the fellowships abroad, there is a large concentration of students in the United States (49 percent), followed by the United Kingdom (19 percent), and Spain and France (12 and 11 percent, respectively).

Figure 8. Mexican distribution of fellowships abroad by country of destination, 1997 (percent)



SOURCE: National Council for Science and Technology (CONACYT) <<http://www.main.conacyt.mx1/>>, 1998.

When the program was established, the general intention was for CONACYT to recover a major portion of the funds. Thus, support was generally granted in the form of loans. The program was also intended to track its results. Depending on the loan amount, loans may be either all-inclusive or complementary; they also may be for master's or doctoral degrees, or for postdoctoral fellowships. For a variety of reasons, both the recovery of funds and the follow-on tracking of graduates have been deficient. Lack of loan repayments has severely restricted the growth of funds intended for this end; also, given the limited tracking, the results of the support provided are not known for certain. The program should increase its coverage, improve its operational efficiency, and obtain greater social participation in funding. Experience has shown that program expansion depends on institutional capacity to attract outside financial resources.

Data from the National Science Foundation (NSF) on Mexican recipients of doctorates in the United States provides information regarding several aspects of the collective behavior of this population. For example, it indicates that 80.7 percent of this population are males, 65.6 percent are married, and the median age at Ph.D. is 34.5 years. (See appendix table 6.) Almost half of the doctorate recipients (46.9 percent) are supported by their own families, particularly those in non-science and -engineering fields (65.7 percent). The category "personal sources of support" includes a recipient's own earnings, family support, and loans. Another 45 percent are supported by a foreign government, which may be interpreted as the Mexican government (i.e., official Mexican fellowship programs including universities, teaching or research assistantships, etc.). There is no equivalent information for groups of Mexican individuals studying in other countries, but some similarities can be presumed, except that teaching or research assistantships seem to be more common in the United States than elsewhere.

CONACYT has implemented actions to support high-quality doctoral programs in Mexico. For example, in 1996, through the Program for the Strengthening of Domestic Graduate Education, it supported 26 graduate programs in higher education institutions with the aim of enlarging their infrastructure, documenting curriculum portfolios, and/or hiring visiting professors for periods not exceeding 1 year. The main recipients were El Colegio de Mexico and CINVESTAV, which together received 35 percent of all actions approved and were geared mostly to the social and exact sciences. Nevertheless, there are still only a few high-quality graduate programs, and they receive fewer applications for enrollment than ought to be the case: many qualified students who could enroll in them fail to do so, partly because they get better fellowships to study abroad. Solving this kind of problem is important because it would serve as an incentive to improve quality in domestic graduate education.

The degree qualifications of academic staff have been improving, although they are still quite insufficient for both teachers and researchers. It is estimated that only 2.5 percent of *licenciatura* teachers have a doctoral degree, while 56 percent have only a *licenciatura*. In these figures, the considerable weight still exerted by the number of teachers-by-the-hour (the *eventuales*) becomes a heavy institutional ballast, for it is difficult to motivate staff to devote time and effort to professional development when their employment condition is so fragile. There is a trend to increase the proportion of permanent positions (full-time and part-time dedication regimes) to the detriment of those covered by *eventuales* teachers. The current understanding of the problem is that the teacher-by-the-hour is always an interesting figure to have in an institution when hoping to bring closer to the university domain people who have other employment, particularly in industry or the services. Such employees, however, should always be a small proportion of the total staff; in Mexico, though, they constitute a large proportion (over 60 percent). CONACYT has instituted a special fellowship program since 1991 to stimulate university teaching staff to carry out post-*licenciatura* studies.

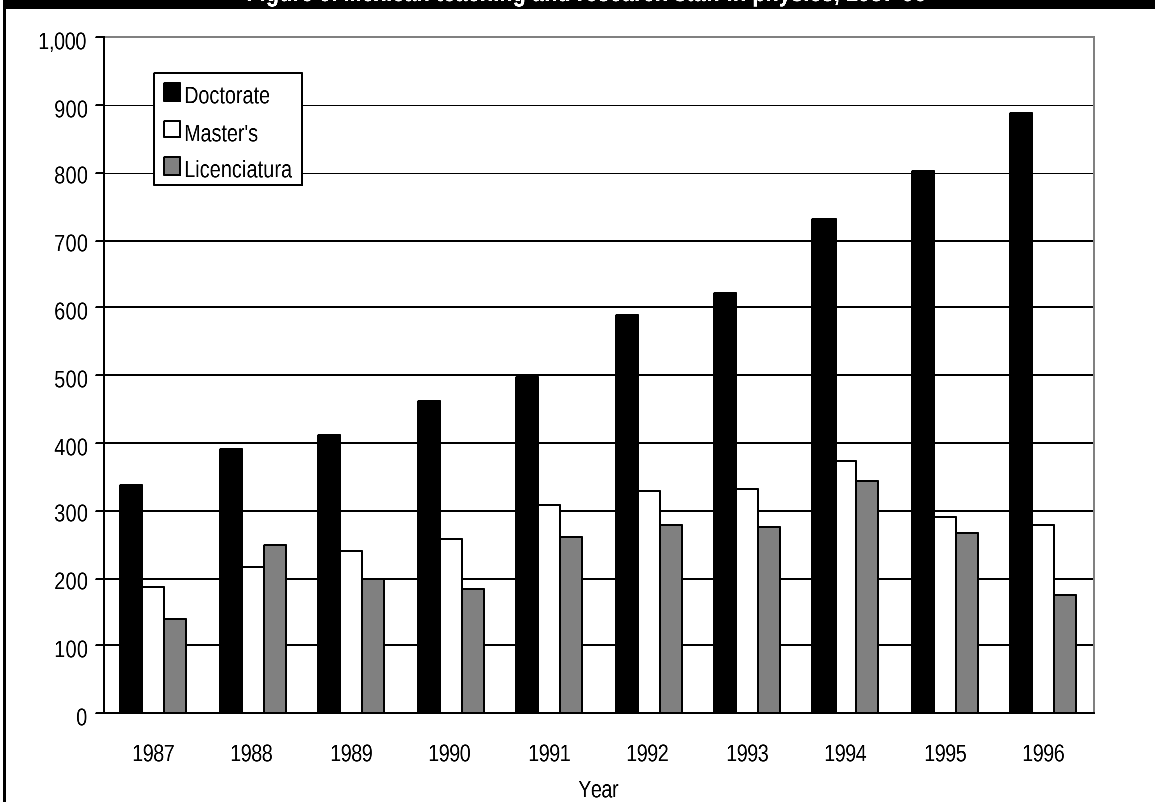
According to an influential viewpoint common in research and development (R&D) circles, new teacher positions should be reserved for persons holding a doctorate or who have a master's degree and are studying in a doctoral program. It is obvious that there is a real and potential demand for master's and doctoral programs. The evolution of teaching and research staff qualifications in the field of physics in Mexican institutions, on which detailed quantitative data are available (figure 9), may be taken to illustrate developments in some fields. But it must also be mentioned that U.S. universities have become more attractive than ever for numerous families who send their children to that country to continue or complete their studies.

International Mobility of Students and Researchers

Although the international relationships of the Mexican scientific community have broadened, especially with the United States and Europe, a good portion of the scientists and technologists are still at the margins of internationalization. Additionally, high-level foreign scientists and technologists do not come to Mexican institutions and research centers for long periods. Mexican students who go abroad to carry out undergraduate and graduate studies represent a modest proportion of total enrollment. In almost all cases, their stay is prolonged. Inversely, the flow of foreign students to Mexican university institutions and research centers is scarce; in general, it is reduced to brief periods.

According to the NSF statistical profile of Mexican doctorate recipients for the 1988-96 period, 1,115 persons were on temporary visas versus 244 on permanent visas

Figure 9. Mexican teaching and research staff in physics, 1987-96



SOURCE: Pérez, A., and V.G. Torrees. La disica mexicana en perspectiva. Interciencia 23(3): 163-75, 1998.

in the United States. Of these, 518 planned to stay longer in the United States, 28.8 percent to carry out postdoctoral studies; another 16.0 percent were seeking postdoctoral study posts, and 33.6 percent were in definite employment or seeking employment (19.5 percent) (appendix table 6).

According to another source (Noguera 1998), Mexico occupies the third place among the countries that export physicians, behind India and the Philippines; it is the first in the world in exports of young physicians less than 35 years old (31.5 percent), followed closely by India (30 percent). Mexico is also first in exporting U.S. physicians newly graduated from Mexican medical faculties who return to their country to carry out well-remunerated medical specialties, after having completed their professional medical studies in Mexico at very low cost. The same source estimates that 7 out of 10 Mexican physicians who are in the United States will stay permanently in that country. Therefore, the effort to repatriate young physicians is not an exclusive responsibility of the government's support programs for scientists.

International mobility is supported by fellowships funded by a number of bilateral and other cooperation mechanisms. They can be by agreement with foundations and governments, by open demand in agreement with universities, or in programs without subsidy. Fellowship amounts and conditions depend on the benefits that third governments, foundations, or other institutions may choose to grant. For example, for the year 1999, the number of loans offered in open demand without subsidy is 583 (this figure includes the offer of universities that have agreements with third-country institutions).

Among the fellowships that are made available by these cooperation mechanisms, the following may be mentioned in connection with CONACYT: with the United States, there is the Fulbright-García Robles program for master's and doctorate degrees, consisting of 80 fellowships for engineering and natural and exact sciences, and 40 fellowships for social sciences, including the following disciplines: economics, education, sociology, philosophy, political science, anthropology, linguistics, and psychology. With Great Britain, within the framework of the Anglo-Mexican Exchange Program (British Council), a total of 10 master's and doctoral fellowships are offered in 1999 for studies in environment, agricultural sciences and fisheries, aquaculture, biotechnology, food science, and electrical and mechanical engineering. The same exchange program (British Embassy) offers five fellowships in economics, international relations, public administration and planning, business administration, and political science and law. France offers a total of 40 doctoral fellowships in civil engineering, chemical engineering, chemistry, biotechnology, biochemistry, microbiology and food science, geological engineering and mining, water resources, electrical and electronic engineering, automation, informatics, agronomy, and ecology and environment (CONACYT 1998a). CONACYT also has exchange and collaboration programs with most Latin American science and technology councils. Among the 50 foreign universities in greatest demand by CONACYT's fellowship-holders, 19 are in the United States, 13 are in Great Britain, 7 each are in France and Spain, and 4 are in Canada (see appendix table 9).

In 1991, the Presidential Fund for Retention in Mexico and Repatriation of Mexican Researchers was established, resulting in 1,149 repatriations through 1996, with the aim of reinforcing the academic staff of higher education institutions (Bonilla-Marín and Martuscelli 1997). CONACYT provides the necessary funds for 1 year to cover salaries and other monetary incentives, depending on the decision of the collective institutional organs and the evaluation committee of the repatriation program. It also covers the travel expenses of the researcher and his or her family to settle in the selected location. The funds are granted to the recipient institution and aim to facilitate the swift hiring of the researcher, thus giving time to the institution to plan the creation of the new position required within the scope of 1 year.

The program has attracted mostly young researchers willing to start their professional lives after obtaining their doctorates or carrying out postdoctoral stays (the average age is 35), while only a few Mexican senior researchers established abroad have applied. The field of biological sciences registers the highest proportion of beneficiaries, followed by those in applied sciences (biological and engineering) and basic sciences. There are few applications from the human and behavioral sciences. The D.F. has a concentration of 42 percent of all repatriated researchers. The percentage of repatriated researchers absorbed by private institutions is low (6 percent); one institution (Instituto Tecnológico de Estudios Superiores de Monterrey) has hired 4.87 percent of these. UNAM (which has absorbed 24 percent), UAM (4 percent), IPN (2.5 percent), and the technological institutes (3 percent) together comprise 58 percent of all the beneficiaries. The majority of researchers—86 percent—come from six countries: Germany, Canada, Spain, France, the United

Kingdom, and the United States. From this latter country come 38 percent of the total. It may be noticed that 2.5 percent corresponds to retention within Mexico.

Of all repatriated researchers, 62 percent have joined the National System of Researchers. Of all those repatriated in the 1991-96 period, 0.9 percent of have gone abroad again. The number of doctors added to the national scientific community through the repatriation program, although lower than that resulting from graduates from Mexican doctoral programs, is comparable to the latter number. Adding up the two contributions affords a very close approximation to the total number of doctors who each year join the Mexican scientific and technological system.

Discussion

Some of the problems detected in the domestic graduate programs in Mexico (Bazúa y Meza 1996, pp.18-19) are:

- lack of definition and little clarity in the aims and objectives of the graduate program and its options;
- weak links between graduate education and the public and private productive sectors;
- the fact that research does not constitute a training line in some master's and doctoral programs;
- few inter-institutional programs;
- insufficient multidisciplinary or interdisciplinary graduate programs;
- absence of an effective tutorial system;
- imbalance in enrollment distribution among different fields of knowledge;
- high student attrition rate;
- low graduation rates and excessive time to degree with regard to institutional expectations;
- low research productivity of teaching staff in some of the graduate programs;
- imbalances in the offer of graduate programs;
- serious educational handicaps among candidates to the graduate programs; and
- absence of links between the graduate level and the *licenciatura* and other educational levels.

In a recent report, OECD (1997) examiners concluded that it is necessary to develop the graduate level, not in an anarchic manner wherein each institution decides for itself, but through the establishment of networks, in order to try to respond effectively to the new needs of research and higher education and to avoid an onerous prolongation of already lengthy studies.

Colombia

Recent Reforms

In the last 30 years, a scientific community in Colombia has begun to take shape, characterized by faculties that concentrate considerable numbers of full-time teachers; foreigners or Colombians trained abroad in new scientific subjects; laboratory equipment quite adequate for its time, provided by international cooperation—the Inter-American Development Bank, Rockefeller and Ford Foundations, UNESCO, etc.; incipient graduate programs; and a public institution that began to fund research. By 1996, the Colombian R&D community was said to number 7,700 persons (RICYT). At the beginning of the 1990s, science and technology were assumed to be the pillars of the current development strategy of Colombia's government, reflected in the National System of Science and Technology that was established by Law 29 of 1990 and implemented in 1991 through its organization into 11 National Programs of Science and Technology: basic sciences; social and human sciences; environmental and habitat sciences; education; health sciences and technologies; agricultural sciences and technologies; industrial technology development and quality; electronics, telecommunications, and informatics; energy and mining; biotechnology; and sea sciences and technologies. The Colombian Institute for the Development of Science and Technology "Francisco José de Caldas" (COLCIENCIAS) was transferred from the Ministry of Education and assigned to the National Department of Planning, in order to increase its capacity of strengthening research and technological development and to make it serve as the technical secretariat of the National Council of Science and Technology.

Within this institutional framework, emphasis is placed on the following aspects:

- integrating the private sector through its participation in the national councils;

- creating new forms of association between the public and private sectors, based on the Law of Science and Technology, through the establishment of mixed corporations of private law;

- decentralizing research through the creation of seven regional commissions of science and technology;

- developing human resources; and

- fostering the integration of Colombian scientists and engineers into international networks of science and technology.

Graduate Enrollment and Degrees

Among the limiting factors of science and technology development, the insufficient number of researchers and qualified human resources was recognized as possibly being the main bottleneck (Departmento Nacional de Planeamiento 1994, p. 5). At the beginning of the 1990s, graduate education in Colombia was considered to be far from fulfilling its mission as a tool for the training of researchers (COLCIENCIAS 1991). In the report of the Misión Ciencia, Educación y Desarrollo produced in 1995 for the Presidency of the Republic, the following goals for capacity building in the domain of human resources in the natural and social sciences and in engineering were set for the forthcoming 10 years:

- training 8,000 scientists with doctorate degrees;

- training 10,000 specialized professionals: individuals holding professional degrees and master's or specialist graduate diplomas; and

- training 18,000 nonspecialized professionals: technologists and technicians devoted to R&D.

These figures derived from population estimates that, according to the Colombian Institute for the Development of Higher Education (ICFES), had graduated from the university in 1990—41,000 from undergraduate education and 2,500 at the graduate level. A survey on the research potential of university students showed that 6 percent of students enrolled in the experimental sciences (medicine, physics, chemistry, and biology) had the requisite conditions to become good researchers. On this basis, assuming that 3 percent of all undergraduates had such a profile and that among graduate students the percentage is closer to 10 percent, it was considered reasonable to foresee at least 1,500 professionals per year with a tendency toward research—a figure close to the 1,800 envisaged in order to reach the proposed goals. The remainder could eventually be provided with the contribution of people from previous generations that in the past could not continue their careers for various reasons but who could be absorbed by the program through the new mechanisms and incentives set in place (Misión Ciencia, Educación y Desarrollo 1995, pp. 231-35).

Table 6. Recipients of university degrees, Colombia, 1990-95

Field	1990	1991	1992	1993	1994	1995
Total	41,431	48,897	46,103	47,016	57,114	54,188
Exact and natural sciences	802	773	528	589	859	685
Engineering and technology	8,105	9,369	8,521	9,493	11,275	11,036
Medical sciences	5,208	5,874	5,758	5,307	7,071	6,968
Agricultural sciences	1,030	1,329	806	972	761	957
Social sciences	25,812	30,817	29,653	29,627	36,136	33,636
Humanities	474	735	837	1,028	1,012	906

SOURCE: Colombian Institute for the Development of Higher Education (ICFES), *Estadísticas de la Educación Superior.*

Table 7. Recipients of masters degrees or equivalent, Colombia, 1990-95

Field	1990	1991	1992	1993	1994	1995
Total	1,226	1,716	1,703	2,359	2,444	2,396
Exact and natural sciences	68	76	78	158	124	87
Engineering and technology	161	143	86	137	168	104
Medical sciences	475	625	649	849	879	920
Agricultural sciences	7	15	0	66	31	25
Social sciences	468	816	826	1,067	1,144	1,127
Humanities	47	41	64	82	98	133

SOURCE: Colombian Institute for the Development of Higher Education (ICFES), *Estadísticas de la Educación Superior.*

The aims of Colombia's current science and technology policy in this regard are to increase the quality and size of the domestic scientific community through training—especially at the doctoral level in the various fields of the natural and social sciences, and in engineering—to stimulate research and give strong incentives to researchers, while helping solve the deficit of this level of qualification in Colombian universities and enabling the generational renewal of researchers. COLCIENCIAS's policy addresses six main lines of action: training toward a degree (doctorate or master's), training in nondegree or continuing education, strengthening of domestic doctoral programs, promotion of young researchers, incentives to researchers, and support of exchange programs and visiting researchers. The government goal in 1994 was to train 2,000 new researchers in the 1994-98 period. Of these, 550 were expected to be trained at the doctoral or master's level, through COLCIENCIAS's programs, granting fellowships in the country and abroad.

Table 8. COLCIENCIAS Human resource program, Colombia, 1995-98

Program	Number of beneficiaries	
	1995-96	1998[b]
Doctorate and master's scholarships....	297	463
Courses and *pasantías* [a]	1,233	2,329
Young researchers...............................	237	435
Support to doctoral infrastructure..........	24	24
Researcher mobility.............................	32	35
Incentives for researchers....................	283	283

[a] pasantías = visit to a foreign university.

[b] Preliminary figures.

SOURCE: The Colombian Institute for the Development of Science and Technology (COLCIENCIAS).

Fellowships

Support for developing a fellowship program was provided by COLCIENCIAS, the Colombian Institute for Educational Loans and Technical Studies Abroad (ICETEX), and the Foundation for the Future of Colombia, as well as new programs of professional training advanced by the various ministries and international cooperation resources. To ensure adequate availability of students, it was considered necessary to support undergraduate programs as well, offering loans or donations geared to the improvement of the educational infrastructure. ICETEX and COLCIENCIAS fellowship mechanisms were reinforced, and both institutions—in a combined effort—signed a series of agreements with international organizations having wide experience in the management of fellowships in several countries. By 1997, they had signed agreements with LASPAU, the British Council, and the Ibero-American States Organization. Talks were also under way with Germany's DAAD and similar agencies in France, Switzerland, Canada, Israel, and Japan (COLCIENCIAS 1997a, p. 7). The basic sciences received 30 percent of the fellowships in the 1995-97 period, followed by the social and human sciences (16 percent) and health science and technology (14 percent).

Taking into account that each fellowship has a 4-year maintenance and fees component, in addition to travel and installation costs, thesis expenses, the acquisition of a

Table 9. Number of fellowship holders by COLCIENCIAS S&T program, Colombia, 1995-97

Program	1995		1996		1997		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total..	139	100.0	141	100.0	183	100.0	463	100.0
Biotechnology...	6	4.3	6	4.3	2	1.1	14	3.0
Agricultural S&T..	5	3.6	9	6.4	14	7.7	28	6.0
Health S&T...	28	20.1	21	14.9	16	8.7	65	14.0
Sea S&T..	3	2.2	8	5.7	6	3.3	17	3.7
Basic sciences...	43	30.9	37	26.2	60	32.8	140	30.2[a]
Environment and habitat..	19	13.7	13	9.2	5	2.7	37	8.0
Social and human science.......................................	11	7.9	27	19.1	38	20.8	76	16.4
Industrial technology development and quality.........	6	4.3	10	7.1	25	13.7	41	8.9
Electronics, information, and telecommunications....	6	4.3	7	5.0	11	6.0	24	5.2
Education...	1	0.7	2	1.4	4	2.2	7	1.5
Energy and mining...	11	7.9	1	0.7	2	1.1	14	3.0

[a] Many are doing molecular biology.

KEY: S&T = Science and technology

SOURCE: The Colombian Institute for the Development of Science and Technology (COLCIENCIAS).

computer, and books, a quick estimate indicates that domestic doctoral fellowships cost considerably less than those granted to study in foreign universities—a little more than half the cost abroad (see appendix table 10).

The nondegree training programs are oriented to the development of postdoctoral and research visits to centers of excellence in the country and abroad, with a duration of between 3 and 24 months. The purpose is to encourage an active exchange between Colombian researchers and their colleagues in other countries through participation in research projects and specialized courses aimed at updating researchers about new techniques. Between 1996 and 1998, eight postdoctoral fellowships were granted. It is expected that this number will grow in the future, since they are perceived as a useful mechanism for making the Colombian research community more dynamic and fostering its international mobility and visibility.

philosophy, 1 in theology, 1 in history, 1 in economics). ICFES is in charge of the accreditation of all graduate programs.

Actions directly related to scientific capacity building through training are complemented with other actions aimed at consolidating and improving the local environment for research. Thus the Program of Young Researchers aims at linking young researchers to high-quality research centers or groups, fostering in them a feeling of belonging to specific scientific communities and encouraging their participation in institutional environments conducive to their growth in science. About 30 percent of the beneficiaries are in the agricultural sciences and technologies (133 individuals), 20.7 percent in the social sciences and humanities (90), 16.1 percent in the health sciences and technologies (70), and 14.7 percent in the basic sciences (64).

Table 10. COLCIENCIAS number of "young researchers" by S&T program, Colombia, 1995-98

Program	1995		1996		1997		1998[a]		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total	112	100	125	100	157	100	41	100	435	100
Biotechnology	0	0	11	8.8	4	2.5	7	17.1	22	5.1
Agricultural S&T	14	12.5	39	31.2	56	35.7	24	58.5	133	30.6
Health S&T	32	28.6	18	14.4	20	12.7	0	0	70	16.1
Sea S&T	0	0	0	0	1	0.6	0	0	1	0.2
Basic sciences	31	27.7	19	15.2	12	7.6	2	4.9	64	14.7
Environment and habitat	3	2.7	3	2.4	16	10.2	0	0	22	5.1
Social and human science	32	28.6	18	14.4	40	25.5	0	0	90	20.7
Industrial technology development and quality	0	0	13	10.4	2	1.3	6	14.6	21	4.8
Electronics, information, and telecommunications	0	0	0	0	6	3.8	0	0	6	1.4
Education	0	0	0	0	0	0	0	0	0	0
Energy and mining	0	0	4	3.2	0	0	2	4.9	6	1.4

[a] Data are through May 31, 1998.

SOURCE: The Colombian Institute for the Development of Science and Technology (COLCIENCIAS).

Another pillar of the COLCIENCIAS program toward the consolidation of the national scientific community is support of the infrastructure and development of National Doctoral Programs in those fields where it is possible to develop good-quality centers in the country. These programs are supported through the funding of research programs and the consolidation of their infrastructure. In 1998, there were 31 doctoral programs in Colombia, 17 in the exact and natural sciences and health (5 in physics, 4 in chemistry, 1 in mathematics, 7 in biology and biomedical sciences); 3 in engineering and technology; 2 in agricultural sciences and technologies; and 8 in the social sciences and humanities (1 in law, 2 in education, 2 in

Currently, there are 103 groups and centers recognized by COLCIENCIAS to which financial aid has been given to help in their maintenance. It is estimated that COLCIENCIAS ought to support an increasing number of units, assuming a reasonable increment of 10 centers and groups per year until 2003.

Through its various mechanisms, COLCIENCIAS is having an impact on the institutional culture with regard to the processes of preselection of candidates who apply to the national fellowship program. Institutions are increasingly giving guaranteed acceptance to young persons with deserving scientific and academic qualifications. It also helps formulate and implement institutional plans for human resource training on the part of universities and other institutions in less developed regions of the country.

International Mobility

The Researchers' Mobility Program has supported a modest number of people in the 1995-98 period, 35 in all. Nonetheless, through requirements of study-loans (return to the country, high domestic and international scientific productivity, establishment of links between Colombian institutions and their research groups with counterparts abroad where the graduate student is receiving his or her training), effective international linkages have been made on behalf of domestic institutions and research groups.

The Colombian government pays great attention to its science and technology community abroad: "diaspora" is the term chosen by the official program about the Colombian Network of Scientists and Engineers Abroad—CALDAS Network. This program was established at the end of 1991 by COLCIENCIAS as intrinsically tied to the international dynamics of the national community. The program's underlying philosophy has been that a network of skilled expatriates is an extension of, and not a substitute for, the national community. Colombian intellectuals linked by this program were in the recent past spread in up to 43 countries, with the largest contingent in the United States. It is a highly qualified community: 71 percent of its members have obtained or are pursuing doctoral studies, and 80 percent have a master's degree or equivalent. A recent analysis of the program suggests that there is a bottleneck in higher education at the level of doctoral studies in the country; this would help explain why three-fourths of those who left did so to pursue graduate studies abroad. Emigration, however, does not seem permanent but rather of the delayed return kind. Although the program does not have the necessary depth of time to allow us to assess this aspect, the final outcome will most likely depend on country conditions. Half the population surveyed had student status, of which 74 percent had enrolled in a Ph.D. program, 18 percent in a master's program, and 8 percent in undergraduate studies. Two-thirds were under professional contract, one-fourth were both studying and working, and 83 percent declared that they were involved in research activities either as advanced students or professionals (Meyer et al. 1997).

Of course, not all expatriates belong to the CALDAS Network, and a population of expatriate individuals does not automatically constitute a diaspora. According to the definition given to this notion by COLCIENCIAS, "an expatriate population becomes a diaspora when it is a community whose members are in communication, have built and institutionalized a collective autonomy, and share some goals and activities. This the CALDAS Network provides through its electronic list, local nodes, and joint projects." According to governmental sources, the Colombian science and technology diaspora comprises around 2,000 people. This represents a little less than half of the people officially involved in R&D activities in Colombia.

Venezuela

Recent Reforms and Trends

The Venezuelan higher education system has experienced an enormous expansion in the last 30 years. Many initiatives for change from different segments linked to higher education popped up in recent years, spurred by internal factors like the aging of the community of researchers, the retirement of an important fraction of university academic staff, the move of many others abroad or to industry and services without their posts being replenished at the same rate, a deterioration of academic staff salaries, and reduction in the number of university students in the basic sciences. Nonetheless, the profound transformations visible in other Latin American countries in response to changed world conditions have been slower to come by in this country. The main external factors of higher education change observed in Venezuela are evaluation, funding, the research issue, and the development of a coordination model. All of these are deeply affected by the crisis of the state.

The funding of higher education has been incremental on the basis of previous budget assignments, although in the last decade criticisms became more intense in view of the system's inability to incorporate incentives for the improvement of the system's internal efficiency and quality, as well as criticisms of the excessive weight of corporate and political parties' pressures, which have undermined public higher education. Institutions have strongly resisted evaluation and accreditation of graduate education. There has been limited financial support for self-evaluation processes, which—along with a centralized system of quota distribution which has introduced rigidities—has promoted conflicts with the student body and become difficult to change.

The evaluation process in Venezuela has been based on a corrective notion; that is, it has been restricted to certain problems, and careful not to change funding structures. Evaluation has been accepted as long as it does not affect existing budget and financial structures. The creation of the Consultative Council of Graduate Studies in 1983 as an advisory organ of the National Universities Council (CNU) enabled the creation of a National System of Graduate Accreditation in 1986. Although the impact and effectiveness of this council have been very modest (up to now, only 20 percent of all graduate programs have submitted to the evaluation procedure of accreditation), nonetheless it deserves to be mentioned as a policy initiative that has to some extent institutionalized a form of specialized evaluation. Also in 1983, CNU established a Universities Institutional Evaluation Commission; in the ensuing decade, some evaluation took place with the participation of the Nucleus of Universities' Planning Directors. Given CNU's past difficulties in articulating the interests of government and universities, it is currently moving toward a new evaluation policy that is more responsive to contextual features. The Presidential Commission for the Development of Higher Education is in charge of designing the Inter-American Development Bank's Venezuelan Program for the Improvement of Higher Education, envisaging two components: a fund for the reform of higher education, and a fund for the institutional support of the reforms.

In 1990, after a decade of efforts by members of the scientific community to get it established, the Consejo Nacional de Investigaciones Científicas y Tecnológicas (CONICIT) created the System for the Researcher's Promotion (PPI). PPI emerged as a national structure of accreditation for researchers through the usual evaluation mechanisms of the scientific community, with the aims of giving them visibility in the domestic context and providing a monetary incentive which, by comparison with the equivalent Mexican SNI, never became really significant in relation to the beneficiaries' salaries. PPI was created as a mechanism that tried first to compensate for a deficit in the collective recognition of the researcher's status and role—which in the past had resulted in a very fragile relationship of research and its fruits with Venezuelan society—and second, to foster the participation of Venezuelan science in the international scientific system (Vessuri and González 1992, and Vessuri 1996). The limitations of this program have been said to lie in its fostering a relative isolation of the individual scientist from other social priorities, as well as the promotion of certain patterns of work organization, particularly solo rather than group research, which is more easily found in basic academic science and which in the long run might be counterproductive for science for development. Meanwhile, other evaluation tools have began to emerge in many universities—though still precariously. These include the Academic Benefit, an incentive created by CNU; and incentive programs implemented by several public universities, such as the Program of Incentives to Research for university academic staff.

It will be necessary to specify what the future role and position of PPI will be, and how the various incentives can be made complementary rather than contradictory. Because the roles of the researcher and research are not yet sufficiently consolidated in Venezuelan society, PPI, although it cannot be permanent, may continue to be necessary for some time. The researcher population of approximately 1,500 may be considered the core of the domestic scientific community, suggesting that a small but very qualified stratum of researchers has become consolidated. Depending on whether strict or broad criteria are used, it may be estimated that the number of people in R&D includes between two and five times that number. The consolidated information about PPI members in 1998 is included in tables 11 and 12.

Table 11. Number of researchers in Venezuela's PPI program, Venezuela, 1998

Institution	Physical, chemical, & mathematical science	Medical, biological & agricultural science	Social science	Engineering, technology & Earth science	Total
Total..........	360	640	310	240	1,550
UCV.......	65	188	103	49	406
ULA.......	88	93	62	37	281
LUZ.......	34	90	57	36	217
USB.......	83	31	43	70	207
Others...	90	238	45	48	439

KEY: PPI= Program for the Promotion of Researchers
ULA= Universidad de Los Andes
USB= Universidad Simón Bolívar
UCV= Universidad Central de Venezuela
LUZ= Universidad del Zulia

SOURCE: National Council of Science and Technology Studies, (CONICIT), *Sistema de Promoción del Investigador,* Caracas,1998.

Table 12. Number of researchers, according to promotion research program (PPI) level, 1990-97

Level	1990	1991	1992	1993	1994	1995	1996	1997
General total...........	760	922	941	929	1,056	1,213	1,302	1,435
Candidate...........	111	171	220	167	197	241	310	322
I......................	390	482	407	472	519	614	632	755
II......................	150	173	213	180	243	262	251	246
III....................	89	96	101	110	82	81	94	97
Emeritus.........	0	0	0	0	15	15	15	15

SOURCE: National Council of Science and Technology Studies, (CONICIT), Indicadores de la capacidad de investigción y desarrollo de Venezuela. Periodo 1990-98. Sistema de Promoción del Investigador, Caracas,1998.

Some fields show a greater weight, as in catalysis, where there are at least 152 active Ph.D. level researchers in 11 institutions (Vessuri 1996). But it is increasingly evident that the traditional way of understanding and doing research in the country—structurally weak, isolated from economic and social processes, and individualized to a large extent—must be drastically changed to make it more effective. Thus, it may be said that Venezuela is in a transitional stage.

CONICIT has undergone internal transformation to ease the modernization of the science and technology system. Since 1994, it has established four main fields of programmatic action for the support of research, innovation processes, policies for the strengthening and coordination of the national effort in science and technology, and internal management and institutional modernization. With regard to the first aim, with which we are more directly concerned here, among the strategic lines of action are training, incorporation, and permanence of more and better researchers; and, linked to these, the strengthening of research in domestic graduate programs. Several actions were started or redefined in the last 3 years:

- Funding was provided for the training of researchers, with some 300 new graduate fellowships envisaged for the 1996-98 period.

- New researchers were incorporated, facilitating the hiring of young researchers in research and teaching activities in higher education institutions, and aiming at 375 graduates.

- Researcher mobility was encouraged. The target was to fund 1,333 new applications, facilitating the participation of active researchers in international events, as well as linking Venezuelan researchers settled abroad with the domestic community and starting a networking program for Venezuelan scientists and engineers resident abroad (the Perez Bonalde Program).

- Research technicians are being trained, with a target of 58 technicians (CONICIT 1996).

- Within the Special New Technologies Program, 20 fellowships in Venezuela and 129 fellowships abroad are being provided; also envisaged are 15 updating courses and the participation of scientists in 10 national events.

- As in Colombia, special lines of action include the support of research groups and the strengthening of domestic graduate programs.

The main emphasis is ensuring that the nation's R&D capacities become a substantial part of its economic and social processes, bringing solutions and opportunities to the productive sector and society in general.

Enrollment and Degrees

Higher education enrollment in Venezuela increased 30 times over the last 30 years. In 1994, higher education accounted for 43.6 percent of the national educational budget, which in turn was 15.36 percent of the national budget. The schooling ratio of higher education went from 6 percent in 1965 to 24 percent in 1990. In 1995, there were 603,217 students enrolled in higher education, 76.2 percent of them in universities. The number of graduates that year was 50,160, 65.6 percent from universities. The total ratio of graduates from higher education in 1995 was generally low—37 percent (50,160 graduates, 136,092 newly enrolled in 1990). Contrary to common expectations, public universities have a higher terminal efficiency than private universities—49 percent: 28,402 graduates in 1995, 57,989 newly enrolled in 1990; versus 26 percent: 4,489 graduates in 1995, 16,955 newly enrolled in 1990—and continue to receive a much larger student enrollment. The situation differs in nonuniversity institutions. In this grouping, the graduate ratio is 20 percent in the public sector (4,269 graduates in 1995, 21,528 newly enrolled in 1990) and 33 percent in the private sector (12,973 graduates in 1995, 39,620 newly enrolled in 1990) (Parra 1998, based on OPSU 1997).

Historically, higher education in Venezuela has been devoted mostly to undergraduate education, although in the last 10 years it has expanded its number of academic graduate programs. In 1972, there were only 89 graduate programs; by 1994, there were 1,047, comprising 7 percent doctoral programs, 46 percent master's, and 47 percent specialization programs. Public universities account for more than half of the graduate programs; of these, the Central University of Venezuela (UCV) has 32 percent of all graduate programs.

FELLOWSHIPS

Although official initiatives to support domestic graduate education go back to at least the mid-1970s, emphasis was placed on graduate fellowship programs to study abroad. However, results were not as effective as expected in terms of a multiplying effect of returning graduates on growth of the local research community; also, it was estimated that a considerable number of students abroad were lost to "brain drain." Therefore, more recent initiatives—developed by CONICIT, FUNDAYACUCHO (Gran Mariscal de Ayacucho Foundation), and several university councils for the development of science, technology, and the humanities—have focused on renewed support of domestic graduate education in fields of domestic strength, combined with a policy for graduate training abroad in strategic fields and in those that are weak at the local level.

The main fellowship programs are those of FUNDAYACUCHO and CONICIT. Between 1984 and 1997, the two combined made available an average of 688 fellowships per year to Venezuelan graduates. Until the current decade, FUNDAYACUCHO's fellowship program was numerically much larger than CONICIT's, having granted a total of 55,484 fellowships from 1975 to 1996 at both the undergraduate and graduate levels. Since 1984, it granted 8,202 graduate fellowships, compared to 1,439 fellowships from CONICIT. The latter specialized in research fellowships on a much smaller scale. Since 1991, however, CONICIT has increased its efforts, and, in 1995-97, its fellowships represented about a third of FUNDAYACUCHO's loans. Throughout the period, the average number of fellowships abroad from the two agencies combined was 47 percent, with a high of 77.74 percent in 1993 and a low of 10.52 percent in 1987. (See appendix table 11.)

Table 13. Number of fellowships and educational loans granted by CONICIT and FUNDAYACUCHO in Venezuela and abroad, 1984-97

Year	General total	Total Venezuela	Total abroad	(%)	CONICIT Total	CONICIT Venezuela	CONICIT Abroad	FUNDAYACUCHO Total	FUNDAYACUCHO Venezuela	FUNDAYACUCHO Abroad
1984	667	348	319	(47.8)	30	21	9	637	327	310
1985	813	664	149	(18.3)	1	1	0	812	663	149
1986	282	215	67	(23.8)	54	37	17	228	178	50
1987	1,178	1,054	124	(10.5)	35	22	13	1,143	1,032	111
1988	213	174	39	(18.3)	37	20	17	176	154	22
1989	127	60	67	(52.8)	3	3	0	124	57	67
1990	657	454	203	(30.9)	80	56	24	577	398	179
1991	987	427	560	(56.7)	124	60	64	863	367	496
1992	554	199	355	(64.1)	154	42	112	400	157	243
1993	921	205	716	(77.7)	209	59	150	712	146	566
1994	565	157	408	(72.2)	24	0	24	541	157	384
1995	473	214	259	(54.8)	152	92	60	321	122	199
1996	865	338	527	(60.9)	251	144	107	614	194	420
1997	1,339	600	739	(45.8)	285	159	126	1,054	441	613

SOURCE: National Council of Science and Technology Studies, (CONICIT), Indicadores de la capacidad de investigción y desarrollo de Venezuela. Periodo 1990-98 Sistema de Promoción del Investigador, Caracas,1998.

The public universities also have fellowship programs to qualify their own academic staff, administered through their science, technology, and humanities development councils. There are no global figures about this universe of fellowships. However, their significance in the overall effort can be grasped from the evolution of the UCV fellowship program. On the whole, from the creation of the mechanism in 1958 through 1996, UCV granted 603 graduate fellowships, of which 21.9 percent were distributed among the social sciences and the humanities. The largest concentration of graduate fellowships was awarded to science faculty staff (25 percent), followed by the agronomy faculty (15.6 percent) and medicine (13.2 percent). The largest concentration of fellowships (47.42 percent) occurred in the 1977-86 period; significantly, the number of doctoral fellowships represented 54.57 percent of the total. This trend continued in the 1987-96 period, with 51.46 percent of all fellowships awarded for doctoral studies.

Note that most doctoral and master's fellowships from FUNDAYACUCHO are for studies abroad, with the largest contingents of students in economics and the social sciences, followed by engineering and technology. The basic sciences, with 22.2 percent in the domestic doctoral programs and 14 percent in foreign ones, have a better representation at this level than at lower levels. At the master's level, 71.1 percent of domestic fellowships go to students in economics and the social sciences; and, although the proportion is lower among master's level fellowships abroad in these disciplines, the proportion continues to be considerable (59.1 percent).

A larger proportion of FUNDAYACUCHO doctorate fellowships are destined for Spain than for any other country (38.2 percent), followed by the United States and the United Kingdom. The remaining destinations show a great dispersion. At the master's level, 68 percent of all fellowships abroad are for the United States; Spain and the United Kingdom trail far behind, with 10.3 percent and 9.6 percent, respectively.

CONICIT has granted a comparable number of fellowship in the 1994-97 period (712). This agency emphasizes the doctorate degree level, which every year has accounted for more than 40 percent of all fellowships granted. A new modality that is growing slowly is that of the postdoctorate. Table 16 provides some indication of destination trends based on the history of CONICIT fellowships. The United States was the destination of 42.9 percent of all fellowships, followed by the United Kingdom with 21.6 percent and France with 14.8 percent.

International Mobility

In recent years, Venezuela has been developing several programs to identify Venezuelan expatriates. CONICIT has initiated a modest scheme, the Perez Bonalde Program, which brings Venezuelan scientists settled abroad in country for short visits to local research institutions and groups in order to fulfill a work agenda geared to increase contacts and international mobility of local scientists; it also aims to incorporate those expatriate researchers in the domestic dynamics of science and technology. Fundación Polar is collecting information about

Table 14. FUNDAYACUCHO educational loans granted at the graduate level, Venezuela and abroad by field of study, 1994-98 (PRCE budget)

Field	Venezuela					Abroad				
		Master's		Doctorate			Master's		Doctorate	
	Total	Number	Percent	Number	Percent	Total	Number	Percent	Number	Percent
Total	393	384	100.0	9	99.9	1,252	1,074	99.4	178	100.1
Basic sciences	5	3	0.8	2	22.2	43	18	1.7	25	14.0
Engineering	61	61	15.9	0	0.0	318	276	25.7	42	23.6
Agricultural and sea science	8	8	2.1	0	0.0	22	13	1.2	9	5.1
Health	10	9	2.3	1	11.1	65	49	4.6	16	9.0
Education	29	26	6.8	3	33.3	60	46	4.3	14	7.9
Economic and social sciences	275	273	71.1	2	22.2	694	635	59.1	59	33.2
Humanities, literature and fine arts	5	4	1.0	1	11.1	50	37	3.5	13	7.3

KEY: PRCE = Educational Credit Reform Budget, Venezuela, World Bank.

NOTE: For the year 1998, the first semester only was considered.

SOURCE: Gran Mariscal de Ayacucho Foundation (FUNDAYACUCHO).

Table 15. FUNDAYACUCHO educational loans granted at the graduate level according to geographical destination, Venezuela, 1994-98 (PRCE budget)

Level/Country	Total	Master's Number	Doctorate Number
Total	1,645	1,458	187
Total abroad	1,252	1,074	178
Total Venezuela	393	384	9
Argentina	2	1	1
Australia	11	5	6
Belgium	3	1	2
Brazil	6	6	0
Canada	20	19	1
Chile	4	4	0
China	1	1	0
Colombia	2	1	1
Costa Rica	29	23	6
France	43	25	18
Germany	4	2	2
Holland	6	6	0
Israel	0	0	0
Italy	7	7	0
Mexico	16	16	0
Nicaragua	9	9	0
Peru	0	0	0
Puerto Rico	3	3	0
Russia	1	0	1
Spain	179	111	68
Sweden	1	1	0
Switzerland	3	1	2
United Kingdom	138	103	35
United States	763	728	35
Uruguay	1	1	0

KEY: PRCE = Educational Credit Reform Budget, Venezuela, World Bank.

NOTE: For the year 1998, the first semester only was considered.

SOURCE: Gran Mariscal de Ayacucho Foundation (FUNDAYACUCHO).

Venezuelan scientists abroad, trying to distinguish those who are pursuing studies from those who are working on a more permanent basis. So far, it has identified some 300 Venezuelan scientists and engineers settled abroad on a more permanent basis. The Venezuelan Embassy at UNESCO headquarters in Paris has started an initiative called TALVEN with a similar purpose. In the near future, these programs should coordinate with each other to produce unified information.

Streamlining Academic R&D in Mexico, Colombia, and Venezuela

The recent reforms introduced in the academic world of the three countries considered here, like those in other Latin American countries, seem to point to the rationalization, disciplining, and greater efficiency of higher education. Since the tools of reform have been basically financial and administrative and not often supplemented with more integral changes, the results remain pending. There is no doubt that groups of researchers have been mobilized around new funding modalities and opportunities. But the bulk of university staff (teachers and research assistants) seem to have received the impact of the reforms in different manners. Some groups feel they have been ill-treated by the imposition of quantitative research evaluation criteria that apply to the tradition of the physical sciences but are not pertinent to the agricultural sciences, technologies, social sciences, and humanities; they feel these are even less able to measure yields in teaching, the effectiveness of adjustment to market demands, etc. Operational measures assumed to make research more efficient, such as supporting large research groups for more or less extended periods (3 to 4 years), may reflect optimal research conditions for some disciplines, but not necessarily for others.

Table 16. Number of fellowships by academic level CONICIT, Venezuela, 1994-97

Year	Fellowships		Master		Doctorate		Postdoctorate		Does not indicate	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total	712	100.0	342		332		32		6	
1994	24	3.4	4	16.7	15	62.5	4	16.7	1	4.2
1995	152	21.4	75	49.3	69	45.4	5	3.3	3	2.0
1996	251	35.3	127	50.6	111	44.2	11	4.4	2	0.8
1997	285	40.0	136	47.7	137	48.1	12	4.2	-	0

KEY: (-) = not applicable

SOURCE: National Council of Science and Technology Studies, (CONICIT) n.d. <<http://www.conicit.gov.ve>>.

Table 17. Number and percentages of fellowships granted by CONICIT, Venezuela, by country of destination, not including domestic fellowships, 1970-97

Country	Number	Percent
Total	898	100
Australia	3	0.3
Belgium	7	0.8
Brazil	25	2.8
Canada	23	2.6
Cuba	1	0.1
Czechoslovakia	2	0.2
France	133	14.8
Germany	14	1.6
Holland	3	0.3
Israel	1	0.1
Italy	5	0.6
Japan	3	0.3
Mexico	4	0.4
New Zealand	1	0.1
Poland	1	0.1
Puerto Rico	3	0.3
Russia	3	0.3
Spain	80	8.9
Sweden	4	0.4
United Kingdom	194	21.6
United States	385	42.9

SOURCE: National Council of Science and Technology Studies, (CONICIT) n.d. <<http://www.conicit.gov.ve>>.

The industrial sector emerges as a strategic partner to facilitate change; its difficulties in the current process of economic aperture and the vulnerability of domestic financial markets affect R&D stability and potential for expansion. The three countries have learned that expansion of high-quality academic research does not necessarily create conditions for high-quality industrial R&D. Academic research policy, therefore, should not be dissociated from industrial firms' applied R&D policy and practice, where the means of government influence are much more indirect, complex, and controversial.

Although in the last decades the range of organizations and institutions has been growing and diversifying in the three countries, the institutional fabric still presents thinly covered holes and empty spaces. In addition to the institutional and organizational insufficiency and marginality of science and technology research with regard to the main route of knowledge production and distribution, confidence in government management—considered in the past to be the natural agency in charge of responding to problems of collective development—has declined. The preexisting export industrial base fed on governments that supported—at least in the early stages—the industrialization process, with policies of exchange rates, restriction of domestic demand, real salary restrictions, export subsidies, export processing zones, and performance requirements for exports, as well as investments in research, training and support infrastructure. Maintenance of industrial growth requires fresh, sustained investments for capacity development.

In countries like these, distant from the technological edge, the returns associated with facilitating technology transfer are much higher than those linked to engaging in original R&D. An important policy to facilitate such transfer is to invest in human resources, especially in higher education. As far as graduate education is concerned, we have seen that total enrollment is very low relative to the numbers graduating from undergraduate programs; the graduate-undergraduate ratio shows the need to prioritize growth of graduate education. There is a definite insufficiency in the level, quality, and variety of human resources required for technological upgrading. The knowledge gap grows dramatically, especially in aspects related to the integration of human resources in innovation systems.

The fact that the majority of teaching/research posts in the public sector corresponds to the status of *funcionario público* (public official) induces too much stability of employment for those who are in the system and an exceedingly high turnover of "marginal" professionals who remain outside the system; this prevents an adequate balance between institutional continuity and renewal. Large segments of public higher education have experienced serious deterioration in a process accompanied by growth of the private sector in education, which covers a portion of the excess demand with a bias toward the commercial sciences and less emphasis on engineering and the exact and experimental sciences. This has direct consequences for R&D, which is carried out mainly in public universities and related research centers. Most programs for the promotion of R&D have been reactive, serving to promote and strengthen what already exists, but unable to give a radical lead in the attainment of objectives or the type of actors involved and their ways of working. Strong inertial trends prevail in the fragmented interests of the scientific communities, without their becoming articulated in broader strategies involving varied and dynamic partnerships. Needless to say, this indicates the lack of density of the socioeconomic tissue.

The number of linkage mechanisms in the academic world and the science and technology public sector has multiplied in the 1990s. But support institutions and policies will not be effective unless there is a significant increase in private investment in R&D without a reduction of already limited public funds. A continuous supportive government presence is needed, but should be focused on what only it can do in the different fronts linked to the industrial and technological processes, while leaving direct production and technology transfer to the private sector.

Technological activity carried out through cooperative schemes is an option increasingly used everywhere, because it facilitates the speed of technical progress and market redistribution. The various forms of partnership between firms, and between these and research institutions and universities, allow some current obstacles to the establishment of innovation capabilities to be overcome. In the three countries discussed here, this kind of interaction is very new. Often, the entrepreneur does not take advantage of results generated by potential partners due to a lack of knowledge of the existence of relevant products and processes for the firm. It is therefore indispensable to multiply the channels and forms of access to technological information and business opportunities available to the entrepreneurial segment.

Education ought to be revitalized at all levels, including not only the training of scientists, engineers, and the technical workforce, but also of managers and entrepreneurs—so that they may gain a better understanding of the importance of innovation and its main components—as well as shopfloor technicians and blue-collar workers who must have a higher level of schooling and skills for raising their flexibility and capacity to adapt to continuing technical change. Although there are valuable schemes in vocational training, especially ones provided by public institutions in close partnership with the private sector—such as Servcio Nacional de Aprendizaje in Colombia, Direccion General de Educacion Tecnologica Industrial in Mexico, and Instituto Nacional de Cooperacion Educativa in Venezuela—they are clearly insufficient. So far, it has not been possible to extend them more widely, for the role of the firms in this field should be much greater. Continuing education and training ought to be stimulated, recognizing that, particularly in scientific and technical fields, education must be a life-long activity.

Although some critics adhering to a narrowly technical and developmental view deplore the pretension of scientific leadership to publish internationally, as if such activity would distance them from domestic relevance, it may reasonably be argued that the change in publishing behavior from locally oriented media to international journals is necessary for a country's technological development. To benefit from worldwide technical and scientific developments, the local researcher must know and understand them; and, therefore, to some extent, contribute actively in those developments. In a global world, information and communication do not recognize national boundaries.

It should be stressed that the importance of supporting basic science in countries with small scientific communities is in the resulting externalities, for it allows access to the international pool of knowledge, skills, and information. When it is argued that the effort should be reoriented because an enormous reservoir of technical and scientific knowledge already exists, this does not mean to cease supporting the scientific and technical communities in those countries. On the contrary, given the level of complexity and sophistication of contemporary knowledge, today more than ever communities of researchers and engineers are needed who are well-versed in the most advanced knowledge and who may read and interpret results and guide strategic decisions of a technical nature.

The short-term focus that has prevailed in the privatization process brings uncertainty to the viability of the reforms aimed at saving and optimizing R&D capacities in the three countries. It is not clear whether the new industrial structures will stimulate the establishment of research facilities in small and medium-sized firms. It is unlikely that the numbers of scientific and technological personnel will grow much in the near future. For the same reasons, the capacity to train R&D staff in national systems will probably remain limited, unless there are deep changes in conception and structure. The numbers of students in key disciplines might remain equally limited.

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APPENDIX

Appendix table 1. Mexican graduate population by level, 1987-97								
Year	Total		Specialization		Master		Doctorate	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1987..................	38,214	100.0	13,084	34.2	23,751	62.2	1,379	3.6
1988..................	39,505	100.0	13,526	34.2	24,676	62.5	1,303	3.3
1989..................	42,655	100.0	14,757	34.6	26,561	62.3	1,337	3.1
1990..................	43,965	100.0	15,675	35.7	26,946	61.3	1,344	3.0
1991..................	44,946	100.0	16,367	36.4	27,139	60.4	1,440	3.2
1992..................	47,539	100.0	17,576	37.0	28,332	59.6	1,631	3.4
1993..................	50,781	100.0	17,440	34.4	31,190	61.4	2,151	4.2
1994..................	54,910	100.0	17,613	32.1	34,203	62.3	3,094	5.6
1995..................	65,615	100.0	18,760	28.6	42,342	64.5	4,513	6.9
1996..................	75,392	100.0	20,852	27.6	49,356	65.5	5,184	6.9
1997..................	87,696	100.0	21,625	24.7	59,913	68.3	6,158	7.0

SOURCE: Asociacíon Nacional de Univeridades e Instituciones de Educación Superior (ANUIES). *Anuario Estadístico. Población escolar de posgrado.* México, D.F.

Appendix table 2. Doctoral student population in Mexico by field, 1997

Field	1st Enrollment & re-enrollment			Graduates 1996		
	Total	Men	Women	Total	Men	Women
Total	6,158	4,038	2,120	734	457	277
Agricultural sciences	420	326	94	48	35	13
Agronomy	270	209	61	29	23	6
Veterinary & zootechnics	150	117	33	19	12	7
Health sciences	456	240	216	103	67	36
Biomedicine	118	54	64	31	16	15
Pharmacology	25	12	13	4	2	2
Medicine	91	68	23	41	32	9
Dentistry	19	10	9	1	0	1
Other specialties	203	96	107	26	17	9
Basic & natural sciences	1,621	1,127	494	123	84	39
Astronomy	14	7	7	1	0	1
Biophysics	4	4	0	0	0	0
Biology	522	315	207	48	33	15
Sciences	15	12	3	0	0	0
Biochemistry	13	12	1	0	0	0
Chemistry	291	181	110	14	6	8
Earth sciences	97	76	21	3	0	3
Sea sciences	72	48	24	2	1	1
Ecology	67	41	26	6	2	4
Physics	413	345	68	39	34	5
Mathematics	113	86	27	10	8	2
Administration & social sciences	1,574	998	576	236	143	93
Administration	83	63	20	24	20	4
Anthropology & archeology	246	123	123	57	31	26
Political sciences	27	20	7	7	6	1
Social sciences	342	212	130	44	25	19
Law	478	340	138	62	38	24
Economy & development	158	124	34	9	7	2
Latin american studies	90	44	46	10	7	3
Geography	34	19	15	1	1	0
Taxes & finances	34	25	9	0	0	0
Psychology	66	20	46	19	6	13
International relations	16	8	8	3	2	1
Education & humanities	1,085	574	511	162	76	86
Education	668	370	298	50	32	18
Philosophy	79	53	26	15	8	7
History	206	98	108	57	24	22
Literature	102	43	59	28	10	18
Linguistics	30	10	20	12	2	10

See SOURCE at end of table.

Appendix table 2. Doctoral student population in Mexico by field, 1997 (Continued)

Field	1st Enrollment & re-enrollment			Graduates 1996		
	Total	Men	Women	Total	Men	Women
Engineering & technology	1,002	773	229	62	52	10
Architecture & design	112	76	36	7	7	0
Biotechnology	191	121	70	9	4	5
Sciences	172	131	41	5	5	0
Computer sciences	49	41	8	1	1	0
Ambiental engineering	6	3	3	0	0	0
Civil engineering	150	131	19	13	11	2
Electric engineering & electronics	175	162	13	12	12	0
Extractive eng., metal. & energy	39	30	9	8	5	3
Industrial engineering	22	16	6	6	6	0
Mechanical engineering	14	13	1	0	0	0
Chemical engineering	23	21	2	1	1	0
Planning	13	11	2	0	0	0
Nutrition technology	36	17	19	0	0	0

SOURCE: Asociacíon Nacional de Univeridades e Instituciones de Educación Superior (ANUIES). *Anuario Estadístico,* 1997.

Appendix table 3. Master's student population in Mexico by field, 1997

Field	1st Enrollment & re-enrollment			Graduates 1996		
	Total	Men	Women	Total	Men	Women
Total	59,913	36,128	23,785	11,164	6,702	4,462
Agricultural sciences	1,368	1,032	336	431	347	84
Common cycle	15	9	6	0	0	0
Agronomy	786	610	176	271	224	47
Forestry development	69	54	15	22	15	7
Veterinary & zootechnics	498	359	139	138	108	30
Health sciences	2,032	1,007	1,025	536	263	273
Biomedicine	161	76	85	67	29	38
Nursing	39	2	37	32	2	30
Pharmacology	97	31	66	18	6	12
Medicine	445	257	188	74	49	25
Nutrition	35	17	18	27	11	16
Dentistry	143	72	71	38	18	20
Other specialties	446	206	240	96	52	44
Psychiatry	21	12	9	4	3	1
Public health	633	332	301	180	93	87
Natural & basic sciences	3,028	1,842	1,186	616	396	220
Astronomy	15	9	5	1	0	1
Biophysics	4	1	3	0	0	0
Biology	727	335	392	124	66	58
Biochemistry	105	52	53	8	3	5
Sciences	75	39	36	19	8	11
Chemistry	432	199	233	89	40	49
Earth sciences	244	205	39	37	32	5
Sea sciences	230	133	97	53	36	17
Ecology	197	109	88	31	15	16
Physics	623	490	133	190	149	41
Mathematics	377	270	107	64	47	17
Social & administration sciences	29,469	18,204	11,265	4,505	2,788	1,717
Administration	27	12	15	2,669	1,814	855
Anthropology & archeology	16,923	11,128	5,795	58	25	33
Archives & library sciences	171	87	84	4	3	1
Political sciences	72	22	50	86	51	35
Social sciences	603	324	279	180	90	90
Communication sciences	518	251	267	54	25	29
International trade	116	68	48	1	1	0
Accounting	510	299	211	19	10	9
Law	2,851	1,828	1,023	349	216	133
Economy & development	2,104	1,430	674	354	230	124
Latin american studies	169	80	89	21	12	9
Taxes & finances	2,425	1,623	802	246	166	80

See SOURCE at end of table.

Appendix table 3. Master's student population in Mexico by field, 1997 (Continued)

Field	1st Enrollment & re-enrollment			Graduates 1996		
	Total	Men	Women	Total	Men	Women
Psychology	2,248	640	1,608	398	102	296
Advertising	47	17	30	5	2	3
Industrial relations	98	50	48	0	0	0
International relations	54	25	29	3	2	1
Tourism	31	16	15	0	0	0
Sales & marketing	172	101	71	55	37	18
Education & humanities	13,792	6,253	7,539	3,051	1,380	1,671
Fine arts	265	107	158	50	24	26
Sports sciences	58	51	7	12	7	5
Education	10,455	4,716	5,739	2,053	916	1,137
Normal education	1,449	651	798	567	258	309
Philosophy	453	280	173	110	68	42
History	454	206	248	84	38	46
Humanities	99	37	62	34	16	18
Languages	12	5	7	21	5	16
Literature	438	154	284	82	31	51
Linguistics	109	46	63	38	17	21
Engineering & technology	10,224	7,790	2,434	2,025	1,528	497
Common cycle	12	7	5	0	0	0
Architecture & design	1,150	770	380	139	103	36
Biotechnology	324	174	150	96	43	53
Sciences	95	57	38	24	9	15
Computation sciences	1,976	1,478	498	461	351	110
Environmental engineering	497	332	165	119	71	48
Civil engineering	1,424	1,188	236	259	213	46
Electric engineering & electronics	1,116	992	124	240	211	29
Extraction engineering, metal.& energy	185	151	34	34	27	7
Physics engineering	15	15	0	4	4	0
Hydraulic engineering	122	96	26	43	33	10
Industrial engineering	1,404	1,114	290	227	185	42
Mechanical engineering	513	491	22	113	107	6
Fishing engineering	38	26	12	17	11	6
Chemical engineering	416	289	127	73	55	18
Transports engineering	74	57	17	34	32	2
Planning	592	441	151	55	38	17
Nutrition engineering	251	96	155	87	35	52
Wood technology	20	16	4	0	0	0

SOURCE: Asociacíon Nacional de Univeridades e Instituciones de Educación Superior (ANUIES). *Anuario Estadístico,* 1997.

Appendix table 4. Specialization student population in Mexico by field, 1997

Field	1st Enrollment & re-enrollment			Graduates 1996		
	Total	Men	Women	Total	Men	Women
Total	21,625	11,895	9,730	8,305	4,451	3,854
Agricultural sciences	82	69	13	53	48	5
Agronomy	16	13	3	24	23	1
Veterinary & zootechnics	66	56	10	29	25	4
Health sciences	12,391	7,196	5,195	3,812	2,194	1,618
Surgery	811	682	129	193	179	14
Nursing	181	11	170	166	9	157
Pharmacology	22	8	14	0	0	0
Medicine	6,714	4,008	2,706	1,940	1,187	753
Nutrition	17	8	9	0	0	0
Dentistry	988	419	569	411	180	231
Other specialties[a]	3,310	1,868	1,442	980	570	410
Psychiatry	66	33	33	29	19	10
Radiology	160	87	73	44	27	17
Public health	122	72	50	49	23	26
Natural & basic sciences	168	91	77	59	31	28
Biology	17	12	5	10	8	2
Biochemistry	31	9	22	12	3	9
Chemistry	28	20	8	16	9	7
Earth sciences	8	5	3	7	5	2
Mathematics	84	45	39	14	6	8
Social & administration sciences	6,117	3,013	3,104	2,946	1,481	1,465
Administration	1,083	542	541	608	290	318
Political sciences	0	0	0	25	23	2
Social sciences	101	12	89	7	5	2
Communication sciences	30	5	25	7	1	6
International trade	134	71	63	92	60	32
Accounting	84	55	29	12	7	5
Law	1,359	715	644	756	404	352
Economy & development	47	26	21	29	13	16
Geography	0	0	0	8	7	1
Taxes & finances	2,231	1,232	999	912	519	393
Psychology	558	150	408	240	55	185
Advertising	55	12	43	22	0	22
Sales & marketing	435	193	242	228	97	131
Education & humanities	1,513	618	895	704	235	469
Education	1,467	588	879	658	221	437
Philosophy	0	0	0	3	2	1
History	35	25	10	9	5	4
Languages	1	0	1	6	1	5
Literature	10	5	5	28	6	22

See explanatory information and SOURCE at end of table.

Appendix table 4. Specialization student population in Mexico by field, 1997 (Continued)

Field	1st Enrollment & Re-enrollment			Graduates 1996		
	Total	Men	Women	Total	Men	Women
Engineering & technology	1,354	908	446	731	462	269
Architecture & design	96	54	42	34	14	20
Biotechnology	8	6	2	9	3	6
Computation sciences	202	31	71	26	15	11
Environmental engineering	98	72	26	60	41	19
Civil engineering	145	125	20	73	66	7
Electric engineering & electronics	34	27	7	3	3	0
Extraction engineering, metal. & energy	42	37	5	14	14	0
Hydraulic engineering	13	13	0	14	13	1
Industrial engineering	591	362	229	482	284	198
Fishing engineering	44	42	2	0	0	0
Textile engineering	12	7	5	9	5	4
Nutrition engineering	64	27	37	7	4	3
Wood technology	5	5	0	0	0	0

[a] 63 Specialties

SOURCE: Asociacíon Nacional de Univeridades e Instituciones de Educación Superior (ANUIES). *Anuario Estadístico,* 1997.

Appendix table 5. Graduates by level of study, Mexico, 1984-96

Level	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Total	6,634	7,047	6,896	7,869	9,916	11,159	9,885	11,548	12,097	12,060	13,632	18,291	16,276
Basic & natural sciences	268	390	324	561	382	347	618	615	536	658	802	863	798
Agricultural sciences	192	217	245	340	250	377	323	324	317	387	494	472	532
Engineering	864	1,018	862	1,227	1,033	836	1,168	1,318	1,445	1,490	2,112	2,603	2,818
Health	1,813	1,913	1,896	2,027	4,503	5,286	3,807	4,211	4,035	3,110	3,024	4,109	4,451
Social sciences	3,497	3,509	3,569	3,714	3,748	3,313	3,969	5,080	5,764	6,415	7,200	10,244	7,677
Specialization	2,749	2,793	3,036	2,939	2,939	5,553	4,525	5,835	6,035	5,616	5,963	7,764	7,601
Basic & natural sciences	25	18	11	69	75	26	47	47	51	110	114	123	59
Agricultural sciences	19	42	72	47	47	43	25	68	53	106	116	79	53
Engineering	195	239	218	226	226	270	198	268	409	463	727	934	731
Health	1,535	1,622	1,572	1,657	1,657	4,133	3,538	3,931	3,680	2,814	2,609	3,517	3,812
Social sciences	975	872	1,163	940	940	1,012	717	1,521	1,842	2,123	2,397	3,111	2,946
Master's	3,640	4,077	3,704	4,758	4,185	4,401	5,091	5,475	5,749	6,092	7,181	10,008	8,113
Basic & natural sciences	231	343	285	448	280	296	487	499	405	465	568	633	616
Agricultural sciences	170	173	164	290	184	328	294	253	255	276	368	373	431
Engineering	669	776	642	994	760	702	962	1,039	1,009	995	1,345	1,614	2,025
Health	268	270	319	340	338	262	234	239	319	254	362	533	536
Social sciences	2,302	2,515	2,294	2,686	2,623	2,813	3,114	3,445	3,761	4,102	4,538	6,855	4,505
Doctorate	245	177	156	172	178	204	269	238	313	352	488	519	572
Basic & natural sciences	12	29	28	44	27	25	84	69	80	83	120	107	123
Agricultural sciences	3	2	9	3	3	6	4	3	9	5	10	20	48
Engineering	0	3	2	7	3	3	8	11	27	32	40	55	62
Health	10	21	5	30	32	48	35	41	36	42	53	59	103
Social sciences	220	122	112	88	113	122	138	114	161	190	265	278	236

SOURCE: Asociacíon Nacional de Univeridades e Instituciones de Educación Superior ANUIES, *Anuarios Estadísticos de Posgrado,* 1985-96.

Appendix table 6. Statistical profile of U.S. doctorate recipients from Mexico, by major field of doctorate, 1988-96

Item	Total all fields		Total S&E	Physical sci.	Earth/ atmos/ ocean sci.	Mathematics	Computer/ info. sci.	Engineering	Bio. sci.	Agric. sci.	Psych/ social sci.	Non-S&E	Humanities	Education	Health sci.	Prof/ other fields
Total Ph.D.s[a]	-	1.4	1.1	102.0	61.0	68.0	26.0	238.0	230.0	198.0	203.0	233.0	91.0	63.0	41.0	38.0
Men	%	80.7	83.3	88.2	93.4	92.6	100.0	92.0	70.9	88.9	70.9	68.2	65.9	58.7	68.3	89.6
Women	%	19.3	16.7	11.8	6.6	7.4	0.0	8.0	29.1	11.1	29.1	31.8	34.1	41.3	31.7	10.6
Permanent visa	%	18.0	15.7	15.7	19.7	16.2	16.4	13.0	13.9	15.7	19.7	28.8	38.5	23.8	19.6	23.7
Temporary visa	%	82.1	84.3	84.3	80.3	83.8	84.6	87.0	86.1	84.3	80.3	71.2	61.5	76.2	80.5	76.3
Married	%	65.6	65.9	54.9	63.9	61.8	53.8	70.2	63.9	81.3	57.1	63.5	57.1	65.1	68.3	71.1
Not married	%	30.0	29.6	42.2	29.5	32.4	38.5	26.9	33.0	13.1	36.5	32.2	39.6	30.2	25.8	23.7
Unknown	%	4.5	4.5	2.9	5.6	5.9	7.7	2.9	3.0	5.6	6.4	4.3	3.3	4.8	4.9	5.3
Median age at Ph.D.	Yrs.	34.5	34.0	31.8	35.5	32.3	32.5	33.2	33.7	36.0	35.2	36.3	36.2	37.7	34.8	36.2
Percent with dependents	%	60.6	61.0	52.0	62.3	67.4	60.0	63.4	56.5	81.3	50.2	58.4	52.7	54.0	63.4	73.7
Sources of support[b]																
Personal	%	46.9	43.0	40.2	32.8	27.9	60.0	46.6	39.6	38.4	66.7	65.7	78.0	54.0	53.7	68.4
Foreign government	%	45.0	48.8	31.4	41.0	48.5	57.7	46.6	50.4	70.2	38.4	26.6	11.0	36.5	51.2	21.1
University	%	77.8	78.4	94.1	73.8	89.7	76.9	85.7	77.4	58.6	80.3	74.7	84.6	58.7	73.2	78.9
Technology assistant	%	44.0	42.5	68.6	32.8	70.6	42.3	45.8	34.3	15.2	54.7	61.5	76.9	30.2	22.0	57.9
Research assistant	%	48.9	52.9	80.4	67.2	30.9	50.0	66.4	50.9	48.0	34.0	29.2	15.4	25.4	63.4	31.6
Other university	%	22.5	21.5	17.6	18.0	25.0	30.8	17.2	21.7	14.1	34.0	27.5	38.5	23.8	17.1	18.4
Other	%	21.9	20.9	13.7	18.0	10.3	19.2	14.3	22.2	14.6	41.4	27.0	16.5	34.9	29.3	36.8
Unknown	%	3.8	3.9	2.9	8.2	2.9	3.8	3.4	3.0	3.5	5.4	3.4	1.1	3.2	4.9	7.9
Median time lapse from baccalaureate to Ph.D.																
Total time	Yrs.	10.3	9.9	8.6	11.5	8.1	8.9	10.0	9.1	11.8	10.1	12.0	10.0	13.3	12.4	14.0
Registered time	Yrs.	6.5	6.4	6.8	7.3	5.8	5.4	6.4	6.5	5.8	6.8	7.3	7.3	7.0	8.4	7.3
Planned location after Ph.D.																
Permanent visas	%	244.0	177.0	16.0	12.0	11.0	4.0	31.0	32.0	31.0	40.0	67.0	35.0	15.0	8.0	9.0
U.S. total	%	71.3	68.9	81.3	58.3	81.8	D	67.7	75.0	48.4	75.0	77.6	85.7	73.3	62.6	66.7
Study	%	26.4	34.4	38.5	42.9	44.4	D	33.3	54.2	13.3	26.7	7.7	10.0	9.1	0.0	0.0
Employment	%	70.1	62.3	61.5	57.1	55.6	D	61.9	33.3	86.7	73.3	88.5	83.3	90.9	100.0	100.0
Unknown	%	3.5	3.3	0.0	0.0	0.0	D	4.8	12.5	0.0	0.0	3.8	6.7	0.0	0.0	0.0
Non-U.S.	%	18.9	22.0	12.6	33.3	18.2	D	12.9	18.8	48.4	12.5	10.4	8.6	13.3	25.0	0.0
Unknown location	%	9.8	9.0	6.3	8.3	0.0	D	19.4	6.3	3.2	12.6	11.9	5.7	13.3	12.5	33.3

See explanatory information and SOURCE at end of table.

Appendix table 6. Statistical profile of U.S. doctorate recipients from Mexico, by major field of doctorate, 1988-96 (Continued)

Item	Total all fields		Total S&E	Physical sci.	Earth/ atmos/ ocean sci.	Mathematics	Computer/ info. sci.	Engineering	Bio. sci.	Agric. sci.	Psych/ social sci.	Non-S&E	Humanities	Education	Health sci.	Prof/ other fields
Temporary visas	%	1.1	949.0	86.0	49.0	57.0	22.0	207.0	198.0	167.0	163.0	166.0	56.0	48.0	33.0	29.0
U.S. total	%	30.9	31.1	55.8	26.5	22.8	50.0	39.1	35.4	12.0	23.9	29.5	37.5	20.8	33.3	24.1
Study	%	54.1	59.7	79.2	69.2	46.2	18.2	46.9	92.9	50.0	20.5	20.4	9.6	20.0	54.6	0.0
Employment	%	44.8	39.0	20.8	23.1	53.8	81.8	53.1	5.7	50.0	74.4	79.5	90.5	80.0	45.5	100.0
Unknown	%	1.2	1.4	0.0	7.7	0.0	0.0	0.0	1.4	0.0	5.1	0.0	0.0	0.0	0.0	0.0
Non-U.S.	%	61.2	61.4	40.7	65.3	70.2	40.9	49.3	61.1	77.8	69.9	59.6	55.4	68.8	54.5	58.6
Unknown location	%	8.0	7.5	3.5	8.2	7.0	9.1	11.6	3.5	10.2	6.1	10.8	7.1	10.4	12.1	17.2
Planned location in the U.S. after Ph.D.	n	518	417	51	20	22	14	102	94	35	69	101	51	21	16	13
Definite postdoc. study	%	28.8	33.8	47.5	35.0	22.7	14.3	23.5	62.8	22.9	10.1	7.9	5.9	9.5	18.8	0.0
Definite employment	%	33.8	30.2	14.8	20.0	50.0	42.9	43.1	7.4	34.3	47.8	48.5	54.9	28.6	31.3	76.9
Seeking postdoc. study	%	16.0	18.5	23.0	25.0	22.7	0.0	20.6	20.0	11.4	13.0	5.9	3.9	4.8	18.8	0.0
Seeking employment	%	19.5	15.6	14.8	15.0	4.5	42.9	11.8	5.3	31.4	26.1	35.6	31.4	57.1	31.3	23.1
Postdoc. plans unknown	%	1.9	1.9	0.0	5.0	0.0	0.0	1.0	4.3	0.0	2.9	2.0	3.9	0.0	0.0	0.0
Definite employment plans in U.S. after Ph.D.	n	175	126	9	4	11	6	44	7	12	33	49	28	6	5	10
Primary work activity																
R&D	%	45.1	53.2	88.9	D	18.2	100.0	56.8	42.9	83.3	33.3	24.5	14.3	50.0	D	20.0
Teaching	%	35.4	27.0	11.1	D	72.7	0.0	20.5	28.6	0.0	42.4	57.1	60.7	50.0	D	70.0
Administrative	%	2.9	1.6	0.0	D	0.0	0.0	2.3	0.0	0.0	3.0	6.1	10.7	0.0	D	0.0
Professional services	%	5.7	7.9	0.0	D	9.1	0.0	9.1	14.3	8.3	6.1	0.0	0.0	0.0	D	0.0
Other	%	1.7	2.4	0.0	D	0.0	0.0	2.3	14.3	0.0	3.0	0.0	0.0	0.0	D	0.0
Unknown	%	9.1	7.9	0.0	D	0.0	0.0	9.1	0.0	8.3	12.1	12.2	14.3	0.0	D	10.0
Type of employer																
Educ. institution[c]	%	59.4	49.2	11.1	D	90.9	16.7	43.2	42.9	41.7	56.7	85.7	85.7	100.0	D	90.0
Industry/Business	%	29.7	38.9	66.7	D	9.1	83.3	52.3	42.9	50.0	6.1	6.1	7.1	0.0	D	0.0
Government	%	4.0	5.6	11.1	D	0.0	0.0	4.5	0.0	8.3	9.1	0.0	0.0	0.0	D	0.0
Non-profit	%	1.7	0.8	11.1	D	0.0	0.0	0.0	0.0	0.0	0.0	4.1	3.6	0.0	D	10.0
Other and unknown	%	5.1	5.6	0.0	D	0.0	0.0	0.0	14.3	0.0	18.2	4.1	3.6	0.0	D	0.0

[a] This table includes all citizens of Mexico who indicated a visa status (permanent of temporary visa). Those with unknown visa status are not included.

[b] In this table a recipient counts once in each source category from which he or she received support. Since students indicate multiple sources of support, the vertical percentages sum to more than 100 percent. "Personal" includes a recipient's own eamings, family support, and loans. Federal research assistants are aggregated with university research assistants.

[c] Includes 2-year and 4-year colleges and universities, medical schools, and elementary/secondary schools.

KEY: D = Data withheld to avoid potential disclosure of confidential information.

SOURCE: National Science Foundation/Division of Science Resources Studies, *Survey of Eamed Doctorates.*

Appendix table 7. Fellowships administered by CONACYT, 1980-96

Year	Fellowships		
	Total	National	Foreign
1980	4,618	3,049	1,569
1981	4,340	2,309	2,031
1982	1,801	826	975
1983	2,540	2,072	468
1984	2,033	1,611	422
1985	2,608	2,032	576
1986	1,843	1,468	375
1987	2,220	1,822	398
1988	2,235	1,791	444
1989	1,677	1,368	309
1990	2,135	1,660	475
1991	5,570	4,181	1,389
1992	6,665	5,103	1,562
1993	9,492	6,988	2,504
1994	11,703	9,170	2,533
1995	16,200	12,840	3,360
1996/p	18,079	14,333	3,746

KEY: /p = Preliminary figures

SOURCE: National Council of Science and Technology Studies (CONACYT), Mexico.

Appendix table 8. Fellowships administered by CONACYT by study level, 1980-96

Year	Total	Master's	Doctorate	Postdoctorate	Other[a]
1980	4,618	2,138	311	9	2,160
1981	4,340	1,677	368	23	2,272
1982	1,801	377	88	3	1,333
1983	2,540	1,481	319	20	720
1984	2,033	1,135	303	19	576
1985	2,608	1,256	364	14	974
1986	1,843	821	268	12	742
1987	2,220	1,083	317	11	809
1988	2,235	1,006	351	21	857
1989	1,677	873	286	19	499
1990	2,135	1,142	453	17	523
1991	5,570	3,448	1,749	22	351
1992	6,665	4,412	2,184	13	56
1993	9,492	6,534	2,569	43	346
1994	11,703	8,056	3,167	53	427
1995	16,200	11,776	4,424	0	0
1996/p	18,079	12,479	5,269	0	331

[a] Includes specialization scholarships, interchange, actualization, language, technical training, and special projects. Data are preliminary.

KEY: /p = Preliminary figures

SOURCE: National Council of Science and Technology Studies (CONACYT), Mexico.

Appendix table 9. The 50 universities in greatest demand by CONACYT fellowship-holders

University	Country
1. The University of Arizona	United States
2. Harvard University	United States
3. Universidad Complutense de Madrid	Spain
4. Stanford University	United States
5. University of Texas at Austin	United States
6. Texas A&M	United States
7. Cornell University	United States
8. Columbia University	United States
9. University of Manchester Institute of S&T	United Kingdom
10. University of Warwick	United Kingdom
11. MIT	United States
12. New Mexico State University	United States
13. University of Essex	United Kingdom
14. Universidad Autónoma de Barcelona	Spain
15. Imperial College of S/T and Medicine	United Kingdom
16. Georgetown University	United States
17. Universidad Politécnica de Cataluña	Spain
18. U.London the London School of Econ. & Pol.Science	United Kingdom
19. University of Michigan	United States
20. UCLA	United States
21. UC Berkeley	United States
22. University of Illinois at Urbana Champaign	United States
23. UC Davis	United States
24. University of Pennsylvania	United States
25. New York University	United States
26. Northwestern University	United States
27. Universidad de Barcelona	Spain
28. University of McGill	Canada
29. Yale University	United States
30. University of Edinburough	United Kingdom
31. University of Cambridge	United Kingdom
32. University of Sheffield	United Kingdom
33. University of Oxford	United Kingdom
34. University of Reading	United Kingdom
35. University of Sussex	United Kingdom
36. University of Toronto	Canada
37. University College London	United Kingdom
38. Universite Pantheon Sorbonne-Paris I	France
39. University of Southampton	United Kingdom
40. Universidad de Salamanca	Spain
41. Universidad Autónoma de Madrid	Spain
42. University of British Columbia	Canada
43. University of Laval	Canada
44. Institut National Polytechnique de Grenoble	France
45. Ecole de Hautes Etudes en Sciences Sociales	France
46. Institut National Polytechnique de Toulouse	France
47. Université Pierre et Marie-Curie-Paris VI	France
48. Universidad Politécnica de Madrid	Spain
49. Université de Paris Sud Paris XI	France
50. Université Paris VI	France

SOURCE: National Council of Science and Technology Studies (CONACYT), *Programa de CyT 1995-2000,* Mexico.

Appendix table 10. Estimated cost of fellowships in Colombia and abroad, 1998

	Maintenance	Enrollment Fees	Pasantía[a]	Total
Abroad	1,100 x 48 = 52,800	6,000 x 8 = 48,000		100,800
Colombia[b]	725 x 42 = 30,450	2,140 x 8 = 17,120	1,100 x 6 = 6,600	54,170

a Visit to a foreign university.

b For the calculation of the value of a scholarship in Colombia, an exchange rate of 1,400/dollar and a monthly maintenance allowance equivalent to five minimum salaries was used. For domestic fees, it is assumed that the value in constant pesos is a little less than half the cost in foreign prestigious universities. The costs of travel, installation, books, computer, etc., cancel each other, for the domestic scholarship incudes a pasantía of some 6 months in a foreign university.

SOURCE: The Columbian Institute for the Development of Science & Technology (COLCIENCIAS), Comité Externo de Asesoramiento y Seguimiento - CEAS, 1998.

Appendix table 11. FUNDAYACUCHO educational loans and fellowships, 1990-96

Year	Total	Venezuela	Abroad
1990	577	398	179
1991	863	367	496
1992	400	157	243
1993	712	146	566
1994	541	157	384
1995	321	122	199
1996	614	194	420

SOURCE: Gran Mariscal de Ayacucho Foundation (FUNDAYACUCHO).

Appendix table 12. Fellowships by the UVC Science & Humanities Development Council by level, 1958-96

Level	Total	1958-66	1967-76	1977-86	1987-96
Total	603	24	124	284	171
Specialization	118	23	38	25	32
Master's	187	0	39	99	49
Doctorate	292	1	47	155	88
Postdoctorate	1	0	0	0	1
Research	5	0	0	5	1

SOURCE: Science & Humanities Development Council (CDCH) and the Central University of Venezuela (UCV).

Appendix table 13. Fellowships by the UVC Science & Humanities Development Council (CDCH) by faculty, 1958-96

Faculty	Total		1958-66	1967-76	1977-86	1987-96
Total	603	(100.0)	24 (4.0)	127 (21.1)	286 (47.4)	166 (27.5)
Agronomy	94	(15.6)	1	34	41	18
Archeology & urbanism	18	(3.0)	1	2	8	7
Sciences	152	(25.2)	2	38	68	44
Economic science	41	(6.8)	5	4	18	14
Juridical science	4	(0.7)	0	1	1	2
Veterinary	28	(4.6)	2	1	22	3
Pharmacy	16	(2.7)	0	2	12	2
Humanities & education	69	(1.4)	3	8	30	28
Engineering	57	(9.5)	4	14	28	11
Medicine	80	(13.3)	5	14	37	24
Odontology	44	(7.3)	1	9	21	13

SOURCE: Science & Humanities Development Council (CDCH) and the Central University of Venezuela (UCV).

Mobility Programs for Scientists and Engineers in Latin America

Hebe Vessuri

Although Latin American and Caribbean countries have made systematic efforts to develop a framework for cooperation and integration, few of the existing frameworks have contributed significantly toward financing science and technology (S&T) cooperation. However, there is growing awareness of the need to increase national support for innovation; in addition, multilateral institutions (especially banks) have played a significant role in Latin America in shaping technological development. The Inter-American Development Bank and the World Bank are key players in funding S&T development projects.

Other multilateral organizations have been active, given the resources available to them, in supporting the S&T base in the region as well; these include the United Nations Educational, Scientific, and Cultural Organization (UNESCO), the Ibero-American Program of Science and Technology Development (CYTED—described below), the Inter-American Organization for Higher Education based in Quebec City, and the Inter-American Association of Associations for the Advancement of Science (Interciencia). All of these organizations have a program component addressing mobility of scientists and engineers. Additionally, numerous bilateral programs exist among the various Latin American countries, notably through their National Organizations for the Promotion of S&T (ONCYTs).

This brief paper highlights some of the most significant organizations and initiatives involving mobility programs for scientists and engineers in Latin America.

Multilateral Organizations

CYTED. Created in 1984 by an agreement signed by 21 Ibero-American countries, CYTED's main objective is to foster cooperation among research groups at universities, research and development (R&D) centers, and innovative firms in Ibero-American countries to achieve transferable S&T results for productive systems and social policy. It also aims to be a bridge for S&T cooperation between Latin America and the European Union through Spain and Portugal. It is made up of 16 thematic subprograms that range from aquaculture to S&T management. It also comprises thematic networks; these are associations of research units of public or private organizations in CYTED countries whose S&T interests and activities are related to the particular network's theme. Although the creation and specialization of human resources is not CYTED's primary aim, it does conduct considerable activity in this area. CYTED's human resource creation activities are mainly directed at network and project components and, secondarily, to other collectives of researchers, teachers, and professionals. These formation activities within CYTED are co-funded. Only those oriented to the improvement of capacity building of the groups participating in CYTED projects may be funded entirely through subprogram funds.

Regarding scientific cooperation, one of the most recent and interesting efforts involves the establishment of Latin American Science Networks in several major fields. These networks are sponsored by UNESCO and the International Council of Scientific Unions through the Committee on Science and Technology in Developing Countries/International Biosciences Networks; they also receive support from the Latin American Academy of Sciences. They have formed a coordinating committee for the discussion of policies and problems affecting the entire scientific community in the region, as well as interdisciplinary topics and projects. For their members, the networks have drawn largely on existing scientific societies and a variety of organizations that bring scientists of the region together in the different disciplines, which means that they are highly representative and well-equipped to work with the respective communities. One of their main activities has been to foster interregional exchanges among young scientists. They are also administering government support and seeking to generate regional mechanisms for the integration and financing of joint efforts in S&T.

Examples of these networks of research and exchange follow.

Latin American Astronomy Network (RELAA). This network has a long-standing tradition of cooperation with members of the International Astronomical Union. Following a recent impetus from the International Council of Scientific Unions and UNESCO, more systematic cooperation has been established among the member countries, namely Argentina, Brazil, Chile, Mexico, Uruguay, and Venezuela.

Latin American Biological Sciences Network (RELAB). This is the oldest of the S&T networks, launched in 1975 with the sponsorship of the United Nations Development Programme (UNDP) and UNESCO. It currently has 14 national, 6 regional, and 2 associate members. RELAB has integration projects at various stages of implementation, including the Regional Program of Biotechnology. Launched with support from UNDP, UNESCO, and the United Nations Industrial Development Organization in 1987, this program has been operating since 1996 with funds from various donors and countries. From the outset, the program has supported the establishment of the Argentine-Brazilian Center for Biotechnology.

Latin American Biotechnology Network. An offshoot of RELAB operating since 1992 with the support of national committees, this network has contributed to policymaking, the establishment of infrastructure, and an increase in investment in biotechnology.

Latin American Physics Network (RELAFI). There is a long-standing practice of cooperation in physics through the Latin American School of Physics, a biennial event held since 1959, and the Latin American Center for Physics (CLAF), which has systematically supported regional activities. In 1994, the Latin American Network of Physics Societies (RELASOFI) was created, comprising CLAF and the 16 physics societies or groups that make up the Latin American Federation of Physics Societies (FELASOFI). In 1996, the Ibero-American Union of Physics Societies was created in response to the need for Spanish and Latin American organizations to present a united front in negotiations within international structures.

Latin American Chemical Sciences Network (RELACQ). Since 1959, the best promoter of academic exchanges in chemistry has been the Latin American Federation of Chemistry Associations. In 1995, it was decided to create RELACQ to give fresh impetus to cooperation; this network has yielded its first tangible products and has good prospects for growth. RELACQ has a counterpart, the Latin American Electronic Network for Chemistry, supported by the Organization for American States (OAS).

Mathematical Union of Latin America and the Caribbean (UMALCA). This union was created at the same time as RELACQ; its predecessor was a regional program supported by the French government. UMALCA carries out and supports a series of activities at the regional level, including the Latin American School of Mathematics and the Regional Mathematics Network, which aims to foster cooperation in research and advanced education.

Latin American Association for Space Geophysics (ALAGE). This network is very young—it was created in 1993—but very active. There is also an embryonic Latin American Network for Earth Sciences (RELACT), which aims to encompass surveys of geology, mineral resources, and water supply being carried out in the basin of the La Plata River in the context of the Southern Cone Common Market (MERCOSUR).

Network for the Popularization of Science and Technology in Latin America and the Caribbean (RED-POP). This network was established with UNESCO support and involves most centers in the region in an exchange of information and experience.

Planning and Management of Science & Technology in Latin America Graduate Programs Network (RED-POST). This network was created in 1989 under UNESCO auspices by formally established Latin American university graduate programs granting master's and doctoral degrees; its purpose is to explicitly promote and channel cooperation and exchange among programs in this field.

UNESCO-UNITWIN. UNESCO has implemented a worldwide system of chairs for the introduction of new themes and subjects in different countries and regions, often through the pairing of universities, whereby both teachers and students circulate and are concentrated in particular sites. In Latin America, the number of UNESCO and UNITWIN chairs has been growing considerably, and the International Latin American and Caribbean Institute for Higher Education in Caracas is firmly committed to expanding these as a mechanism.

LATINDEX. The purpose of this regional cooperation project in the field of scientific information and documentation is to create a computerized system based on a regional network of information centers in order to keep up to date a catalogue and index of the scientific journals published in Latin America and the Caribbean.

Bilateral Programs

Inter-American University Organization (OIU). Since its foundation in 1980, OIU has fostered exchange activities between educational institutions in the Americas. In 1983, it created the Institute for University Management and Leadership (IGLU) with the aim of developing training activities, career development activities, etc., for the university and other higher education leaders belonging to this organization.

Organization of Ibero-American States for Education, Science and Culture (OEI). This intergovernmental organization was created in 1955, with of aim of strengthening cultural identity in the integration process, through the promotion of capabilities linked to the social, cultural, and economic development of Ibero-America. The target group for 1999-2002 will be the 14- to 19-year-old age group, although interventions might also be planned for other populations. Emphasis will be placed on supporting policy design and management; as an Ibero-American organization, OEI will try to reinforce its role as an agent between the European Union and Latin America. Its funding is covered by obligatory quotas from the governments of the member states, as well as from contributions for particular projects made by institutions, foundations, and other interested organizations.

Collaboration on University Management: A Bridge Between Universities and Scholars in Europe and Latin America (COLUMBUS). Since its creation in 1987, this nongovernmental organization made up of affiliated public and private universities from both Latin America and Europe has supported the modernization of higher education and institutional development in Latin America, facilitating the exchange of successful experiences, systematically exploring critical areas of institutional management, training senior university officials, and organizing support services and specific management projects. It has greatly enhanced international and intraregional mobility of university authorities and has effectively contributed to the introduction of an evaluatory culture in higher education institutions in the region.

Academic and Professional Programs for the Americas (LASPAU). This nonprofit organization affiliated with Harvard University designs, develops, and implements academic and professional exchange programs on behalf of individuals and institutions in the United States, Canada, Latin America, and the Caribbean. LASPAU places a high value on the role of exchange in institutional development and on access to exchange programs by all individuals, regardless of socioeconomic level, geographical location, sex, or race. The organization offers a strong regional focus, administrative expertise, and a foundation in the Harvard community. Drawing on extensive knowledge of the Latin American and Caribbean academic communities, LASPAU has collaborated with the United States Information Agency since 1975 in the administration of a Faculty Development Program which brings more than 150 educators each year from Latin America and the Caribbean to the United States.

Fulbright-LASPAU Partnership. The success of the LASPAU Faculty Development Program has encouraged other associations between the Fulbright Program and LASPAU, including the Central American Program of Undergraduate Scholarships (CAMPUS), the Amazon Basin Scholarship Program, the Caribbean and Central American Ecology Program, cost-sharing initiatives by Fulbright commissions and United States Information Science (USIS) offices, and a series of workshops and seminars offered to Fulbright grantees and alumni both in the United States and abroad. Today, LASPAU actively partners with U.S. and Latin American universities, Fulbright commissions, and USIS offices to design flexible programs that meet the needs of countries, institutions, and the grantees themselves.

International Development Research Center (IDRC). In addition to its important cooperation program with Latin America for the development of a scientific base in the region, IDRC has supported close to 200 Latin American and Caribbean scholars in the past 10 years. Chile, Peru, and Colombia have the largest percentages of students currently funded.

Montevideo Group (AUGM). The association of universities in the Montevideo Group has accumulated cooperation and exchange experiences since 1991, and has developed the Common Academic Space Program (ESCALA) to promote the creation of a kind of subregional virtual university. The mobility of teachers and researchers in an early phase and the later widening of the program to cover student mobility within the southern subregion is playing a crucial role in the development of a "subregional integrating dimension" of higher education, supported and stimulated by MERCOSUR. Higher institutions linked to the program have begun to take this mobility into account in establishing their structures and aims.

OAS Common Market for Scientific and Technological Knowledge Program (MERCOCYT). Modeled in part on the European Union Framework Program for R&D, this program is a mechanism to promote S&T capacity building in the region and has been in operation since the beginning of the 1990s. Among its main components are projects of scientific and technological integration (such as exchanges and training of highly qualified personnel, research and management of technology and networks of centers of excellence, and data intercommunication).

Latin American Faculty of Social Sciences (FLACSO). Established in 1957 with headquarters in Santiago, Chile, and UNESCO support, FLACSO is an autonomous cooperative initiative of UNESCO and the governments of the region aimed at promoting education, research, and technical cooperation in the social science field throughout the subcontinent. The organization's autonomy and regional character are ensured by the participation of all member countries and eminent intellectuals in its governing bodies and by the Latin American origins of its academic, student, and administrative body, which carries out activities in its 10 academic units and in the general secretariat. Its Latin American nature is also strengthened by the content and scope of its teaching and research programs, which are geared to the region's scientific and social needs. Assistance comes from financial contributions by member country governments and from an extensive network of cooperation agreements with various institutions in the public and private sectors of this and other continents. FLACSO's basic functions are to provide training in the social sciences through postgraduate and specialization courses; perform research in the social science field on Latin American problems; disseminate by all available means, and with the support of governments and appropriate institutions, advances in the social sciences, particularly its own research results; promote the interchange of social science teaching materials in and for Latin America; and, by means of extension and cooperation work, collaborate with university institutions and similar international, regional, and national bodies, both governmental and private, to encourage development in the social sciences.

Latin American Social Sciences Council (CLACSO). Since its creation in 1966, CLACSO has formed the most extensive coordination body for social science research centers in Latin America and the Caribbean, and currently includes 117 member centers. Its executive secretariat has always operated in Buenos Aires. CLACSO has developed a basic work program that strengthens interchange mechanisms in order to bring about a greater integration of Latin American social sciences. It protects the working conditions of social scientists at member centers and other institutions in the region whose academic activities and/or personnel were marred by years of authoritarian repression. Its postgraduate program deals with two major areas: the Southern Cone Research Program, which, with financial support from CLACSO, provided aid in the countries of the subregion to researchers experiencing work difficulties because of their political and/or theoretical views; and, in cooperation with UNDP and UNESCO, the Young Researchers Training Program, since it had become apparent that the main problems in the region were a lack of funds for research and the difficulties experienced by young university graduates in obtaining funds from international agencies.

In recent years, the council's academic activity has been directed at its own medium- and long-term planning against a background of institutional reorganization, rethinking the Commissions and Groups Program to counteract the effects of thematic/organizational dispersion, and continuing action in subject matter areas of particular importance for the analysis of democratization and adjustment processes in the region. CLACSO's 26 working groups and commissions have a membership of some 3,000 researchers in a program of academic exchange, debate, and publication. In 1994, special attention was devoted to nine central themes (commissions) involving the working groups. In view of the increasing development of various Latin American information networks, the Network of Networks (Red de Redes) project was established with IDRC support to improve end user access to existing information resources by linking up 18 regional information networks. During the 1992-95 period, CLACSO was responsible for general coordination of the International Development Information Network for the social sciences, Phase II. That project encouraged the coordinators of each association to develop mechanisms and strategies for new forms of telecommuting. IDRC in Ottawa provided financial support; additional technical support came from the Organisation for Economic Co-operation and Development.

OTHER

No listing of mobility mechanisms for scientists and engineers in Latin America would be complete without mentioning the fellowship and other collaborating programs set up by several developed countries through their embassies: the United States, the United Kingdom, France, Germany, the Netherlands, Japan, Italy, and Spain, among others. Another important recent initiative is that of the European Union, through its Alfa-Program of collaboration with Latin America.

U.S. GRADUATE EDUCATION

Jean M. Johnson, Alan Rapoport, and Mark Regets

TRENDS IN GRADUATE ENROLLMENT

Enrollment in U.S. graduate science and engineering (S&E) programs grew for almost 20 years, reached a peak of 436,000 students in 1993, and then began to shrink. From 1975-93, the overall number of students in graduate programs increased steadily at an average annual rate of 2 percent. Subsequent declining enrollment from 1993-97 has averaged 1.6 percent annually. Fewer students enrolling in engineering, mathematics, and computer sciences account for most of the decline. Engineering, mathematics, and computer science enrollments grew at a rate of almost 4 percent annually from 1975-92, but declined 3 percent annually from 1992-95. Engineering enrollment has continued to decline, while enrollment in mathematics and computer sciences increased slightly in 1996 and 1997. Trends differ when examining subfields: within the natural sciences, the physical sciences have decreasing graduate enrollment, while the biological sciences have increasing enrollment (NSF 1999a).

Graduate student enrollment in S&E, although shrinking, is becoming more diverse. In 1977, women represented only one-quarter of S&E graduate enrollment; by 1997, they represented 40 percent of enrollment. The increasing enrollment of minorities in graduate S&E programs partially stems from changing demographics—the higher growth rate in the minority population relative to the white population. While women and minorities continued a decade-long trend of increased enrollment in graduate S&E programs, foreign students and U.S. citizen white males began a downward trend in their enrollment levels. (See appendix tables 1 and 2 and NSF 1999a.) The decline in foreign student enrollment in U.S. institutions is likely influenced by the increasing educational opportunities in other countries.

MASTER'S DEGREES

The overall trend in U.S. S&E programs at the master's degree level shows rapidly increasing numbers of earned degrees throughout the 1980s and an even stronger growth in the 1990s. This growth is mainly accounted for by rising numbers of earned degrees in the social sciences and engineering, with relatively stable numbers in the natural sciences, mathematics, and computer sciences. (See appendix table 3.)

BY SEX

Over the 20-year period 1975-95, males accounted for the strong growth in master's degrees in engineering, mathematics, and the computer sciences. Females were primarily responsible for the strong growth in social sciences; they also obtained a larger share of degrees in the natural sciences. The proportion of master's degrees earned by females increased considerably in the last two decades—not only in the natural sciences, but in engineering as well. In 1975, females earned 21 percent of the natural science degrees at the master's level and almost 3 percent of the engineering degrees. By 1997, females accounted for 43 percent of the natural science degrees and 16 percent of engineering. (See appendix table 3.)

BY RACE/ETHNICITY

In the 1990s, minority groups in the United States earned, in most cases, increasing numbers as well as increasing shares of master's degrees in S&E fields. The number of S&E degrees earned by Asian/Pacific Islanders consistently increased, especially in engineering, mathematics, and the computer sciences. The number of S&E master's degrees obtained by blacks grew modestly in most fields, with strong growth in the social sciences. Hispanics earned a moderately increasing number—and proportion—of degrees in the social sciences, as well as in engineering. White students showed modest growth in natural science and engineering degrees in the 1990s and strong growth in the social sciences. Notwithstanding these gains, the share of master's degrees earned by white students in all fields declined during the 1977-97 period. (See appendix table 4.)

BY CITIZENSHIP

Analysis of master's degrees by citizenship shows a trend toward a larger proportion of degrees going to foreign students in engineering, mathematics, and the computer sciences. In 1977, foreign students earned 22 percent of the engineering degrees and 11 percent of the mathematics and computer science degrees. By 1995, foreign representation at the master's level was 34 percent in engineering and 35 percent in mathematics and computer sciences. The rate of growth of overall S&E

master's degrees obtained by foreign students slowed somewhat in the 1993-96 period, mainly due to a leveling off of their earned degrees in mathematics and the computer sciences. (See appendix table 4.) Engineering degrees awarded to foreign students declined in 1997, echoing the decline in foreign graduate enrollment in engineering from 1993-96. (See appendix table 2.)

Doctoral Degrees

A decade of relatively stable production of S&E doctoral degrees granted in the United States from 1975-85 was followed by a decade of increasing production of such degrees; in 1996, over 27,000 S&E doctorates were awarded. Large increases in the numbers of earned degrees were evident in engineering, mathematics, and the computer sciences. The number of degrees in these fields doubled from 1985-96. (See figure 1.) The natural science fields—particularly the biological sciences—also contributed to the rising number of degrees during this period, increasing by 25 percent (NSF, 1999d).

By Sex

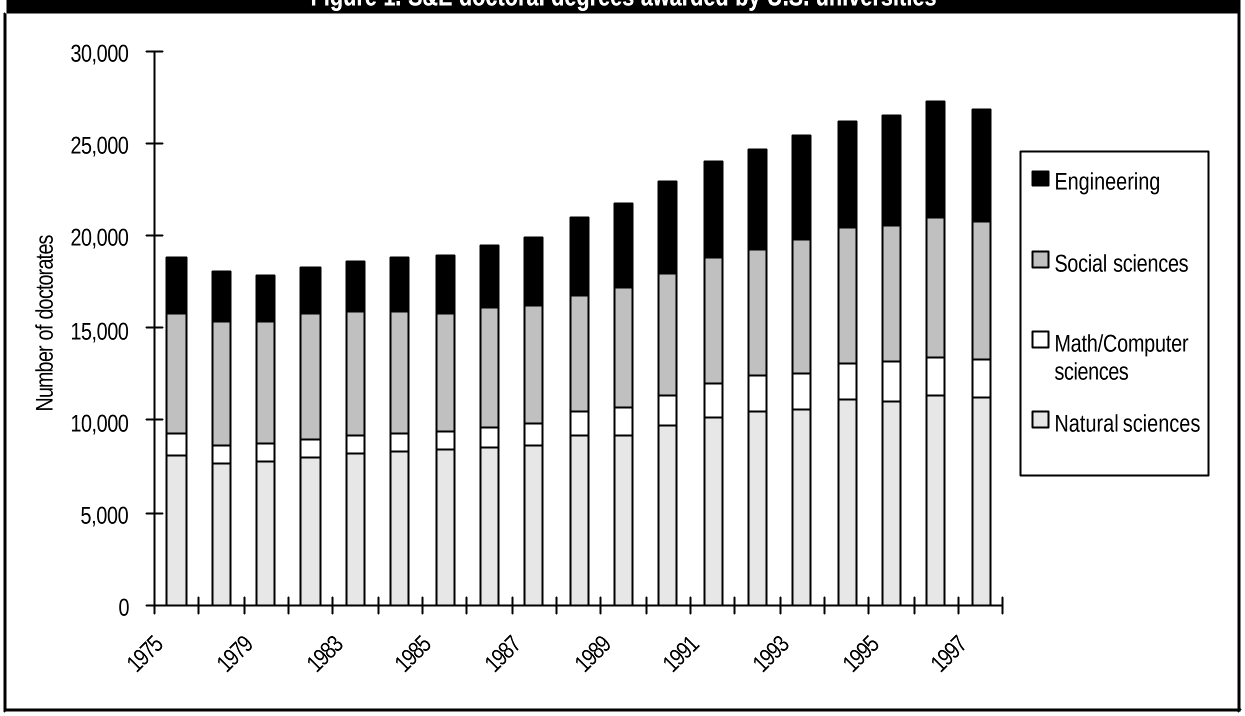
Male doctoral students accounted for much of the growth in engineering, mathematics, and the computer sciences; female doctoral recipients were largely responsible for the increasing number of natural science degrees. Within the past two decades, the share of S&E doctorates earned by women doubled, rising from almost 16 percent in 1975 to 33 percent in 1997. The proportion of increase has differed by field. By 1997, females earned half of the doctoral degrees in the social sciences and 40 percent in the biological sciences. Growth in the proportion of degrees awarded to women was greatest in engineering subfields. By 1997, women earned 12 percent of all engineering degrees, and 16 to 18 percent of doctoral degrees in chemical and material engineering. (See appendix table 5.)

By Race/Ethnicity

Underrepresented minorities within U.S. universities received over 7 percent of all S&E doctorates awarded to U.S. citizens and permanent residents in 1995; this was up slightly from 4 percent in 1977. As a group, these minorities received 6 percent of earned degrees in the natural sciences, 4 percent in mathematics and the computer sciences, 10 percent in the social sciences, and 6 percent in engineering.[1] For black Ph.D. recipients, the largest numerical increases in the past decade have been in the

[1]When considering the total number of earned S&E doctoral degrees (including those to foreign students), the percentages earned by underrepresented minorities are smaller. See NSB (1998), chapter 2.

Figure 1. S&E doctoral degrees awarded by U.S. universities



SOURCE: See appendix table 5.

biological and social sciences. The largest percentage increases have been in the biological sciences and engineering. (See appendix table 6.)

Graduate Education Reforms in the United States

Needs for Reform

The Committee on Science, Engineering, and Public Policy (COSEPUP) of the National Academy of Sciences recently reviewed U.S. graduate programs in S&E. The resulting report, *Reshaping the Graduate Education of Scientists and Engineers* (COSEPUP 1995), recommends broadening the education of doctoral students to better meet their actual career needs. The report noted that the current focus of doctoral programs on research training in a narrow discipline gradually evolved over previous decades when the demand for research was rising. U.S. R&D spending increased rapidly from the late 1970s to the latter part of the 1980s; consequently, doctoral R&D employment increased by almost 5 percent annually. Today, however—the report goes on to explain—an even smaller minority than previously will enter academic research. Only one-third of future doctoral recipients in S&E will enter the tenured academic system; two-thirds will be employed in nonacademic settings. The report concludes that doctoral course offerings should be expanded to reflect the diversity and complexity of these employment options. What these options will all require is the ability to apply an advanced understanding of science and engineering to societal needs. Consequently, S&E doctoral students will need:

- education in the broad fundamentals of their fields,
- familiarity with several subfields,
- the ability to communicate complex ideas to nonspecialists, and
- the ability to work well in teams.

Focus of Reforms

A variety of graduate reforms predated or stemmed from the recommendations of the COSEPUP report. These reforms focus on the education needs of students. Graduate programs are being expanded to include not only multidisciplinary coursework, but also to answer to students' needs for business and teaching skills. The Council of Graduate Schools has held a series of national discussions with graduate deans about the need to prepare students more effectively for their roles as future faculty. Subsequently, the 1997 meeting of the National Science Board on the Federal Role in Graduate and Postdoctoral Programs recommended Federal encouragement to universities to increase diversity and the appropriate broad training of the S&E labor force (NISE 1998).

Forces for Change

Underlying these policy studies are a variety of forces for graduate education reform. These include recent demographic, economic, technological and social changes, as well as the increasing complexity of viable solutions to real-world problems.

Among the demographic forces for change is a larger number of women and minorities earning bachelor's degrees in S&E fields for potential recruitment into graduate S&E programs (along with a declining population and enrollment of whites and declining enrollments of foreign students). Emerging reforms that build on this demographic trend are graduate enhancement programs for underrepresented minority students and recruitment and retention programs for women in science and engineering. For example, Rice University initiated a graduate program for increasing diversity in computational sciences, and the University of Arizona and Notre Dame University promote the Graduate Education for Minorities Consortium (GEM) of industries, colleges, and universities to increase minority recruitment and retention (NISE 1998).

Economic and technological forces are combining to influence changes in graduate education. Spiraling education costs—which are increasing faster than the cost of living—are contributing to the growth of proprietary (for-profit) universities with cost-effective programs. The capital expense of major research programs is necessitating shared research facilities. Collaborative agreements among consortia of universities are being made to ensure efficient use of resources and expertise of graduate faculty. For example, in a new doctoral program in technology management, a consortium of nine universities across eight states links the top laboratories and faculty of key technical specializations (such as digital communication systems and industrial composite materials). This arrangement allows the participants to ensure the broad education needed to manage such advanced technologies (NISE 1998).

Another force for change is technology. Information technologies and distance learning technologies are changing how instruction can be given. For example, Engineering Research Centers supported by the National Science Foundation (NSF) are developing multidisciplinary engineering curricula through interactive instructional modules. (These centers are briefly described below under "Background: Federal Support for S&E.") These modules can assist in teaching principles of diverse subjects using graphics, diagrams, and animation to convey key concepts, along with interactive exercises for practicing the principles' application. Through alternative instructional delivery systems, both graduate students in university classrooms and researchers within private companies can use this software.

The growing demand for public accountability is driving the U.S. educational system to improve instruction in mathematics and science. At the graduate education level, this demand for accountability is focused on the improvement of teaching, with an increased focus on the educational and career needs of students rather than the research needs of faculty. Several universities have initiated efforts to improve both graduate and undergraduate instruction in science and engineering, such as Preparing Future Faculty programs and training for teaching assistants (NISE 1998).

Another dynamic for change is an emerging demand for broadly educated Ph.D. recipients who are able to address the complexity of real-world problems and contribute to their solution. For example, at a recent forum for graduate education reform, the director of research for the U.S. Department of Energy explained that the department—which is one of the largest Federal supporters of basic research in the natural sciences—needs an S&T workforce that can flexibly cross disciplines to solve complex problems in several mission areas. Issues that need to be addressed by the department include the security of existing nuclear stockpiles, the development and use of new energy technologies, the health and environmental effects of energy use, and structural genomics (which combines the disciplines of biology and informatics) in the human genome program (NISE 1998).

The above innovations—as well as new multidisciplinary programs and other efforts to broaden the preparation of graduate students—were addressed at a recent National Institute for Science Education, University of Wisconsin at Madison, forum on graduate education. For more information, see NISE (1998).

S&E Graduate Support

During the course of their graduate careers, most S&E students are likely to be involved in some type of research activities.[2] S&E graduate students thus play a unique role in the U.S. academic research system, in that they are both an input to and an output of this system. U.S. research universities have traditionally coupled advanced education with research, thereby generating new knowledge and producing advanced S&E talent. This complex, symbiotic relationship is exemplified by the va-

Background: Federal Support for S&E

Scientists played a key role in World War II within Federal defense research sites; following the war, policymakers chose to support scientists within universities. The Vannebar Bush Report stated that an increasing number of highly qualified scientists and engineers would be crucial to the U.S. economy, and recommended public support of advanced students in science and mathematics within universities. That policy produced significant Federal support for university-based S&T research and the training of scientists and engineers. These funds increased further following Sputnik, the Cold War, and the creation of the National Institutes of Health (NIH) and the National Science Foundation. By the early 1960s, NIH funding of university research exceeded total funding of university-based research by the Department of Defense.* This compact between the Federal Government and universities has continued to the present, with Federal academic R&D reaching $21 billion (in 1992 constant dollars) in 1996 (NSB 1998).

*Cited by Robert Rosenzweig, former president of the Association of American Universities, see *Stanford Today* (1998).

[2]See chapter 5, "Integration of Research with Graduate Educa-

riety of support mechanisms and sources through which financial resources are provided to S&E graduate students.[3] Support mechanisms include fellowships, traineeships, research assistantships, and teaching assistantships.[4] Sources of support include Federal agency; non-federal support (from academic institutions, state and local governments, foreign governments, nonprofit institutions, and industrial firms); and self-support (from loans or personal or family financial contributions). Most graduate students are supported by more than one source and mechanism during their time in graduate school; they also often receive support from several different sources and mechanisms in any given academic year.

Trends in Support

The recent enrollment declines reported earlier for all S&E graduate students affected the number of full-time students in 1995. For the first time in almost two decades, enrollment of full-time S&E graduate students declined slightly in 1995. A 12-year trend of steady increases in enrollment of full-time graduate students whose primary source of support was the Federal Government also ended, as did an even longer upward trend in the number of graduate students whose primary source of support was from non-federal sources.[5] For more information on Federal support, see sidebar on Background: Federal Support for S&E. The number of self-supported graduate students also declined for the first time since 1988. (See appendix table 7.)

Since 1980, there have been significant shifts in the relative usage of different types of primary support mechanisms. (See figure 2.) These shifts have been due more to rapid growth in some support mechanisms than to an absolute decline in the number of students supported by any of these mechanisms. The proportion of graduate students with research assistantships as their primary support mechanism increased from 22 to 27 percent between 1980 and 1995. This increase was offset by drops in the proportions of students supported by traineeships (from 7 to 5 percent) or by teaching assistantships (from 23 to 20 percent). Most of these changes had occurred by the late 1980s, with proportional shares being relatively stable during the first half of the 1990s. The proportion supported by fellowships fluctuated between 8 and 9 percent between 1980 and 1995; that with self-support as the primary mechanism fluctuated between 28 and 32 percent. These overall shifts in support mechanisms were evidenced for both students supported primarily by Federal sources and for those supported by non-federal sources. (See appendix table 7.)[6]

Patterns of Support by Institution Type

The proportions of full-time S&E graduate students with primary support from various sources and mechanisms differ for private and public universities. (See figure 3.) A larger proportion of full-time graduate students rely primarily on self-support in private academic institutions as opposed to those in public institutions—39 versus 30 percent in 1995.

Non-federal sources are the primary source of support for a larger proportion of students in public institutions (50 percent) than in private ones (41 percent). At both private and public institutions, about 20 percent of students receive their primary support from the Federal Government.

A larger proportion of students attending public academic institutions rely on research assistantships and teaching assistantships as their primary support mechanism (30 and 23 percent, respectively) than those attending private institutions (21 and 13 percent, respectively). This is balanced by greater reliance on fellowships and traineeships in private institutions (14 and 8 percent, respectively) than in public ones (7 and 4 percent, respectively).

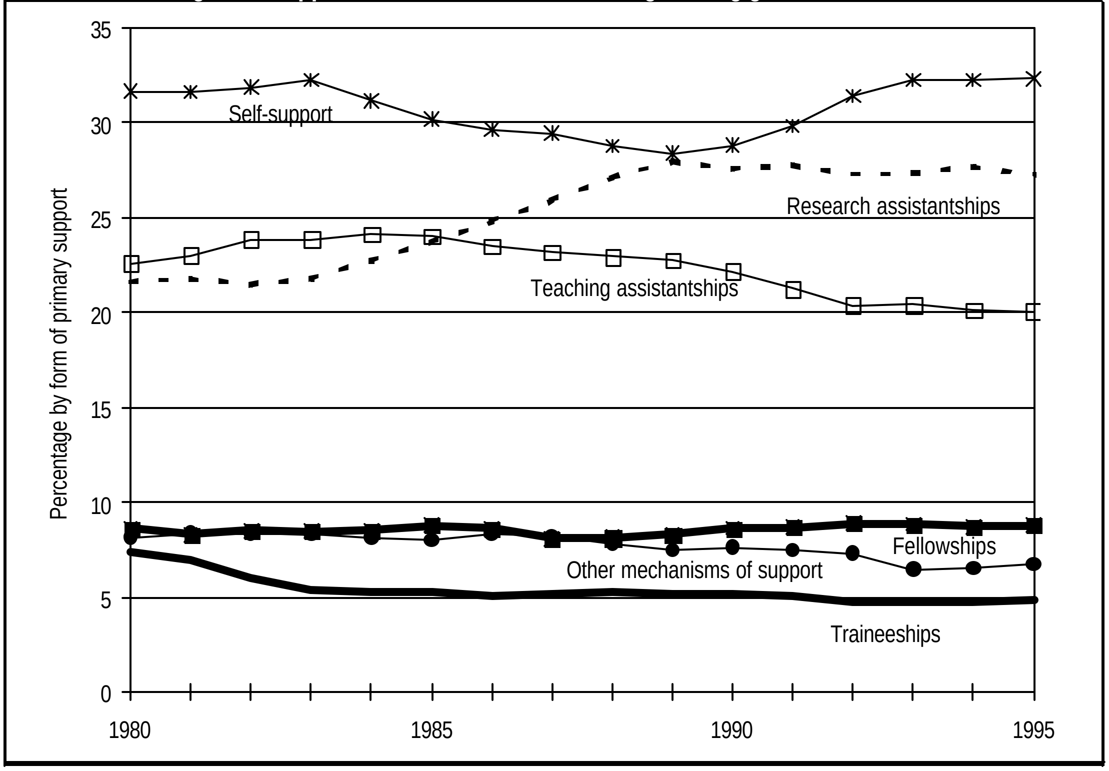
[3] All the data presented here on mechanisms and sources of support for S&E graduate students are from the NSF-NIH annual fall Survey of Graduate Students and Postdoctorates in Science and Engineering. In this survey, departments report the primary (largest) source and mechanism of support for each full-time degree-seeking S&E graduate student. No financial support data are collected for part-time students. Many of the full-time students may be seeking master's degrees rather than Ph.D.s, particularly in the engineering and computer science fields. Throughout this section on support, S&E include the health fields (medical sciences and other life sciences.)

[4] A *fellowship* is any competitive award (often from a national competition) made to a student that requires no work of the recipient. A *traineeship* is an award given to a student selected by the university. An *assistantship* is classified as research or teaching depending on the duties assigned to the student.

[5] Total Federal support of graduate students is likely to be underestimated since reporting includes only direct Federal support to a student and support to research assistants financed through the direct costs of Federal research grants. This omits students supported by departments through the indirect costs portion of research grants; such support would appear as institutional (non-federal) support, since the university has discretion over how to use these funds.

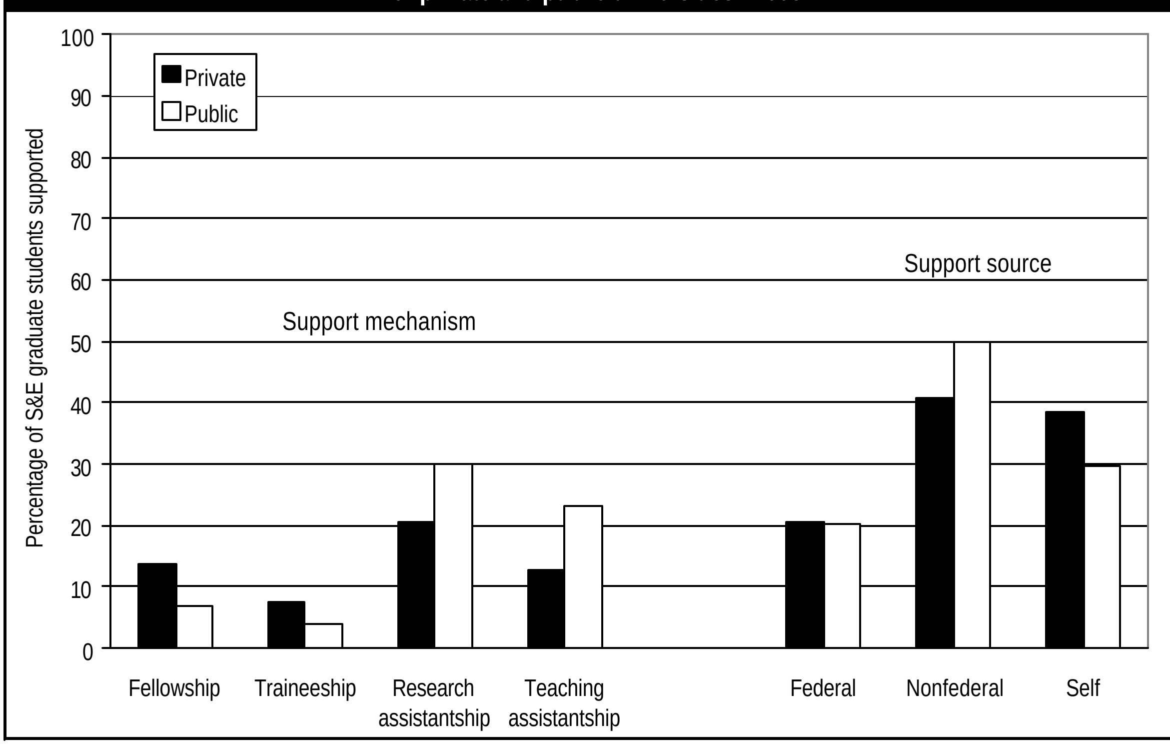
[6] For additional details on trends in support mechanisms by

Figure 2. Support for full-time science and engineering graduate students



SOURCE: See appendix table 7.

Figure 3. Percentage of S&E graduate students by mechanism and source of primary support, for private and public universities: 1995



NOTE: Mechanism percentages do not total 100 because other mechanisms are not included.
SOURCE: National Science Board, *Science & Engineering Indicators-1998,* NSB 98-1 (Arlington, VA: National Science Foundation), appendix table 5-35.

Primary Mechanism and Source of Support by S&E Field

Research Assistantships. Although research assistantships accounted for 27 percent of all primary support mechanisms in 1995, their role differed across S&E fields. They comprised more than 50 percent of the primary support mechanisms for graduate students in astronomy, atmospheric sciences, oceanography, agricultural sciences, chemical engineering, and materials engineering. They accounted for less than 20 percent in all the social sciences, mathematical sciences, and psychology. (See appendix table 8.)

Just as the significance of research assistantships differs across fields, so too does that of the Federal Government as the primary source of support for research assistantships. Overall, the Federal Government was the primary source of support for about half of graduate research assistants. However, it was the primary source of support for 75 percent of the research assistants in the physical sciences, just over 60 percent in both the environmental and computer sciences, but only 20 percent in the social sciences and 32 percent in psychology. (See appendix table 9.)

Teaching Assistantships. Teaching assistantships accounted for 20 percent of all primary support mechanisms in 1995. But they comprised more than 30 percent of the primary support mechanisms for graduate students in chemistry, physics, mathematics, and earth sciences; and less than 12 percent in the atmospheric sciences, oceanography, agricultural sciences, medical sciences, aeronautical engineering, and materials engineering. (See appendix table 8.) The Federal Government has an almost negligible role in supporting teaching assistantships.

Fellowships and Traineeships. Although fellowships accounted for only 9 percent of all primary support mechanisms in 1995, they are a much more important mechanism of primary support for students in the history of science, anthropology, and astronomy where they comprised 37, 20, and 17 percent of the primary support mechanisms, respectively. Students with traineeships as their primary support mechanism accounted for just under 5 percent of all full-time S&E graduate students in 1995. For students in the biological sciences, medical sciences, and other life sciences, however, traineeships accounted for between 11 and 14 percent of primary support. (See appendix table 8.)

The Federal Government was the primary source of support for about one-quarter of all graduate students with a fellowship as their primary mechanism of support and for about two-thirds of those with a traineeship as their primary mechanism of support. The Federal Government was a more important primary source for fellowships to graduate students in the atmospheric sciences, aeronautical engineering, and astronomy, providing 63, 56, and 50 percent, respectively, of the primary fellowship support. In contrast, it provided only 14 percent of primary fellowship support in the social sciences. The Federal Government provided almost 80 percent of primary support for traineeships in the life sciences, compared to 24 percent in computer sciences and 21 percent in the social sciences. (See appendix table 9.)

Self-Support. About one-third of full-time S&E graduate students were supported primarily by loans or from personal or family financial contributions. The importance of this type of support also differed across S&E fields. About 40 percent of students in the computer sciences, medical sciences, anthropology, and industrial engineering—and more than 50 percent of those in psychology and political science—relied on self-support as their primary support mechanism. Conversely, less than 10 percent of the students in astronomy, chemistry, physics, and the atmospheric sciences relied on self-support as their primary support. (See appendix table 8.)

Impacts of Graduate Support Mechanisms

There has long been great interest in whether the amount and type of financial support given to graduate students has an effect on degree completion rates, time to degree, and productivity and success in the labor market. How effective have the large investments in graduate education made by government, academia, and the private sector been? How do the various modes of support—teaching assistantships, research assistantships, fellowships, and subsidized loans—compare in terms of recipients' educational and career outcomes?

Hypotheses of Relative Merits. The merits of various support mechanisms have been discussed and a number of hypotheses developed about the advantages and disadvantages of different mechanisms. In fact, some of the characteristics of a specific mechanism cited as disadvantages by some individuals are cited as advantages by others. For instance, the portability of fellowships and the independence they give to graduate students are seen by some as a distinct advantage because they provide these students with great freedom to pursue a wide variety of interests. Others argue that students with fellowships are more likely than those supported by traineeships or research assistantships to become isolated from their peers and from the faculty in their departments; they thus may either be less likely to complete their Ph.D. or to take longer to do so. Some argue that although having a fellowship at the beginning of one's graduate career may be detrimental, having one when working on a dissertation is highly advantageous.

Similarly, some hold that since research assistantships are directed to the needs of funded research projects, doctoral students can become so involved on a specific project that they have little time for independent exploration or other educational activities, thus limiting the areas in which they acquire experience. A counter argument is that the research skills and experience students acquire by focusing on a specific project are indispensable to the high-quality, state-of-the-art research being conducted at U.S. universities and industrial laboratories; students with research assistantships thus may complete doctoral dissertations more frequently and faster than those with other forms of support. Some argue that strong reliance on research assistantships can bias research and graduate training toward those areas that have long track records rather than to new and innovate areas, and that they also may prevent beginning faculty from attracting graduate students. Others argue that it is the widespread availability of research grants that provides young faculty the opportunity to work closely with graduate students.

Lack of Quantifiable Data. Unfortunately, it is extremely difficult to examine many of these hypotheses analytically either because of the absence of data or the inability to capture the hypothesized outcomes quantitatively.[7] In addition, most graduate students depend on multiple sources and mechanisms of support while in graduate school, and frequently on different sources and mechanisms in different phases of graduate work. This makes it quite difficult, if not impossible, to identify a one-to-one relationship between a student and a support source or mechanism.

Furthermore, there is a selection problem that is not easily overcome. Most external organizations and graduate institutions award financial support based on merit. In addition, the type of support that a student receives is affected by a graduate department's view (and perhaps sometimes by the student's own view) of the student's relative ability to teach or to support research. If students receiving support have more ability or motivation than other students, the former are likely to be more successful than the latter irrespective of the effects of support mechanisms. To the extent that graduate support allocation decisions are successful in sorting students by merit and aptitude, it becomes more difficult to statistically isolate the effect of receiving graduate support from the effects of other student differences.

General Conclusions. Despite these difficulties, various studies have looked at some aspects of graduate support and student outcomes. A recent review of this literature summarized the results as follows (Bentley and Berger 1998):

- The bulk of the evidence suggests that students receiving support enjoy higher completion rates and shorter time to degree than students without support.

- The evidence of the differential effects of alternative support mechanisms on completion rates is inconsistent. However, students holding fellowships appear to finish doctoral programs more quickly than teaching and research assistants.

- Several scholars present evidence that research assistants are more productive scholars than other students, both in graduate school and later in their careers.

- Only one study included in this review attempts to determine whether the dollar amount of support matters. That study did not find evidence that increasing the amount of support improves outcomes.

[7]National Science Board (NSB). 1996 Report from the Task Force on Graduate and Postdoctoral Education NSB/GE 96-2. Arlington, VA: National Science Foundation. This task force, established in 1995 to examine the merits, mix, and impact of several modes of funding support used by NSF in graduate and postdoctoral education, concluded that sufficient links between national data and NSF support data did not exist, and so no recommendations could be made on

Employment of Degreed Scientists and Engineers

Appendix table 10 shows the distribution of those in S&E occupations in the United States. Of the 11.5 million people with some kind of S&E degree, only 3.2 million are in jobs strictly labeled as science and engineering.[8] Of these, nearly two-thirds are employed by private, for-profit employers. By this strict occupational measure of S&E workers, Ph.D. recipients make up 13 percent of the U.S. S&E workforce. If the definition were extended to include all workers with S&E degrees, the proportion of doctorate-holders would fall to 4 percent.

International Mobility of Doctoral Students and Recipients: Foreign Doctoral Students in the United States

In the past decade, foreign students have accounted for the large growth in S&E doctoral degrees in U.S. universities. The number of foreign S&E doctoral recipients graduated from U.S. universities doubled from over 5,000 in 1986 to 10,000 in 1996. This doubling translates to an 8-percent average annual increase. In contrast, the rate of increase in doctoral degrees to U.S. citizens averaged less than 2 percent annually (NSB 1998).

Within natural science and engineering fields, the proportion of doctoral degrees earned in U.S. universities by foreign citizens climbed from 25 percent in 1985 to 33 percent in 1994; it has since begun to level off. In 1997, the share of natural science and engineering degrees earned by foreign students decreased slightly to 31 percent. This drop was mainly due to a decline in doctoral degrees earned by South Korean and Taiwanese students. Both of these economies (which are major contributors of foreign graduate students to the United States) have increased their internal capacity for graduate education in S&E, evidenced by the increasing number of in-country doctoral degrees in these fields (NSB 1998).

Even as Asian students entered U.S. graduate programs in record numbers, Asian universities were expanding their own doctoral degree programs in S&E fields. These two phenomena are related. The desire to increase in-country capacity to educate students through the doctoral level necessitated sending students abroad so as to prepare more S&E faculty for expanded graduate programs within Asian universities. For the period 1988-94, the Asian effort to receive doctoral training in U.S. universities was particularly intense, as evidenced by an increase from 2,872 earned degrees in 1989 to 6,229 in 1994. The annual rate of growth in S&E doctoral degrees earned by Asian students during this period was over 17 percent. However, this rate of growth has slowed considerably in the last few years, and in 1997, the number of degrees earned by Asian students within U.S. universities declined.

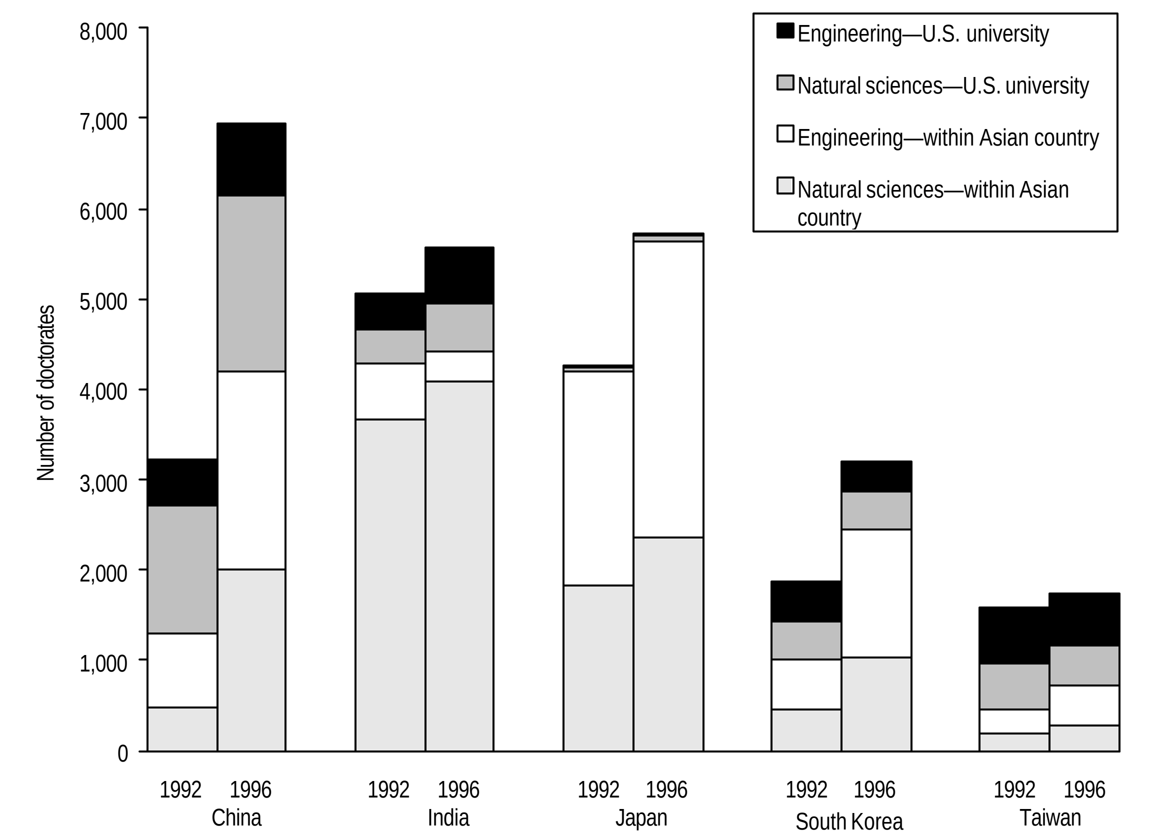
Although Ph.D. production in S&E fields is growing at a faster rate in Asian countries than in the United States, the Asian base is lower. In 1997, 18,513 S&E doctoral degrees were earned in five Asian countries. In that same year, U.S. universities produced almost 27,000 S&E doctorates; however, over 5,500 of these degrees were earned by foreign students from Asia. In 1997, the number of doctoral S&E degrees earned at universities within four Asian economies exceeded the number of such degrees earned by Asian foreign students at U.S. universities. Only for Taiwan do U.S.-earned doctoral degrees outnumber those earned within Taiwanese universities. (See figure 4 and text table 1.)

Patterns of International Mobility and Diffusion of S&T Knowledge

Technology transfer is often said to occur best through people. Thus, the mobility of foreign students throughout Europe, Asia, and the Americas is a significant source of diffusion of S&E knowledge in the world. NSF statistical data are limited to certain patterns of mobility to the United States. The Survey of Earned Doctorates captures the number of S&E doctoral degrees earned by foreign students, students' planned location after completing their degrees, and any firm offers they've received of U.S. postdoctoral study or employment. The Scientists and Engineers Statistical Data System (SESTAT) captures the extent of the contribution of foreign-born scientists and engineers to the U.S. labor force. Little is known,

[8]Other SESTAT survey responses provide strong evidence that many individuals with S&E degrees in non-S&E occupations do use their knowledge from their field of degree and may also be engaged in

Figure 4. Doctoral degrees in natural sciences and engineering awarded within Asian countries and to Asian foreign students within U.S. universities: 1992 and 1996



SOURCE: See text table 1.

Text table 1. Doctoral NS&E degrees awarded within Asian countries and to Asian foreign students within U.S. universities

Field and Location of Degree	Student nationality									
	China		India		Japan		South Korea		Taiwan	
	1992	1996	1992	1994	1992	1996	1992	1996	1992	1996
Total NS&E degrees	3,229	6,955	5,064	5,570	4,270	5,734	1,866	3,197	1,596	1,744
Natural sciences—within Asian country	473	1,999	3,665	4,077	1,833	2,351	459	1,024	191	282
Engineering—within Asian country	823	2,195	629	348	2,362	3,297	552	1,420	264	435
Natural sciences—U.S. university	1,425	1,960	365	520	50	54	418	430	504	452
Engineering—U.S. university	508	801	405	625	25	32	437	323	637	575

KEY: NS&E = natural sciences and engineering

NOTES: Natural sciences include the physical, biological, agricultural, earth, atmospheric, and oceanographic sciences, as well as mathematics, computer and information sciences. Data are latest available year for within-country degrees in India (1994).

SOURCES: **China**— National Research Center for Science and Technology for Development, unpublished tabulations, 1996; **India**—Department of Science and Technology, *Research and Development Statistics 1994-95* (New Delhi: 1996); **Japan**—Monbusho, Monbusho Survey of Education (Tokyo: annual series); **South Korea**—Ministry of Education, *Statistical Yearbook of Education* (Seoul:1996); **Taiwan**—*Educational Statistics of the Republic of China* (Taipei: 1997); **United States**—National Science Board, *Science & Engineering Indicators-1998,* NSB 98-1 Arlington, VA: National Science Foundation.

however, of the return flow of foreign students and the contribution they make to build the S&T infrastructure in their home countries. Little is also known of those foreign graduate students who do not complete a doctoral degree. For example, Japanese industry sends its research personnel to top U.S. universities for 1 to 2 years of advanced study in particular fields (NSF 1997).

The diffusion of S&T knowledge may also occur through networking, without physical relocation of scientists and engineers for extended stays. Choi (1995) has shown extensive networking by Asian-born faculty and researchers working in the United States to advise, disseminate information, and assist in building their home country S&T infrastructure. This tendency is particularly true for foreign-born faculty in S&E departments. In 1993, foreign-born faculty in U.S. higher education accounted for 37 percent of engineering professors and over a quarter of mathematics and computer science teachers. More research is needed on the extent of this diffusion of S&E knowledge through exchange visits or electronic dissemination.

Cooperative research and information technologies are also diffusing S&T knowledge. International cooperative science programs often provide support for immigrant scientists and engineers to collaborate with home country scientists and to advise on building up a research area in a particular area of interest. For example, many of the grantees in the NSF U.S.-China Cooperative Science Program are Chinese American scientists and engineers who are most able to work effectively within the Chinese environment. Electronic dissemination through the Internet is allowing the dissemination of innovative teaching modules as well as specific information needed by home country S&T institutions.

Stay Rates of Foreign Doctoral Recipients in the United States

Until 1992, around half of the foreign students who earned Ph.D.s in S&E in U.S. universities planned to locate in the United States after completing their degree. A significantly smaller proportion (one-third) received firm offers to remain in the United States for academic or industrial employment. The proportion of foreign doctoral recipients who plan to locate in the United States and accept firm offers differs considerably by country and region. Students from Asia, who are the most numerous, also represent the largest percentage who plan to locate in the United States. In contrast, students from North and South America, who are the least numerous, have a smaller proportion planning to locate in the United States.

For the period 1992-96, the proportions of foreign doctoral recipients planning to remain in the United States increased: over 68 percent planned to locate in the United States, and nearly 44 percent had firm offers to do so. This recent increase in stay rates, which may be temporary, is mainly accounted for by the sharp increase in the percentage of Chinese students with firm plans to stay in the United States. In 1990, 42 percent of the approximately 1,000 Chinese doctoral recipients in U.S. universities had firm plans to stay. By 1996, 57 percent of the nearly 3,000 Chinese doctoral recipients from U.S. universities had firm plans to remain in the United States. The underlying cause for this shift is the large number of Chinese students granted permanent residence status in the United States in 1992, following China's response to student demonstrations. Selected countries in Europe (Eastern Europe) and the Americas (Canada), however, also increased their stay rates after completing advanced degrees from a U.S. university. Their numbers are small in comparison to Asia's: 200 from Eastern Europe and 100 from Canada.

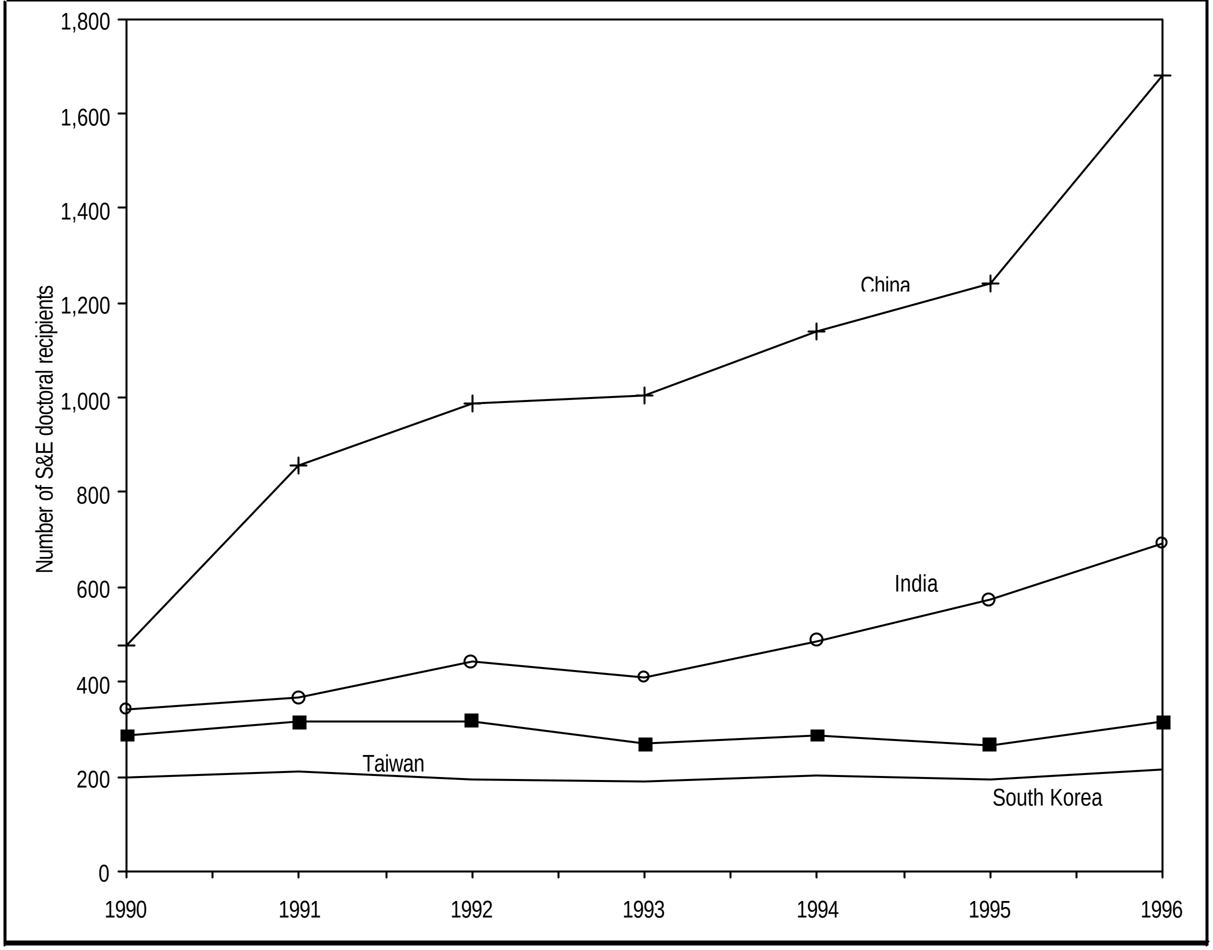
Among Asian countries, China and India apparently have a limited capacity to provide high-level employment to large numbers of returning S&E doctorate-holders. In 1996, 57 to 59 percent of the U.S. S&E doctoral recipients from these countries choose to accept further study or employment in the United States. In contrast, only a small percentage of 1996 doctoral recipients from South Korea and Taiwan (24 and 28 percent, respectively) accepted offers in the United States. The trend in the 1990s has been for relatively few doctoral recipients from these countries to remain in the United States; this is particularly true of South Korean engineering doctoral recipients (NSF 1998). (See figure 5.)

To a large extent, the definite plans of foreign doctoral recipients to remain in the United States revolve around postdoctoral study rather than employment. Among students born in those countries accounting for the largest numbers of foreign doctoral awards, the majority of definite plans to remain in the United States were for further study (58 percent on average between 1988 and 1996); followed by employment in R&D (27 percent); teaching (7 percent), or other professional employment (8 percent).

A recent study of foreign doctoral recipients working and earning wages in the United States (Finn 1997) shows that about 47 percent of the foreign students who earned doctorates in 1990 and 1991 were working in the United States in 1995. The percentages are higher in the physical sciences and engineering, and lower in the life and social sciences. These stay rates differ more by country of origin than by discipline, however. A very large percentage of the 1990-91 foreign doctoral recipients from India and China were still working in the United States in 1995. In contrast, only 10 percent of South Koreans who earned engineering doctorates from U.S. universities in 1990-91 were working in the United States in 1995.

Foreign doctoral recipients from 1970-72 were also examined in the same study. Finn estimated that 47 percent were working in the United States in 1995, and

Figure 5. U.S. S&E doctoral recipients from selected Asian countries with firm plans to remain in the United States



SOURCE: National Science Foundation, Division of Science Resources Studies, Survey of Earned Doctorates, special tabulations.

that the stay rate for that group had fluctuated around 50 percent during the 15 years leading up to 1995. There is no evidence of significant net return migration of these scientists and engineers after 10 or 20 years of work experience in the United States. This does not mean that there is not significant return migration: such migration is known to occur. However, the fairly constant stay rates indicate that any tendency of the 1970-72 cohorts to leave the United States after gaining work experience here has been largely offset by others from the same cohorts returning to the United States after going abroad.

Employment of Foreign-Born Scientists and Engineers

In total, there were 135,000 foreign-born S&E doctoral recipients working in the United States in 1993. (See text table 2 and appendix table 12.) They accounted for 25.6 percent of all U.S.-employed S&E doctorate-holders. Academia is the largest sector of employment for foreign-born S&E doctorate-holders. In industry, however, they actually make up a larger proportion of total S&E doctoral recipients: nearly one-third.

Asia was the place of birth for over half of the foreign-born S&E doctorate-holders working in the United States—76,000. Although this number is for the whole Asian continent, the two largest source countries combined—China and India—provided more S&E Ph.D. recipients to the U.S. labor force than all of Europe.

U.S. Doctoral Recipients Residing Outside the United States

In 1995, at least 19,600 U.S. native-born naturalized citizen and permanent resident Ph.D. scientists and engineers lived outside the United States (text table 3). These included:

Text table 2. Employed foreign-born science and engineering doctoral recipients in the United States	
Place of birth	Total employed
All foreign-born	135,000
Percent of foreign-born of total S&E Ph.D.s employed	25.6
Africa	7,000
Asia	76,000
China	21.000
India	21.000
Japan	3.000
Korea	4.000
Taiwan	9.000
Other	18.000
Central/South America	10.000
Argentina	2.000
Brazil	1.000
Chile	1,000
Cuba	2,000
Mexico	1,000
Other	3,000
Europe	38.000
France	1.000
Germany	6.000
Greece	2.000
Italy	2.000
Netherlands	1.000
United Kingdom	10.000
Other	16.000
North America and other	8.000

NOTE: Numbers rounded to nearest 1,000.

SOURCE: National Science Foundation, Division of Science Resources Studies, 1993, Scientists and Engineers Data System (SESTAT) data file.

- 3 percent (13,900) of all native-born S&E doctorate-holders,
- 7 percent (1,400) of all foreign-born S&E doctorate-holders with U.S. citizenship at time of degree, and
- 14 percent (4,300) of all permanent resident S&E doctorate-holders at time of degree.

Not included are U.S. citizen Ph.D. scientists who held only a temporary student visa or work visa when they received their doctorate; it may be reasonable to assume that this group is as likely to work outside the United States as those who had already been naturalized by the time of degree.

The likelihood of foreign residence for U.S. natives is greatest for those with the most recent degrees—ranging from 2 percent of native-born doctorate-holders who received their Ph.D. between 1945 and 1954 to 3 percent of those who received their doctorate between 1985 and 1994. By field, the proportion of native-born Ph.D. recipients resident in foreign countries is greatest in the mathematical and computer sciences and in the social sciences (4 percent for each). It is lowest in the physical sciences.

Good estimates of the number of U.S. scientists and engineers who work abroad are not available, and the numbers presented here should be treated as lower bound estimates.[9]

[9]These estimates are based on a match of administrative data from the NSF 1995 Survey of Doctorate Recipients to individual data from the NSF Doctoral Record File created from the Survey of Earned Doctorates. The National Research Council (NRC) attempted to identify when a nonresponse was caused by the sampled individual residing outside the United States as of the April reference date. To the extent that individuals residing outside the United States are more prevalent in the sample portion never located by NRC than they are in the located sample, these numbers will underestimate the extent of emigration. Note that since a short-term trip abroad would not count as residence and since the Survey of Doctorate Recipients data are collected over several months, there is little danger of miscategorizing a short absence as working abroad. There is, however, a somewhat greater danger of listing a person as living abroad who left the United States for many years and has since returned.

Text table 3. Estimates of U.S. citizens and permanent resident Ph.D. graduates residing outside the U.S.: 1995

Field of Ph.D.	Native born		Foreign-born with citizenship at time of Ph.D.		Permanent resident at time of Ph.D.		Total citizen or permanent resident at time of Ph.D.	
	Number abroad	Percent of total abroad	Number abroad	Percent of total abroad	Number abroad	Percent of total abroad	Number abroad	Percent of total abroad
All S&E	13,900	3.3	1,400	7.4	4,300	13.6	19,600	4.1
Life sciences	3,400	2.7	200	5.0	900	12.0	4,500	3.3
Math and computer	1,000	4.2	100	4.2	200	10.2	1,200	4.6
Physical sciences	2,200	2.5	300	8.7	800	12.6	3,200	3.3
Social sciences	5,900	4.2	300	7.5	1,200	18.0	7,400	4.9
Engineering	1,500	3.0	500	9.1	1,300	13.1	3,300	5.0

NOTE: This should be considered a lower bound estimate since only those definitely identified as being outside the United States were counted.

SOURCE: National Science Foundation, Division of Science Resources Studies, Doctorate Record File and administrative records associated with collection of the 1995 Survey of Doctorate Recipients.

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APPENDIX

Appendix table 1. Graduate enrollment in science and engineering, by field and sex: 1975-97

Field	1975	1977	1979	1981	1983	1985	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
	Total enrollment																
Science and engineering	303,190	311,816	319,171	332,086	347,065	358,126	373,341	375,277	382,747	397,135	412,697	430,644	435,886	431,251	422,555	415,363	407,644
Natural sciences [a]	95,489	101,221	100,871	100,617	102,979	104,074	104,963	105,529	107,301	109,364	112,474	116,699	119,489	120,833	120,325	117,677	114,697
Mathematics/computer sciences	25,307	25,160	26,721	32,318	40,691	47,332	50,559	51,304	51,729	54,031	54,562	56,648	56,189	53,707	51,941	52,607	52,769
Social sciences [b]	114,123	116,750	119,851	119,596	112,276	110,729	113,866	115,615	119,674	126,115	132,085	139,262	143,350	143,688	143,090	141,856	139,170
Engineering	68,271	68,685	71,728	79,555	91,119	95,991	103,953	102,829	104,043	107,625	113,576	118,035	116,858	113,023	107,199	130,223	101,008
	Male enrollment																
Science and engineering	NA	233,862	229,860	232,209	240,525	247,464	256,149	254,005	256,849	263,394	271,845	280,397	279,289	272,120	262,341	253,629	245,615
Natural sciences [a]	NA	76,073	72,945	70,721	70,711	70,745	70,685	69,869	70,263	70,800	71,753	73,754	74,086	73,878	72,488	69,951	67,234
Mathematics/computer sciences	NA	19,482	20,376	23,628	28,877	34,417	36,948	37,334	37,756	39,633	39,994	41,644	41,129	39,087	37,554	37,596	37,008
Social sciences [b]	NA	73,322	70,687	66,051	59,625	57,391	57,526	57,097	58,387	60,008	62,237	64,197	64,908	64,181	63,114	61,111	59,080
Engineering	NA	64,985	65,852	71,809	81,312	84,911	90,990	89,705	90,443	92,953	97,861	100,802	99,166	94,974	89,185	84,971	82,293
	Female enrollment																
Science and engineering	NA	77,954	89,311	99,877	106,540	110,662	117,192	121,272	125,898	133,741	140,852	150,247	156,597	159,131	160,214	161,734	162,029
Natural sciences [a]	NA	25,148	27,926	29,896	32,268	33,329	34,278	35,660	37,038	38,564	40,721	42,945	45,403	46,955	47,837	47,726	47,463
Mathematics/computer sciences	NA	5,678	6,345	8,690	11,814	12,915	13,611	13,970	13,973	14,398	14,568	15,004	15,060	14,620	14,387	15,011	15,761
Social sciences [b]	NA	43,428	49,164	53,545	52,651	53,338	56,340	58,518	61,287	66,107	69,848	75,065	78,442	79,507	79,976	80,745	80,090
Engineering	NA	3,700	5,876	7,746	9,807	11,080	12,963	13,124	13,600	14,672	15,715	17,233	17,692	18,049	18,014	18,252	18,715

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

KEY: NA= not available

NOTE: For detailed statistical tables on graduate enrollments, see Division of Science Resources Studies home page (http://www.nsf.gov/sbe/srs/stats.htm), Fall 1997 Supplementary Data Releases: Trends in Graduate Enrollment: 1975-1997.

SOURCE: National Science Foundation, Division of Science Resources Studies, *Graduate Students and Postdoctorates in Science and Engineering: Fall, 1997,* NSF 99-325 (Arlington, VA, 1999).

Appendix table 2. Graduate enrollment in science and engineering, by field, race/ethnicity, and citizenship: 1983-97

Field and race/ethnicity	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
	Total enrollment														
Science and engineering	347,014	349,875	358,201	368,212	373,425	375,287	382,769	397,135	412,697	430,644	435,886	431,251	422,555	415,363	407,644
Natural sciences [a]	102,968	103,547	103,990	105,541	104,974	105,529	107,301	109,364	112,474	116,699	119,489	120,833	120,325	117,677	114,697
Mathematics/computer sciences	40,713	42,985	47,341	49,316	50,575	51,304	51,729	54,031	54,562	56,648	56,189	53,707	51,941	52,607	52,769
Social sciences [b]	112,236	110,647	110,808	111,499	113,939	115,625	119,696	126,115	132,085	139,262	143,350	143,688	143,090	141,856	139,170
Engineering	91,097	92,696	95,982	101,856	103,937	102,829	104,043	107,625	113,576	118,035	116,858	113,023	107,199	103,223	101,008
	U.S. citizen enrollment														
Total S&E	276,784	277,682	281,388	284,231	284,631	281,672	284,686	294,318	304,063	321,182	330,169	329,095	324,017	317,209	308,835
Natural sciences [a]	84,700	84,712	83,663	82,854	80,562	79,431	79,242	79,521	81,148	84,893	88,164	89,890	90,648	89,276	87,376
Mathematics/computer sciences	30,306	31,532	34,499	35,448	35,669	35,895	35,352	36,561	36,306	38,041	38,135	36,580	35,338	34,991	34,413
Social sciences [b]	98,173	96,644	95,978	96,018	97,831	98,743	102,746	108,810	114,376	121,653	126,279	126,586	126,299	124,748	122,460
Engineering	63,605	64,794	67,160	69,911	70,569	67,603	67,346	69,426	72,233	76,595	77,591	76,039	71,732	68,194	64,586
White, S&E	224,705	224,705	224,705	224,705	224,705	229,037	229,694	238,472	243,602	253,435	256,859	255,719	245,889	238,077	227,936
Natural sciences [a]	74,337	74,046	71,971	71,713	69,100	68,737	68,110	68,736	69,472	71,328	72,552	74,134	73,296	71,777	69,021
Mathematics/computer sciences	23,823	24,040	25,511	26,053	26,806	27,479	26,560	27,897	26,921	27,744	27,332	26,205	24,398	23,644	22,432
Social sciences [b]	77,963	75,787	76,129	76,930	79,157	80,492	83,531	88,632	92,425	96,967	99,535	99,360	96,239	93,544	90,466
Engineering	48,582	48,582	48,582	48,582	48,582	52,329	51,493	53,207	54,784	57,396	57,440	56,020	51,956	49,112	46,017
Asian/Pacific Islander, S&E	9,353	10,172	12,000	12,775	14,572	15,188	15,693	17,155	18,136	21,752	24,059	26,474	25,901	25,947	26,078
Natural sciences [a]	2,378	2,526	2,712	2,761	3,043	3,478	3,604	3,928	4,267	5,035	6,162	6,606	6,778	6,899	6,835
Mathematics/computer sciences	1,666	1,816	2,491	2,770	3,235	3,438	3,430	3,710	3,724	4,362	4,586	5,264	5,174	5,494	5,754
Social sciences [b]	1,903	2,018	1,992	2,130	2,436	2,362	2,648	2,830	3,029	3,863	4,324	4,827	4,941	5,117	5,335
Engineering	3,406	3,812	4,805	5,114	5,858	5,910	6,011	6,687	7,116	8,492	8,987	9,777	9,008	8,437	8,154
Black, S&E	10,903	10,711	10,462	10,470	10,429	11,191	11,775	12,774	13,691	15,445	17,118	17,611	18,283	19,071	19,363
Natural sciences [a]	1,980	2,000	1,982	1,845	1,817	1,972	2,093	2,184	2,302	2,711	3,042	3,007	3,289	3,487	3,558
Mathematics/computer sciences	971	960	1,031	1,151	1,210	1,261	1,311	1,496	1,617	1,687	1,878	1,855	1,844	1,989	1,960
Social sciences [b]	6,574	6,306	6,062	6,022	5,986	6,458	6,755	7,308	7,747	8,673	9,639	9,965	10,294	10,700	10,971
Engineering	1,378	1,445	1,387	1,452	1,416	1,500	1,616	1,786	2,025	2,374	2,559	2,784	2,856	2,895	2,874

See explanatory information and SOURCE at end of table.

Appendix table 2. Graduate enrollment in science and engineering, by field, race/ethnicity, and citizenship: 1983-97 (Continued)

Field and race/ethnicity	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
	U.S. citizen enrollment														
Hispanic, S&E	8,811	8,681	8,613	8,660	8,823	9,098	9,436	10,159	11,045	12,246	13,381	13,281	14,117	14,638	14,988
Natural sciences [a]	1,919	1,892	2,092	2,118	2,071	2,228	2,386	2,375	2,552	2,726	3,075	2,933	3,209	3,338	3,574
Mathematics/computer sciences	615	585	750	723	817	844	847	916	980	1,082	1,111	1,002	1,064	1,126	1,152
Social sciences [b]	4,836	4,713	4,290	4,217	4,205	4,307	4,496	4,982	5,389	5,975	6,501	6,485	7,036	7,239	7,451
Engineering	1,441	1,491	1,481	1,602	1,730	1,719	1,707	1,886	2,124	2,463	2,694	2,861	2,808	2,935	2,811
American Indian/Alaskan Native, S&E	911	830	736	743	783	918	860	1,054	1,120	1,243	1,309	1,383	1,516	1,539	1,599
Natural sciences [a]	224	206	167	196	183	216	180	255	251	282	318	336	393	374	412
Mathematics/computer sciences	53	71	79	52	76	71	74	64	62	99	100	79	125	94	103
Social sciences [b]	454	361	368	365	401	488	484	583	622	685	680	726	767	837	846
Engineering	180	192	122	130	123	143	122	152	185	177	211	242	231	234	238
Unknown, S&E	22,101	24,179	25,825	23,961	21,160	16,240	17,228	14,704	16,469	17,061	17,443	14,627	18,311	17,937	18,871
Natural sciences [a]	3,862	4,042	4,819	4,221	4,348	2,800	2,869	2,043	2,304	2,811	3,015	2,874	3,683	3,401	3,976
Mathematics/computer sciences	3,178	4,060	4,637	4,699	3,525	2,802	3,130	2,478	3,002	3,067	3,128	2,175	2,733	2,644	3,012
Social sciences [b]	6,443	7,459	7,145	6,354	5,646	4,636	4,832	4,475	5,164	5,490	5,600	5,223	7,022	7,311	7,391
Engineering	8,618	8,618	9,224	8,687	7,641	6,002	6,397	5,708	5,999	5,693	5,700	4,355	4,873	4,581	4,492
	Foreign citizen enrollment														
Total S&E	70,230	72,193	76,813	83,981	88,794	93,615	98,083	102,817	108,634	109,462	105,717	102,156	98,538	98,154	98,809
Natural sciences [a]	18,268	18,835	20,327	22,687	24,412	26,098	28,059	29,843	31,326	31,806	31,325	30,943	29,677	28,401	27,321
Mathematics/computer sciences	10,407	11,453	12,842	13,868	14,906	15,409	16,377	17,470	18,256	18,607	18,054	17,127	16,603	17,616	18,356
Social sciences [b]	14,063	14,003	14,830	15,481	16,108	16,882	16,950	17,305	17,709	17,609	17,071	17,102	16,791	17,108	16,710
Engineering	27,492	27,902	28,822	31,945	33,368	35,226	36,697	38,199	41,343	41,440	39,267	36,984	35,467	35,029	36,422

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

KEY: NA= not available

NOTE: For detailed statistical tables on graduate enrollments, see Division of Science Resources Studies home page (http://www.nsf.gov/sbe/srs/stats.htm), Fall 1997 Supplementary Data Releases: Trends in Graduate Enrollment, 1975-1997.

SOURCE: National Science Foundation, Division of Science Resources Studies, *Graduate Students and Postdoctorates in Science and Engineering: Fall, 1997,* NSF 99-325 (Arlington, VA, 1999).

Appendix table 3. Earned master's degrees, by field and sex: 1975–96

Field	1975	1977	1979	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
	All master's degree recipients																	
All degrees	293,651	318,241	302,075	296,798	290,931	285,462	287,213	289,829	290,532	300,091	311,050	324,947	338,498	354,207	370,973	389,008	399,428	408,932
Science and engineering	63,198	67,397	64,226	64,366	67,716	68,564	70,562	71,831	72,603	73,655	76,425	77,788	78,368	81,107	86,425	91,411	94,309	95,313
Natural sciences	14,831	15,360	15,443	14,349	14,380	14,231	13,972	13,910	13,400	13,184	13,218	12,928	12,682	13,232	13,474	14,367	14,793	16,158
Physical	4,298	3,641	3,650	3,366	3,285	3,544	3,605	3,649	3,574	3,708	3,876	3,805	3,777	3,922	3,965	4,263	4,241	4,364
Earth/atm/ocean	1,503	1,659	1,777	1,876	1,959	1,982	2,160	2,234	2,051	1,920	1,819	1,596	1,499	1,425	1,397	1,418	1,483	1,487
Biological/agricultural	9,030	10,060	10,016	9,107	9,136	8,705	8,207	8,027	7,775	7,556	7,523	7,527	7,406	7,885	8,112	8,686	9,069	10,307
Mathematics/computer sciences	6,637	6,496	6,101	6,787	8,160	8,939	9,989	11,241	11,808	12,600	12,829	13,327	12,956	13,320	14,100	14,350	14,495	14,355
Mathematics	4,338	3,698	3,046	2,569	2,839	2,749	2,888	3,171	3,327	3,434	3,430	3,684	3,632	3,665	3,751	3,804	3,932	3,742
Computer sciences	2,299	2,798	3,055	4,218	5,321	6,190	7,101	8,070	8,481	9,166	9,399	9,643	9,324	9,655	10,349	10,546	10,563	10,613
Social/behavioral sciences	26,563	29,529	27,403	26,779	26,290	25,249	25,629	25,584	25,325	25,145	26,635	27,538	28,717	29,537	31,187	33,977	36,391	37,039
Psychology	7,104	8,320	8,031	8,039	8,439	8,073	8,481	8,363	8,165	7,925	8,652	9,308	9,802	9,852	10,412	11,572	13,132	13,043
Social sciences	19,459	21,209	19,372	18,740	17,851	17,176	17,148	17,221	17,160	17,220	17,983	18,230	18,915	19,685	20,775	22,405	23,259	23,996
Engineering	15,167	16,012	15,279	16,451	18,886	20,145	20,972	21,096	22,070	22,726	23,743	23,995	24,013	25,018	27,664	28,717	28,630	27,761
Chemical engineering	1,078	1,179	1,276	1,406	1,545	1,798	1,814	1,641	1,386	1,322	1,321	1,205	1,025	1,145	1,220	1,287	1,369	1,416
Civil engineering	3,268	3,606	3,165	3,428	3,504	3,551	3,542	3,281	3,267	3,134	3,296	3,213	3,404	3,755	4,438	4,918	5,168	5,002
Electrical engineering	3,471	3,788	3,596	3,902	4,819	5,519	5,649	6,147	6,895	7,455	7,849	8,009	7,942	8,274	8,828	8,870	8,743	8,156
Industrial engineering	1,687	1,609	1,502	1,631	1,432	1,557	1,463	1,653	1,728	1,816	1,823	1,834	2,039	2,370	2,745	2,882	2,873	3,027
Mechanical engineering	2,032	2,094	2,012	2,419	2,683	2,964	3,272	3,256	3,380	3,513	3,703	1,834	3,680	3,826	4,169	4,277	4,368	4,009
Other engineering	3,631	3,736	3,728	3,665	4,903	4,756	5,232	5,118	5,414	5,486	5,751	6,104	5,923	5,648	6,264	6,483	6,109	6,151
Engineering technology	371	505	496	532	622	694	816	925	883	980	1,135	1,194	1,188	1,278	1,555	1,547	1,577	NA
	Males																	
All degrees	162,115	168,210	153,772	147,431	145,114	143,998	143,716	143,932	141,655	145,403	149,399	154,025	156,895	162,299	169,753	176,762	179,198	180,360
Science and engineering	49,410	50,899	46,614	45,505	46,718	47,033	48,232	48,611	48,759	49,820	50,845	51,230	50,441	52,157	55,454	57,970	58,518	57,860
Natural sciences	11,709	11,633	11,223	10,222	9,814	9,513	9,290	9,133	8,652	8,562	8,383	8,052	7,794	8,118	8,181	8,539	8,730	9,224
Physical	3,645	2,981	2,971	2,691	2,600	2,698	2,775	2,736	2,684	2,817	2,836	2,754	2,703	2,834	2,794	3,030	2,958	2,914
Earth/atm/ocean	1,309	1,433	1,467	1,470	1,515	1,517	1,639	1,717	1,531	1,433	1,337	1,218	1,116	1,057	1,006	994	1,032	1,051
Biological/agricultural	6,755	7,219	6,785	6,061	5,699	5,298	4,876	4,680	4,437	4,312	4,210	4,080	3,975	4,227	4,381	4,515	4,740	5,259
Mathematics/computer sciences	4,871	4,730	4,469	4,939	5,672	6,174	6,941	7,713	8,011	8,759	8,833	9,176	8,709	9,199	9,773	10,128	10,130	9,999
Mathematics	2,910	2,398	1,989	1,692	1,859	1,795	1,877	2,055	2,026	2,057	2,060	2,208	2,146	2,219	2,219	2,311	2,353	2,236
Computer sciences	1,961	2,332	2,480	3,247	3,813	4,379	5,064	5,658	5,985	6,702	6,773	6,968	6,563	6,980	7,554	7,817	7,777	7,763
Social/behavioral sciences	18,035	19,222	16,580	15,222	14,101	13,301	13,273	13,069	12,796	12,581	12,968	13,276	13,282	13,491	13,930	15,009	15,660	15,628
Psychology	4,059	4,316	3,688	3,371	3,254	2,980	3,064	2,937	2,838	2,599	2,814	3,025	2,994	2,929	2,928	3,287	3,735	3,670
Social sciences	13,976	14,906	12,892	11,851	10,847	10,321	10,209	10,132	9,958	9,982	10,154	10,251	10,288	10,562	11,002	11,722	11,925	11,958

See explanatory information and SOURCE at end of table.

Appendix table 3. Earned master's degrees, by field and sex: 1975–96 (Continued)

Field	1975	1977	1979	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Males																		
Engineering	14,795	15,314	14,342	15,122	17,131	18,045	18,728	18,696	19,300	19,918	20,661	20,726	20,656	21,349	23,570	24,294	23,998	23,009
Chemical engineering	1,051	1,110	1,156	1,230	1,369	1,590	1,529	1,401	1,143	1,107	1,092	1,013	852	914	996	1008	1063	1110
Civil engineering	3,161	3,421	2,951	3,112	3,122	3,136	3,128	2,908	2,792	2,721	2,851	2,693	2,864	3,120	3,607	3,965	4,123	3,938
Electrical engineering	3,413	3,654	3,453	3,681	4,484	5,081	5,154	5,508	6,178	6,642	6,933	7,018	7,008	7,229	7,777	7,721	7,539	6,960
Industrial engineering	1,631	1,534	1,374	1,465	1,226	1,279	1,236	1,374	1,409	1,492	1,465	1,493	1,603	1,898	2,190	2,346	2,361	2,403
Mechanical engineering	2,012	2,039	1,939	2,292	2,517	2,765	3,044	3,002	3,133	3,218	3,377	3,276	3,320	3,455	3,769	3,860	3,918	3,555
Other engineering	3,527	3,556	3,469	3,342	4,413	4,194	4,637	4,503	4,645	4,738	4,943	5,233	5,009	4,733	5,231	5,394	4,994	5,043
Engineering technology	281	389	371	380	519	580	674	710	678	738	892	888	888	971	1,172	1,164	1,136	NA
Females																		
All degrees	131,536	150,031	148,303	149,367	145,817	141,464	143,497	145,897	148,877	154,688	161,651	170,922	181,603	191,908	201,220	212,246	220,230	228,572
Science and engineering	13,788	16,498	17,612	18,861	20,998	21,531	22,330	23,220	23,844	23,835	25,580	26,558	27,927	28,950	30,971	33,441	35,791	37,453
Natural sciences	3,122	3,727	4,220	4,127	4,566	4,718	4,682	4,777	4,748	4,622	4,835	4,876	4,888	5,114	5,293	5,828	6,063	6,934
Physical	653	660	679	675	685	846	830	913	890	891	1,040	1,051	1,074	1,088	1,171	1,233	1,283	1,450
Earth/atm/ocean	194	226	310	406	444	465	521	517	520	487	482	378	383	368	391	424	451	436
Biological/agricultural	2,275	2,841	3,231	3,046	3,437	3,407	3,331	3,347	3,338	3,244	3,313	3,447	3,431	3,658	3,731	4,171	4,329	5,048
Mathematics/computer sciences	1,766	1,766	1,632	1,848	2,488	2,765	3,048	3,528	3,797	3,841	3,996	4,151	4,247	4,121	4,327	4,222	4,365	4,356
Mathematics	1,428	1,300	1,057	877	980	954	1,011	1,116	1,301	1,377	1,370	1,476	1,486	1,446	1,532	1,493	1,579	1,506
Computer sciences	338	466	575	971	1,508	1,811	2,037	2,412	2,496	2,464	2,626	2,675	2,761	2,675	2,795	2,729	2,786	2,850
Social/behavioral sciences	8,528	10,307	10,823	11,557	12,189	11,948	12,356	12,515	12,529	12,564	13,667	14,262	15,435	16,046	17,257	18,968	20,731	21,411
Psychology	3,045	4,004	4,343	4,668	5,185	5,093	5,417	5,426	5,327	5,326	5,838	6,283	6,808	6,923	7,484	8,285	9,397	9,373
Social sciences	5,483	6,303	6,480	6,889	7,004	6,855	6,939	7,089	7,202	7,238	7,829	7,979	8,627	9,123	9,773	10,683	11,334	12,038
Engineering	372	698	937	1,329	1,755	2,100	2,244	2,400	2,770	2,808	3,082	3,269	3,357	3,669	4,094	4,423	4,632	4,752
Chemical engineering	27	69	120	176	176	208	285	240	243	215	229	192	173	231	224	279	306	306
Civil engineering	107	185	214	316	382	415	414	373	475	413	445	520	540	635	831	953	1045	1,064
Electrical engineering	58	134	143	221	335	438	495	639	717	813	916	991	934	1,045	1,051	1,149	1,204	1,196
Industrial engineering	56	75	128	166	206	278	227	279	319	324	358	341	436	472	555	536	512	624
Mechanical engineering	20	55	73	127	166	199	228	254	247	295	326	354	360	371	400	417	450	454
Other engineering	104	180	259	323	490	562	595	615	769	748	808	871	914	915	1,033	1,089	1,115	1,108
Engineering technology	90	116	125	152	103	114	142	215	205	242	243	306	300	307	383	383	441	NA

KEY: NA = not available

SOURCES: National Center for Education Statistics, Earned Degrees and Completion Surveys (Washington, DC: 1996), unpublished tabulations; and National Science Foundation, Division of Science Resources Studies, *Science Engineering Degrees 1966-96,* NSF 99-330 (Arlington, VA).

Appendix table 4. Earned master's degrees, by field, race/ethnicity, and citizenship: 1977–96

Field and race/ethnicity	1977	1979	1981	1985	1987	1989	1990	1991	1992	1993	1994	1995	1996
							All master's degree recipients						
All degrees	318,241	302,075	296,798	287,213	290,532	311,050	324,947	338,498	354,207	370,973	389,008	399,428	408,932
Science and engineering	63,779	59,684	59,598	64,726	66,774	70,333	72,228	72,828	76,184	81,415	86,080	88,431	88,730
Natural sciences [a]	16,234	16,350	15,332	14,045	13,461	13,260	12,966	12,713	13,226	13,462	14,340	14,770	16,093
Mathematics/computer sciences	6,496	6,101	6,787	9,989	11,808	12,829	13,327	12,956	13,549	14,251	14,529	14,522	14,260
Social sciences [b]	24,798	21,723	20,763	19,757	19,448	20,509	21,950	23,152	24,399	26,044	28,504	30,522	30,620
Engineering	16,251	15,510	16,716	20,935	22,057	23,735	23,985	24,007	25,010	27,658	28,707	28,617	27,757
Engineering technology	NA	NA	NA	816	883	1,135	1,188	1,555	1,547	1,577	1,547	1,577	1,651
							U.S. citizens and permanent residents						
All degrees	300,334	281,811	273,184	254,401	246,939	278,927	290,345	300,887	314,555	326,864	342,502	350,672	360,682
Science and engineering	55,963	50,846	49,340	50,751	50,330	55,190	55,890	55,779	58,177	61,265	65,201	67,110	68,151
Natural sciences [a]	14,437	14,410	13,411	11,676	10,721	10,756	10,234	9,857	10,191	10,317	10,929	11,471	12,720
Mathematics/computer sciences	5,760	5,099	5,342	7,385	8,179	9,411	9,729	9,078	9,268	9,334	9,522	9,486	9,308
Social sciences [b]	23,071	19,920	18,785	17,230	15,990	18,035	19,181	20,357	21,607	23,075	25,400	27,232	27,361
Engineering	12,695	11,417	11,802	14,460	15,440	16,988	16,746	16,487	17,111	18,539	19,350	18,921	18,762
Engineering technology	NA	NA	NA	596	712	909	959	1,175	1,256	1,268	10,026	10,191	10,593
White, all degrees	266,109	249,401	241,255	223,649	216,807	230,322	236,874	247,524	257,062	265,668	273,913	277,437	282,713
Science and engineering	50,420	45,748	43,967	43,982	43,360	43,945	44,450	44,513	45,649	47,975	50,711	51,417	51,791
Natural sciences [a]	13,405	13,282	12,411	10,559	9,623	9,262	8,722	8,300	8,393	8,504	8,859	9,242	10,332
Mathematics/computer sciences	5,256	4,625	4,708	6,176	6,729	6,818	7,020	6,705	6,743	6,818	6,665	6,547	6,340
Social sciences [b]	20,315	17,759	16,701	15,061	14,171	15,033	15,849	16,873	17,761	18,733	20,718	21,807	21,546
Engineering	11,444	10,082	10,147	12,186	12,837	12,832	12,859	12,635	12,752	13,920	14,469	13,821	13,573
Engineering technology	NA	NA	NA	526	581	802	830	1,041	994	982	994	982	1,053
Asian/Pacific Islander, all degrees	5,145	5,519	6,304	7,805	8,129	10,174	9,994	11,070	12,293	13,169	14,559	15,906	17,281
Science and engineering	1,749	1,929	2,170	3,285	3,455	4,100	4,055	4,310	4,763	4,846	5,422	5,683	5,942
Natural sciences [a]	388	469	365	450	464	545	504	532	610	615	698	802	933
Mathematics/computer sciences	198	253	376	779	962	1,072	1,125	1,203	1,306	1,303	1,461	1,478	1,472
Social sciences [b]	426	357	350	505	379	491	563	567	624	668	820	831	916
Engineering	737	850	1,079	1,551	1,650	1,992	1,863	2,008	2,223	2,260	2,443	2,572	2,621
Engineering technology	NA	NA	NA	25	46	40	60	40	46	55	46	55	61
Black, all degrees	21,041	19,422	17,152	13,960	13,173	13,455	14,473	15,857	17,420	18,897	20,936	22,954	24,588
Science and engineering	2,321	2,003	1,801	1,742	1,784	1,652	1,847	2,090	2,356	2,554	2,849	3,339	3,518
Natural sciences [a]	351	382	351	290	301	238	225	261	306	310	347	383	402
Mathematics/computer sciences	200	136	137	233	280	257	302	383	393	406	474	498	530
Social sciences [b]	1,530	1,239	1,053	889	800	802	933	1,048	1,191	1,274	1,439	1,793	1,912
Engineering	240	246	260	330	403	355	387	398	466	564	589	665	674
Engineering technology	NA	NA	NA	37	42	55	47	61	72	85	72	85	81

See explanatory information and SOURCE at end of table.

Appendix table 4. Earned master's degrees, by field, race/ethnicity, and citizenship: 1977–96 (Continued)

Field and race/ethnicity	1977	1979	1981	1985	1987	1989	1990	1991	1992	1993	1994	1995	1996
Hispanic, all degrees	7,071	6,470	7,439	7,730	7,781	8,133	8,495	9,684	10,256	11,371	13,177	13,905	15,394
Science and engineering	1,325	1,001	1,237	1,514	1,584	1,585	1,587	1,736	1,806	2,092	2,514	2,585	2,730
Natural sciences [a]	245	227	251	332	310	266	262	281	288	334	436	392	413
Mathematics/computer sciences	91	61	102	149	183	178	169	213	215	240	244	273	264
Social sciences [b]	738	498	599	687	579	673	710	774	815	937	1,115	1,209	1,305
Engineering	251	215	285	346	512	468	446	468	488	581	719	711	748
Engineering technology	NA	NA	NA	6	17	10	19	25	37	40	37	40	47
American Indian/Alaskan Native, all degrees	968	999	1,034	1,257	1,049	1,082	1,050	1,125	1,228	1,344	1,618	1,542	1,693
Science and engineering	148	165	165	228	147	209	181	200	198	253	273	299	304
Natural sciences [a]	48	50	33	45	23	41	31	34	37	46	44	52	41
Mathematics/computer sciences	15	24	19	48	25	45	13	23	19	22	24	27	30
Social sciences [b]	62	67	82	88	61	90	102	103	100	135	145	177	177
Engineering	23	24	31	47	38	33	35	40	42	50	60	43	56
Engineering technology	NA	NA	NA	2	26	2	3	8	3	6	3	6	7
	Foreign citizens												
All degrees	17,345	19,427	22,058	26,952	28,264	32,123	34,602	37,611	39,652	44,109	46,506	48,756	48,250
Science and engineering	7,805	8,544	9,749	12,506	13,045	15,143	16,338	17,049	18,007	20,150	20,879	21,321	20,579
Natural sciences [a]	1,797	1,895	1,864	2,178	2,132	2,504	2,732	2,856	3,035	3,145	3411	3299	3373
Mathematics/computer sciences	736	937	1,368	2,394	2,903	3,418	3,598	3,878	4,281	4,917	5007	5036	4952
Social sciences [b]	1,727	1,752	1,954	2,240	2,229	2,474	2,769	2,795	2,792	2,969	3,104	3,290	3,259
Engineering	3,545	3,960	4,563	5,694	5,781	6,747	7,239	7,520	7,899	9,119	9,357	9,696	8,995
Engineering technology	NA	NA	NA	124	127	131	172	279	291	309	291	309	298

[a] Natural sciences here include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences.

[b] Social sciences include psychology, sociology, and other social sciences.

KEY: NA = not available

NOTES: Data by racial/ethnic group were collected on a biennial schedule until 1990 and annually thereafter. Data by racial/ethnic group are collected by broad fields of study only; therefore, these data cannot be adjusted to the exact field taxonomies used by the National Science Foundation.

SOURCE: National Science Foundation, Division of Science Resources Studies, *Science and Engineering Degrees, by Race, Ethnicity of Recipients: 1989-96,* Early Release Tables, Website, and previous editions.

Appendix table 5. Earned doctoral degrees, by field and sex: 1975–97

Field	1975	1977	1979	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
	All doctoral degree recipients																		
All degrees	32,952	31,716	31,239	31,356	31,281	31,337	31,297	31,902	32,370	33,501	34,326	36,067	37,522	38,856	39,771	41,017	41,610	42,415	42,705
Science and engineering	18,799	18,008	17,872	18,257	18,635	18,748	18,935	19,437	19,894	20,933	21,731	22,867	24,019	24,673	25,441	26,202	26,515	27,230	26,847
Natural sciences	8,103	7,676	7,817	7,995	8,194	8,336	8,436	8,483	8,655	9,172	9,185	9,763	10,159	10,435	10,529	11079	11024	11,392	11,256
Physical	3,076	2,721	2,674	2,627	2,814	2,851	2,934	3,120	3,238	3,350	3,261	3,524	3,625	3,780	3,699	3,977	3,840	3,838	3,711
Earth, atmospheric, and oceanographic	625	689	642	583	624	608	599	559	602	695	723	738	815	794	771	824	778	794	862
Biological/agricultural	4,402	4,266	4,501	4,785	4,756	4,877	4,903	4,804	4,815	5,127	5,201	5,501	5,719	5,861	6,059	6,278	6,406	6,760	6,683
Mathematics/computer sciences	1147	964	979	960	987	993	998	1,128	1,190	1,264	1,471	1,597	1,839	1,927	2,026	2021	2188	2,043	2,001
Mathematics	1,147	933	769	728	701	698	688	729	740	749	859	892	1,039	1,058	1,146	1,118	1,190	1,122	1,112
Computer sciences	0	31	210	232	286	295	310	399	450	515	612	705	800	869	880	903	998	921	889
Social/behavioral sciences	6,538	6,720	6,582	6,774	6,673	6,506	6,335	6,450	6,337	6,310	6,532	6,613	6,806	6,873	7,188	7280	7296	7,490	7,538
Psychology	2,751	2,990	3,091	3,358	3,347	3,257	3,118	3,126	3,173	3,074	3,208	3,281	3,250	3,263	3,419	3,380	3,419	3,491	3,489
Social sciences	3,787	3,730	3,491	3,416	3,326	3,249	3,217	3,324	3,164	3,236	3,324	3,332	3,556	3,610	3,769	3,900	3,877	3,999	4,049
Engineering	3,011	2,648	2,494	2,528	2,781	2,913	3,166	3,376	3,712	4,187	4,543	4,894	5,215	5,438	5,698	5,822	6,007	6,305	6,052
Chemical engineering	396	329	315	317	392	409	504	531	584	685	712	658	691	725	737	725	708	798	764
Civil engineering	361	336	302	358	397	408	391	429	477	531	538	553	575	594	624	684	656	697	653
Electrical engineering	714	667	611	549	625	660	716	806	779	1,010	1,137	1,276	1,405	1,483	1,543	1,673	1,731	1,740	1,695
Mechanical engineering	487	372	366	360	379	427	513	536	657	715	760	884	875	987	1,030	1,015	1,024	1,052	1,010
Materials engineering	272	248	236	234	268	271	303	305	392	374	380	440	489	485	535	539	588	572	573
Other engineering	781	696	664	710	720	738	739	769	823	872	1,016	1,083	1,180	1,164	1,229	1186	1300	1,446	1,357
	Males																		
All degrees	25,751	23,858	22,302	21,464	20,748	20,638	20,553	20,595	20,938	21,682	21,813	22,962	23,652	24,436	24,658	25,211	25,277	25,470	25,383
Science and engineering	15,870	14,775	14,128	14,056	13,920	13,956	14,044	14,270	14,582	15,271	15,622	16,498	17,088	17,593	17,789	18,283	18,242	18,584	18,051
Natural sciences	6,960	6,530	6,436	6,409	6,360	6,483	6,452	6,426	6,484	6,779	6,649	7,101	7,320	7,413	7,311	7713	7534	7,681	7,501
Physical	2,812	2,477	2,382	2,318	2,441	2,452	2,467	2,610	2,710	2,783	2,642	2,863	2,946	3,010	2,919	3,149	2,962	2,996	2,878
Earth, atmospheric, and oceanographic	595	630	584	527	529	502	491	464	490	560	575	597	636	606	611	641	608	622	658
Biological/agricultural	3,553	3,423	3,470	3,564	3,390	3,529	3,494	3,352	3,284	3,436	3,432	3,641	3,738	3,797	3,781	3,923	3,964	4,063	3,965
Mathematics/computer sciences	1,038	837	833	822	838	841	859	959	1,000	1,087	1,208	1,329	1,523	1,602	1,624	1648	1737	1,673	1,597
Mathematics	1,038	811	650	616	588	583	582	608	615	628	704	734	840	853	882	882	925	891	852
Computer sciences	0	26	183	206	250	258	277	351	385	459	504	595	683	749	742	766	812	782	745

See SOURCE at end of table.

Appendix table 5. Earned doctoral degrees, by field and sex: 1975–97 (Continued)

Field	1975	1977	1979	1981	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Males																			
Social/behavioral sciences	4,913	4,834	4,427	4,396	4,065	3,870	3,765	3,734	3,628	3,504	3,597	3,589	3,497	3,646	3,678	3735	3658	3,701	3,648
Psychology	1,878	1,902	1,831	1,885	1,750	1,626	1,577	1,527	1,475	1,393	1,408	1,368	1,254	1,335	1,331	1,278	1,247	1,163	1,165
Social sciences	3,035	2,932	2,596	2,511	2,315	2,244	2,188	2,207	2,153	2,111	2,189	2,221	2,243	2,311	2,347	2,457	2,411	2,538	2,483
Engineering	2,959	2,574	2,432	2,429	2,657	2,762	2,968	3,151	3,470	3,901	4,168	4,479	4,748	4,932	5,176	5,187	5,313	5,529	5,305
Chemical engineering	391	319	306	306	369	382	463	470	524	620	632	580	608	612	643	612	599	655	641
Civil engineering	356	328	298	348	384	383	371	408	459	501	484	504	534	544	570	604	580	618	573
Electrical engineering	698	646	600	527	612	645	681	768	747	962	1,070	1,192	1,326	1,368	1,418	1,526	1,558	1,571	1,545
Mechanical engineering	483	366	361	354	371	412	487	518	640	686	731	846	818	942	973	946	961	974	923
Materials engineering	267	238	228	217	238	245	271	281	347	341	335	391	412	424	457	456	494	489	467
Other engineering	764	677	639	677	683	695	695	706	753	791	916	966	1,050	1,042	1,115	1043	1121	1,222	1,156
Females																			
All degrees	7,201	7,858	8,937	9,892	10,533	10,699	10,744	11,307	11,432	11,819	12,513	13,105	13,870	14,420	15,113	15,806	16,333	16,945	17,322
Science and engineering	2,929	3,233	3,744	4,201	4,715	4,792	4,891	5,167	5,312	5,662	6,109	6,369	6,931	7,080	7,652	7,919	8,273	8,646	8,769
Natural sciences	1,143	1,146	1,381	1,586	1,834	1,853	1,984	2,057	2,171	2,393	2,536	2,662	2,839	3,022	3,218	3,366	3,490	3,711	3,755
Physical	264	244	292	309	373	399	467	510	528	567	619	661	679	770	780	828	878	842	833
Earth, atmospheric, and oceanographic	30	59	58	56	95	106	108	95	112	135	148	141	179	188	160	183	170	172	204
Biological/agricultural	849	843	1,031	1,221	1,366	1,348	1,409	1,452	1,531	1,691	1,769	1,860	1,981	2,064	2,278	2355	2442	2,697	2,718
Mathematics/computer sciences	109	127	146	138	149	152	139	169	190	177	263	268	316	325	402	373	451	370	404
Mathematics	109	122	119	112	113	115	106	121	125	121	155	158	199	205	264	236	265	231	260
Computer sciences	0	5	27	26	36	37	33	48	65	56	108	110	117	120	138	137	186	139	144
Social/behavioral sciences	1625	1886	2155	2378	2608	2636	2570	2716	2709	2806	2935	3024	3309	3227	3510	3545	3638	3,789	3,890
Psychology	873	1,088	1,260	1,473	1,597	1,631	1,541	1,599	1,698	1,681	1,800	1,913	1,996	1,928	2,088	2,102	2,172	2,328	2,324
Social sciences	752	798	895	905	1,011	1,005	1,029	1,117	1,011	1,125	1,135	1,111	1,313	1,299	1,422	1,443	1,466	1,461	1,566
Engineering	52	74	62	99	124	151	198	225	242	286	375	415	467	506	522	635	694	776	747
Chemical engineering	5	10	9	11	23	27	41	61	60	65	80	78	83	113	94	113	109	143	123
Civil engineering	5	8	4	10	13	25	20	21	18	30	54	49	41	50	54	80	76	79	80
Electrical engineering	16	21	11	22	13	15	35	38	32	48	67	84	79	115	125	147	173	169	150
Mechanical engineering	4	6	5	6	8	15	26	18	17	29	29	38	57	45	57	69	63	78	87
Materials engineering	5	10	8	17	30	26	32	24	45	33	45	49	77	61	78	83	94	83	106
Other engineering	17	19	25	33	37	43	44	63	70	81	100	117	130	122	114	143	179	224	201

SOURCE: National Science Foundation, Division of Science Resources Studies, *Science and Engineering Doctorate Awards: 1997,* NSF 99-323 (Arlington, VA: 1999), and previous editions.

Appendix table 6. Earned doctoral degrees by field, race/ethnicity, and citizenship: 1977–97

Field and race/ethnicity	1977	1979	1981	1983	1985	1987	1989	1991	1992	1993	1994	1995	1996	1997
	All doctoral degree recipients[a]													
All degrees	31,716	31,239	31,356	31,281	31,297	32,370	34,326	37,534	38,890	39,801	41,034	41,743	42,415	42,705
Science and engineering	18,008	17,872	18,257	18,635	18,935	19,894	21,731	24,023	24,675	25,443	26,205	26,535	27,230	26,847
Natural sciences [b]	7,676	7,817	7,995	8,194	8,436	8,655	9,185	10,164	10,437	10,530	11,082	11,033	11,392	11,256
Mathematics/computer sciences	964	979	960	987	998	1,190	1,471	1,839	1,927	2,026	2,021	2,187	2,043	2,001
Social sciences [c]	6,720	6,582	6,774	6,673	6,335	6,337	6,532	6,806	6,873	7,189	7,280	7,307	7,490	7,538
Engineering	2,648	2,494	2,528	2,781	3,166	3,712	4,543	5,214	5,438	5,698	5,822	6,008	6,305	6,052
	U.S. citizens and permanent residents													
All degrees	27,487	26,784	26,341	25,634	24,694	24,562	25,026	27,430	27,990	28,708	30,894	32,059	31,506	30,601
Science and engineering	14,881	14,711	14,654	14,518	14,065	14,055	14,591	15,914	15,942	16,573	18,187	18,996	18,628	18,005
Natural sciences [b]	6,427	6,604	6,640	6,706	6,634	6,450	6,628	7,063	7,039	7,092	8,106	8,362	8,067	7,809
Mathematics/computer sciences	769	778	713	664	631	671	824	969	996	1,099	1,200	1,387	1,159	1,122
Social sciences [c]	5,886	5,712	5,830	5,666	5,206	5,021	4,910	5,408	5,387	5,685	5,828	5,905	6,019	5,793
Engineering	1,799	1,617	1,471	1,482	1,594	1,913	2,229	2,474	2,520	2,697	3,053	3,342	3,383	3,281
White, all degrees	23,654	22,396	22,470	22,251	21,306	21,122	21,570	23,185	23,625	24,052	24,594	24,719	24,685	23,789
Science and engineering	12,875	12,314	12,573	12,671	12,169	12,052	12,501	13,323	13,326	13,737	13,889	13,902	13,999	13,623
Natural sciences [b]	5,598	5,620	5,771	5,981	5,903	5,663	5,800	6,111	6,019	5,950	6,123	5,978	5,952	5,866
Mathematics/computer sciences	671	658	610	569	527	548	688	774	803	886	880	988	834	827
Social sciences [c]	5,177	4,879	5,099	4,993	4,551	4,383	4,287	4,601	4,624	4,876	4,866	4,846	4,953	4,668
Engineering	1,429	1,157	1,093	1,128	1,188	1,458	1,726	1,837	1,880	2,025	2,020	2,090	2,260	2,262
Asian/Pacific Islander, all degrees	910	1,102	1,073	1,042	1,070	1,168	1,268	1,531	1,764	2,017	3,546	4,309	3,697	3,140
Science and engineering	745	884	827	780	809	925	986	1,180	1,345	1,610	2,989	3,671	3,091	2,527
Natural sciences [b]	342	377	344	359	346	369	403	474	560	686	1,481	1,858	1,550	1,255
Mathematics/computer sciences	42	55	56	54	50	67	76	123	138	156	259	345	251	205
Social sciences [c]	112	146	142	120	132	162	146	178	196	241	382	435	395	363
Engineering	249	306	285	247	281	327	361	405	451	527	867	1,033	895	704
Black, all degrees	1,191	1,112	1,110	1,005	1,043	910	962	1,166	1,116	1,280	1,279	1,477	1,457	1,476
Science and engineering	342	347	346	338	374	319	366	464	408	469	500	560	576	607
Natural sciences [b]	85	84	89	84	100	95	105	116	107	136	153	171	187	191
Mathematics/computer sciences	9	12	11	6	10	13	9	19	9	14	21	16	20	11
Social sciences [c]	233	231	227	219	230	186	219	274	243	269	272	302	295	308
Engineering	15	20	19	29	34	25	33	55	49	50	54	71	74	97

See explanatory information and SOURCE at end of table.

Appendix table 6. Earned doctoral degrees by field, race/ethnicity, and citizenship: 1977–97 (Continued)

Field and race/ethnicity	1977	1979	1981	1983	1985	1987	1989	1991	1992	1993	1994	1995	1996	1997
Hispanic, all degrees	489	547	529	608	634	708	694	867	909	973	1,030	1,061	1,105	1,181
Science and engineering	203	234	240	284	296	357	382	492	513	542	548	571	623	645
Natural sciences [b]	76	84	93	86	107	138	157	191	208	226	254	234	229	251
Mathematics/computer sciences	12	12	5	7	18	15	15	21	20	23	20	21	26	34
Social sciences [c]	91	114	126	162	149	170	163	220	214	227	208	239	270	265
Engineering	24	24	16	29	22	34	47	60	71	66	66	77	98	95
American Indian/Alaskan Native, all degrees	66	81	85	82	96	115	94	132	149	120	143	149	187	151
Science and engineering	31	29	28	30	41	53	53	56	69	43	64	69	96	71
Natural sciences [b]	14	6	8	13	21	20	25	27	26	17	24	26	34	24
Mathematics/computer sciences	1	1	1	1	0	3	2	1	4	2	3	2	5	2
Social sciences [c]	15	19	15	15	19	23	19	22	28	22	31	31	43	33
Engineering	1	3	4	1	1	7	7	6	11	2	6	10	14	12
Temporary residents														
Total, all degrees	3,448	3,587	3,940	4,498	5,227	5,612	6,648	9,311	9,953	9,932	9,406	8,810	9,610	8,463
Science and engineering	2,675	2,689	2,983	3,412	4,047	4,468	5,391	7,641	8,092	8,113	7,521	6,994	7,802	6,948
Natural sciences [b]	1,079	1,046	1,140	1,273	1,517	1,704	1,975	2,936	3,213	3,191	2,815	2,501	3,026	2,786
Mathematics/computer sciences	170	181	226	281	327	445	524	846	876	865	791	747	817	730
Social sciences [c]	651	645	675	688	784	787	952	1,226	1,260	1,273	1,262	1,222	1,243	1,036
Engineering	775	817	942	1,170	1,419	1,532	1,940	2,633	2,743	2,784	2,653	2,524	2,716	2,396
Citizenship unknown														
Total, all degrees	781	868	1,075	1,149	1,376	2,196	2,652	793	947	1,161	734	874	1,299	3,641
Science and engineering	452	472	620	705	823	1,371	1,749	468	641	757	497	545	800	1,894
Natural sciences [b]	170	167	215	215	285	501	582	165	185	247	161	170	299	661
Mathematics/computer sciences	25	20	21	42	40	74	123	24	55	62	30	53	67	149
Social sciences [c]	183	225	269	319	345	529	670	172	226	231	190	180	228	709
Engineering	74	60	115	129	153	267	374	107	175	217	116	142	206	375

[a] Data include all doctorates awarded to U.S. citizens and permanent residents, temporary residents, and people of unknown citizenship.

[b] Natural sciences include physical, earth, atmospheric, oceanographic, biological, and agricultural sciences. Social sciences include psychology, sociology, and other social sciences.

[c] Social sciences include psychology, sociology, and other social sciences.

SOURCE: National Science Foundation, Division of Science Resources Studies, *Science and Engineering Doctorate Awards: 1997,* NSF 99-323 (Arlington, VA: 1999), and previous editions.

Appendix table 7. Full-time S&E graduate students, by source and mechanism of primary support: 1980-95

Year	All mechanisms	Fellowships	Traineeships	Research assistantships	Teaching assistantships	Other	Self-support
	Total number of students						
1980	238,492	20,532	17,550	51,567	53,890	19,446	75,507
1981	242,118	20,106	16,777	52,722	55,746	20,210	76,557
1982	244,830	20,873	14,640	52,580	58,334	20,455	77,948
1983	252,092	21,365	13,514	54,904	60,072	20,960	81,277
1984	253,959	21,638	13,465	57,735	61,257	20,697	79,167
1985	257,351	22,576	13,665	60,995	61,822	20,635	77,658
1986	266,197	22,966	13,526	66,011	62,563	22,246	78,885
1987	271,080	21,965	14,096	70,214	62,859	22,166	79,780
1988	275,204	22,361	14,397	74,588	63,071	21,584	79,203
1989	282,741	23,476	14,527	79,059	64,316	21,082	80,281
1990	292,854	25,269	15,212	80,747	64,973	22,265	84,388
1991	307,049	26,697	15,417	85,175	65,229	22,956	91,575
1992	322,753	28,666	15,376	88,032	65,739	23,565	101,375
1993	329,876	29,170	15,452	90,158	67,344	21,378	106,374
1994	332,453	28,976	15,716	92,033	66,900	21,672	107,156
1995	330,235	28,954	16,108	89,983	66,147	22,294	106,749
	Number with primary support from Federal sources						
1980	52,969	4,635	13,306	29,316	662	5,050	-
1981	50,903	4,093	12,176	29,147	619	4,868	-
1982	47,411	4,097	10,077	28,313	428	4,496	-
1983	47,764	4,118	9,114	29,152	498	4,882	-
1984	47,793	4,125	8,970	29,463	400	4,835	-
1985	49,058	4,423	8,954	30,433	549	4,699	-
1986	51,365	4,600	8,688	32,739	495	4,843	-
1987	53,542	4,449	8,922	34,996	444	4,731	-
1988	55,492	4,569	8,664	36,752	504	5,003	-
1989	57,444	5,177	8,682	38,555	490	4,540	-
1990	59,274	6,316	9,242	38,504	609	4,603	-
1991	63,017	7,447	9,630	40,790	476	4,674	-
1992	65,634	7,761	10,055	42,588	643	4,587	-
1993	67,697	7,515	10,188	44,504	846	4,644	-
1994	68,583	6,945	10,418	45,633	780	4,807	-
1995	67,469	6,904	10,314	44,503	732	5,016	-
	Number with primary support from non-federal sources						
1980	110,016	15,897	4,244	22,251	53,228	14,396	-
1981	114,658	16,013	4,601	23,575	55,127	15,342	-
1982	119,471	16,776	4,563	24,267	57,906	15,959	-
1983	123,051	17,247	4,400	25,752	59,574	16,078	-
1984	126,999	17,513	4,495	28,272	60,857	15,862	-
1985	130,635	18,153	4,711	30,562	61,273	15,936	-
1986	135,947	18,366	4,838	33,272	62,068	17,403	-
1987	137,758	17,516	5,174	35,218	62,415	17,435	-
1988	140,509	17,792	5,733	37,836	62,567	16,581	-

See explanatory information and SOURCE at end of table.

Appendix table 7. Full-time S&E graduate students, by source and mechanism of primary support: 1980-95 (Continued)

Year	All mechanisms	Fellowships	Traineeships	Research assistantships	Teaching assistantships	Other	Self-support
	Number with primary support from non-federal sources						
1989....................	145,016	18,299	5,845	40,504	63,826	16,542	-
1990....................	149,192	18,953	5,970	42,243	64,364	17,662	-
1991....................	152,457	19,250	5,787	44,385	64,753	18,282	-
1992....................	155,744	20,905	5,321	45,444	65,096	18,978	-
1993....................	155,805	21,655	5,264	45,654	66,498	16,734	-
1994....................	156,714	22,031	5,298	46,400	66,120	16,865	-
1995....................	156,017	22,050	5,794	45,480	65,415	17,278	-
	Percentage of students						
1980....................	100.0	8.6	7.4	21.6	22.6	8.2	31.7
1981....................	100.0	8.3	6.9	21.8	23.0	8.3	31.6
1982....................	100.0	8.5	6.0	21.5	23.8	8.4	31.8
1983....................	100.0	8.5	5.4	21.8	23.8	8.3	32.2
1984....................	100.0	8.5	5.3	22.7	24.1	8.1	31.2
1985....................	100.0	8.8	5.3	23.7	24.0	8.0	30.2
1986....................	100.0	8.6	5.1	24.8	23.5	8.4	29.6
1987....................	100.0	8.1	5.2	25.9	23.2	8.2	29.4
1988....................	100.0	8.1	5.2	27.1	22.9	7.8	28.8
1989....................	100.0	8.3	5.1	28.0	22.7	7.5	28.4
1990....................	100.0	8.6	5.2	27.6	22.2	7.6	28.8
1991....................	100.0	8.7	5.0	27.7	21.2	7.5	29.8
1992....................	100.0	8.9	4.8	27.3	20.4	7.3	31.4
1993....................	100.0	8.8	4.7	27.3	20.4	6.5	32.2
1994....................	100.0	8.7	4.7	27.7	20.1	6.5	32.2
1995....................	100.0	8.8	4.9	27.2	20.0	6.8	32.3
	Percentage with primary support from Federal sources						
1980....................	100.0	8.8	25.1	55.3	1.2	9.5	-
1981....................	100.0	8.0	23.9	57.3	1.2	9.6	-
1982....................	100.0	8.6	21.3	59.7	0.9	9.5	-
1983....................	100.0	8.6	19.1	61.0	1.0	10.2	-
1984....................	100.0	8.6	18.8	61.6	0.8	10.1	-
1985....................	100.0	9.0	18.3	62.0	1.1	9.6	-
1986....................	100.0	9.0	16.9	63.7	1.0	9.4	-
1987....................	100.0	8.3	16.7	65.4	0.8	8.8	-
1988....................	100.0	8.2	15.6	66.2	0.9	9.0	-
1989....................	100.0	9.0	15.1	67.1	0.9	7.9	-
1990....................	100.0	10.7	15.6	65.0	1.0	7.8	-
1991....................	100.0	11.8	15.3	64.7	0.8	7.4	-
1992....................	100.0	11.8	15.3	64.9	1.0	7.0	-
1993....................	100.0	11.1	15.0	65.7	1.2	6.9	-
1994....................	100.0	10.1	15.2	66.5	1.1	7.0	-
1995....................	100.0	10.2	15.3	66.0	1.1	7.4	-

See explanatory information and SOURCE at end of table.

Appendix table 7. Full-time S&E graduate students, by source and mechanism of primary support: 1980-95 (Continued)

Year	All mechanisms	Fellowships	Traineeships	Research assistantships	Teaching assistantships	Other	Self-support
	Percentage with primary support from non-federal sources						
1980	100.0	14.4	3.9	20.2	48.4	13.1	-
1981	100.0	14.0	4.0	20.6	48.1	13.4	-
1982	100.0	14.0	3.8	20.3	48.5	13.4	-
1983	100.0	14.0	3.6	20.9	48.4	13.1	-
1984	100.0	13.8	3.5	22.3	47.9	12.5	-
1985	100.0	13.9	3.6	23.4	46.9	12.2	-
1986	100.0	13.5	3.6	24.5	45.7	12.8	-
1987	100.0	12.7	3.8	25.6	45.3	12.7	-
1988	100.0	12.7	4.1	26.9	44.5	11.8	-
1989	100.0	12.6	4.0	27.9	44.0	11.4	-
1990	100.0	12.7	4.0	28.3	43.1	11.8	-
1991	100.0	12.6	3.8	29.1	42.5	12.0	-
1992	100.0	13.4	3.4	29.2	41.8	12.2	-
1993	100.0	13.9	3.4	29.3	42.7	10.7	-
1994	100.0	14.1	3.4	29.6	42.2	10.8	-
1995	100.0	14.1	3.7	29.2	41.9	11.1	-

KEY: (-) = not applicable

NOTE: Science and engineering includes the health fields (medical sciences and other life sciences).

SOURCE: National Science Board, *Science & Engineering Indicators--1998,* NSB 98-1 (Arlington, VA: National Science Foundation), appendix table 5-34.

Appendix table 8. Full-time S&E graduate students, by field and mechanism of primary support: 1995

Field	All mechanisms	Research assistantships	Fellowships	Traineeships	Teaching assistantships	Other	Self-support
	Total number of students						
Total S&E	330,235	89,983	28,954	16,108	66,147	22,294	106,749
Total sciences	262,373	62,958	22,921	15,099	55,931	17,289	88,175
Physical sciences	28,892	11,808	2,354	688	11,710	730	1,602
Astronomy	871	439	148	28	225	5	26
Chemistry	16,750	6,466	1,270	445	7,386	372	811
Physics	11,054	4,842	929	215	4,073	349	646
Other	217	61	7	0	26	4	119
Mathematical sciences	13,422	1,451	1,274	222	7,316	675	2,484
Computer sciences	16,564	3,921	924	216	3,364	1,551	6,588
Environmental sciences	11,290	4,661	891	136	2,507	730	2,365
Atmospheric sciences	959	619	67	8	107	69	89
Earth sciences	5,810	2,151	512	59	1,855	334	899
Oceanography	2,228	1,257	195	24	215	166	371
Other	2,293	634	117	45	330	161	1,006
Life sciences	100,132	29,158	8,104	10,942	13,089	6,587	32,252
Agricultural sciences	9,630	5,401	454	146	941	477	2,211
Biological sciences	48,283	19,182	5,395	5,308	9,293	2,143	6,962
Medical sciences	13,863	2,928	1,272	1,661	1,246	1,292	5,464
Other	28,356	1,647	983	3,827	1,609	2,675	17,615
Psychology	35,762	4,626	1,824	1,115	6,152	3,094	18,951
Social sciences	56,311	7,333	7,550	1,780	11,793	3,922	23,933
Anthropology	5,792	452	1,168	132	1,278	344	2,418
Economics	11,746	2,094	1,546	271	3,028	809	3,998
History of science	340	17	127	10	99	18	69
Linguistics	2,486	177	369	50	701	282	907
Political science	17,660	1,624	2,468	777	2,666	1,136	8,989
Sociology	7,353	1,131	915	241	2,145	431	2,490
Other	10,934	1,838	957	299	1,876	902	5,062
Total engineering	67,862	27,025	6,033	1,009	10,216	5,005	18,574
Aeronautical/astronautical engineering	2,693	1,175	262	31	315	377	533
Chemical engineering	5,962	3,100	791	105	907	218	841
Civil engineering	12,248	4,225	924	196	1,850	816	4,237
Electrical engineering	18,303	6,684	1,455	156	3,137	1,439	5,432
Industrial engineering	5,328	1,339	300	37	824	504	2,324
Mechanical engineering	11,119	4,419	942	187	1,950	777	2,844
Materials engineering	3,880	2,535	371	48	352	123	451
Other engineering	8,329	3,548	988	249	881	751	1,912

See SOURCE at end of table.

Appendix table 9. Federal Government as primary source of support, by selected mechanisms and field: 1995

Field	Research assistantships	Fellowships	Traineeships
	Percentage with primary Federal support		
Total S&E	49.5	23.8	64.0
Total sciences	50.6	22.6	65.4
Physical sciences	75.0	33.8	58.0
Astronomy	76.3	50.0	28.6
Chemistry	73.0	31.4	56.0
Physics	77.7	34.7	66.0
Other	52.5	0.0	NA
Mathematical sciences	45.4	23.2	32.4
Computer sciences	61.9	25.6	24.1
Environmental sciences	63.0	33.3	49.3
Atmospheric sciences	81.9	62.7	12.5
Earth sciences	62.3	29.5	47.5
Oceanography	67.5	29.2	58.3
Other	38.0	40.2	53.3
Life sciences	48.1	27.0	77.8
Agricultural sciences	34.5	15.6	10.3
Biological sciences	54.8	29.0	72.6
Medical sciences	39.8	23.6	78.9
Other	30.1	25.6	87.1
Psychology	32.0	17.2	36.6
Social sciences	20.1	13.9	20.6
Anthropology	22.6	18.1	16.7
Economics	25.5	13.3	9.2
History of science	5.9	16.5	40.0
Linguistics	32.8	20.6	34.0
Political science	7.1	10.9	12.5
Sociology	21.0	11.6	51.5
Other	23.4	17.2	25.8
Total engineering	46.8	28.6	43.2
Aeronautical/astronautical engineering	56.9	56.1	58.1
Chemical engineering	45.2	26.3	63.8
Civil engineering	37.4	23.3	16.3
Electrical engineering	49.6	27.8	27.6
Industrial engineering	30.5	20.3	48.6
Mechanical engineering	49.8	33.7	39.6
Materials engineering	54.2	33.4	50.0
Other engineering	47.5	25.0	64.3

KEY: NA = not available

SOURCE: National Science Foundation, Division of Science Resources Studies, Survey of Graduate Students and Postdoctorates in Science and Engineering unpublished tabulations.

Appendix table 10. Number of employed scientists and engineers by sector of employment, broad occupation and highest degree: 1995

Field of Employment	Total	Computer and mathematics scientists	Life scientists	Physical scientists	Social scientists	Engineers
			Total			
All Sectors	3,185,600	949,500	305,300	274,300	317,500	1,339,000
4-year universities and colleges	291,100	41,000	84,300	51,100	71,900	42,800
Other educational institutions	275,200	83,000	64,700	28,500	67,600	31,400
Business/industry for profit	1,970,300	683,200	75,600	138,600	57,600	1,015,300
Self-employed	113,800	23,600	7,400	6,500	42,600	33,800
Non-profit	91,000	27,600	11,000	5,600	33,700	13,200
Federal government	252,400	53,300	37,700	27,600	17,100	116,600
State/local government	191,700	37,900	24,600	16,400	27,000	85,900
			Bachelor's			
All Sectors	1,844,000	625,000	121,500	128,100	60,600	908,800
4-year universities and colleges	63,400	10,500	20,500	11,800	10,800	9,800
Other educational institutions	85,900	34,700	20,000	8,700	8,400	14,200
Business/industry for profit	1,324,800	482,800	39,200	78,800	16,100	708,000
Self-employed	48,800	16,000	3,600	3,100	2,800	23,400
Non-profit	41,100	19,500	4,300	2,200	8,700	6,300
Federal government	150,400	35,100	17,100	12,400	5,700	80,100
State/local government	129,500	26,400	16,800	11,200	8,100	66,900
			Master's			
All Sectors	892,700	268,000	64,000	67,200	135,800	357,900
4-year universities and colleges	45,800	10,000	6,700	7,000	11,400	10,800
Other educational institutions	128,800	39,900	19,900	12,800	42,000	14,200
Business/industry for profit	524,300	179,400	16,700	32,600	26,100	269,600
Self-employed	39,500	6,200	2,100	2,100	21,000	8,100
Non-profit	31,700	6,500	2,200	1,000	16,900	5,200
Federal government	70,800	15,400	10,600	7,400	5,600	31,800
State/local government	51,800	10,600	5,900	4,400	12,800	18,200
			Doctorate			
All Sectors	418,300	53,800	102,400	78,900	113,300	69,900
4-year universities and colleges	181,300	20,400	56,800	32,400	49,700	22,100
Other educational institutions	45,400	8,300	12,900	7,100	14,100	3,000
Business/industry for profit	114,600	18,700	17,800	27,200	14,900	36,000
Self-employed	23,100	1,500	1,300	1,300	16,900	2,100
Non-profit	16,300	1,600	3,900	2,500	6,700	1,700
Federal government	28,400	2,500	8,300	7,700	5,600	4,300
State/local government	9,300	900	1,600	700	5,400	700
			Professional			
All Sectors	30,600	2,700	17,400	200	7,900	2,500
4-year universities and colleges	600	-	400	-	-	100
Other educational institutions	15,100	100	11,900	-	3,100	-
Business/industry for profit	6,600	2,200	2,000	100	600	1,600
Self-employed	2,300	-	300	-	1,900	100
Non-profit	2,000	-	700	-	1,300	-
Federal government	2,800	300	1,700	100	300	400
State/local government	1,200	-	300	-	800	100

KEY: (-) = not applicable

SOURCE: National Science Foundation, Division of Science Resources Studies, Scientists and Engineers Data System (SESTAT) 1995.