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Chapter Title: A Stock Flow Model of Academic Labor Supply

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7 A Stock Flow Model of Academic Labor Supply

7.1 A Conceptual Model

Figure 7.1 presents a schematic representation of the various components of academic labor supply.[1] After tracing through the figure to highlight the wide variety of areas at which public policies might be directed, the following section presents data on a number of the component stocks and flows.

The potential flow of American undergraduate students into doctoral study depends initially on the number of undergraduate seniors and the major fields they have chosen to study. Choice of undergraduate major is important because in many fields it is rare for students to enter doctoral study from anything other than an undergraduate major in the same, or a closely related, field. In 1988, for example, 73 percent of new doctorates in physics and astronomy, 80 percent of new doctorates in chemistry, 76.4 percent of new engineering doctorates, 62 percent of new doctorates in economics, and 57 percent of new humanities doctorates had undergraduate majors in their doctorate field (National Research Council 1989d, app. A, table 2).

Once students receive undergraduate degrees, they face a number of options. They can enter graduate study directly and become Ph.D. students at American institutions of higher education, they can search for employment, they can pursue graduate study toward other degrees (e.g., business, law, medicine, or the other professions), or they can pursue foreign study. Some of the individuals who fail to enter doctoral study at American institutions directly after receiving their undergraduate degrees may enter at some later date.

1. For expository convenience, Figure 7.1 assumes that all academics have doctoral degrees. I return to a discussion of substituting faculty with for faculty without doctorates in chapter 10. Since the vast majority of faculty at two-year colleges do not have doctoral degrees (Table 6.1), this figure and the discussion that follows should be thought of as applying to the four-year college market.

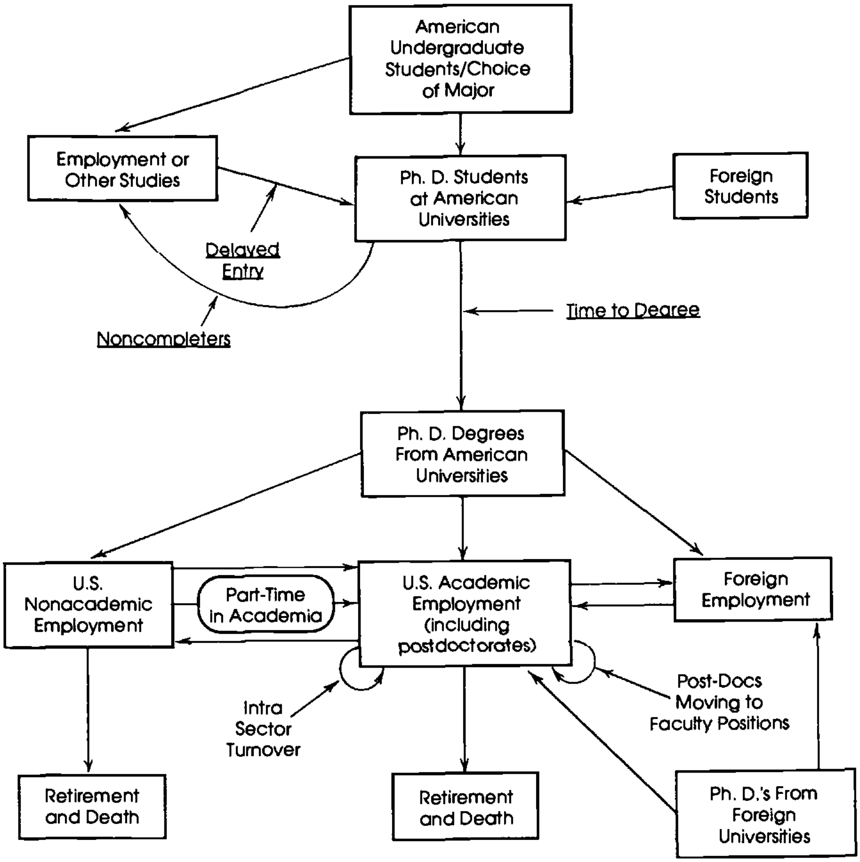

Figure 7.1 Academic labor supply.

The sum of American students who are direct and delayed entrants and of foreign students who both want to pursue doctoral study in the United States and are admitted determines the flow of students into doctoral programs in American universities.

Doctoral study is a risk endeavor, and some students will fail to complete their programs, either because they prove unsuitable academically, because their interests change, or because finances force them to drop out. These students will accept employment in the United States or abroad or enroll in other types of educational programs. The remaining students will ultimately receive doctoral degrees from American universities. Of key concern is the length of time that it takes these students to complete their degrees. Other things being equal, the longer it takes to complete degrees, the less attractive prospective students will find doctoral programs, and the greater noncompletion rates are likely to be.

Students who receive doctorates from American universities face a number of options. Some move directly into academic positions in the United States. Others, especially in the sciences, accept postdoctoral research positions in which they receive additional research experience for one or two years, and then some of these ultimately obtain faculty positions. Others accept nonacademic positions in the United States, and still others accept foreign employment. Some of those initially employed in the nonacademic sector in the United States or in the academic or nonacademic sectors abroad may at a later date find employment in the U.S. academic sector. In addition, American colleges and universities may try to hire new doctorates produced at foreign universities directly as faculty members. Finally, doctorates employed full-time in the nonacademic sector may "moonlight" and also be employed part-time in the academic sector.

Each year, approximately 15 percent of full-time assistant professors and 7–10 percent of the full-time associate and full professors who are employed in American colleges and universities "turn over" and are not employed at the same institution in the next year (Ehrenberg, Kasper, and Rees, in press, tables 1–3). At the assistant professor level, turnover reflects both voluntary movement to other U.S. academic institutions, foreign institutions, or the nonacademic sector and involuntary mobility to these places owing to denial of reappointment or tenure. At the associate professor level, turnover reflects primarily voluntary mobility. Finally, at the full professor level, it reflects voluntary mobility to other positions, retirements, and deaths. The age distribution of the faculty obviously has a major effect on out-mobility from the academic sector: younger faculty are more likely to move to a nonacademic employer, and older faculty are more likely to retire or die.

7.2 Trends in Academic Labor Supply

7.2.1 The Production of Doctorates

During the last two decades, substantial changes have occurred in the distribution of college students' majors. Table 7.1 presents information on the share of bachelor's degrees conferred by U.S. academic institutions in different disciplines for the period 1970–71 to 1987–88. During this period, the proportion of students majoring in business almost doubled, rising to nearly one-quarter of all bachelor's degrees granted. The shares of engineering and other professional degrees increased substantially, while the shares of education and arts and science degrees declined substantially. Within the arts and sciences, the humanities and social sciences were hit the hardest, with the former's share declining by over one-third and the latter's share declining by an even greater amount. Presumably, many students who in previous years would have majored in the social sciences now major in business. More generally, changes in decisions about field of study made by women are an impor-

Table 7.1 **Share of Bachelor's Degrees Conferred by U.S. Institutions of Higher Education in Different Disciplines**

Category	1970–71	1975–76	1980–81	1985–86	1987–88
Business	.137	.154	.213	.241	.246
Education	.210	.167	.116	.088	.092
Engineering	.059	.050	.081	.097	.099
Other professional	.096	.177	.203	.189	.171
Arts and sciences	.488	.442	.390	.385	.359
Humanities	.147	.118	.097	.090	.095
Life sciences	.043	.059	.046	.039	.037
Physical sciences	.058	.046	.054	.081	.070
Psychology	.045	.054	.044	.041	.045
Social sciences	.185	.136	.107	.095	.101
Interdisciplinary	.010	.030	.042	.040	.041

Sources: Author's computations from data in U.S. Department of Education (1989, table 205) and unpublished tabulations of the data for 1987–88 provided by the Education Information Branch, Office of Educational Research and Improvement, U.S. Department of Education.

Table 7.2 **Discipline Distribution of Doctorates Awarded by U.S. Colleges and Universities, 1960–88**

	Share of Doctorates Awarded in the:						
	Physical Sciences	Engineering	Life Sciences	Social Sciences	Humanities	Education	Professional/ Other
1960	.221	.082	.178	.171	.164	.159	.025
1964	.217	.116	.165	.158	.151	.164	.028
1968	.203	.124	.162	.152	.151	.176	.032
1972	.168	.106	.154	.165	.153	.214	.040
1973	.157	.100	.153	.171	.160	.214	.045
1976	.137	.086	.153	.189	.148	.234	.053
1980	.133	.080	.176	.189	.125	.245	.053
1984	.142	.093	.184	.189	.113	.217	.062
1988	.159	.125	.184	.172	.106	.190	.064

Source: *Summary Report 1988: Doctorate Recipients from United States Universities* (Washington, D.C.: National Academy Press, 1989), tables A, C.

tant cause of these changing proportions, and, presumably, these reflect, at least partially, a widening of career options for women (Turner and Bowen 1990).

Some of these trends are reflected in the disciplinary distribution of doctorates awarded by American colleges and universities, which is presented for the period 1960–88 in Table 7.2. What is most striking is the one-third drop since the early 1970s in the proportion of doctoral degrees awarded in the humanities, which reflects the importance influence that an individual's undergraduate major has on his or her field of graduate study (see the previous section). The share of doctoral degrees granted in the social sciences has not declined substantially; this apparent divergence from the comparable undergraduate trend may partially reflect the possibility that the shift in students from undergraduate social science to business majors was a shift of students who were unlikely to choose doctoral study.

The shift in the distribution of degrees awarded is also heavily influenced by the inflow of foreign graduate students. As Table 7.3 indicates, over the last 30 years the share of new doctorates from American universities awarded to U.S. citizens and permanent residents has fallen from about 90 to 80 percent. The decline has been most pronounced in the physical sciences and engineering, where foreign students (temporary residents in the United States) represented about 30 and 35 percent, respectively, of new doctorates awarded in 1988. As will be shown below, foreign students are less likely to remain in the United States once they receive their degrees. Thus, given the total number of new doctorates produced, an increase in the proportion who are foreign may reduce the potential academic labor supply to American colleges and universities.[2]

While the number of doctorates produced in American academic institutions has remained roughly constant, the time it takes for students to complete their degrees has lengthened during the past two decades. Data on median years of time spent enrolled as a doctoral student are reported for the period 1968–88 by field and year of degree in Table 7.4. Median *registered time* to degree rose over the period by almost a year and a half, from 5.5 to 6.9 years. The increase in registered time to degree was somewhat smaller in the sciences and engineering but considerably larger in other fields, including the humanities, where registered time to degree rose by three years, from 5.5 to 8.5 years.[3]

2. The distinction made between permanent and temporary residents depends on an individual's immigration status. Permanent residents are noncitizens who have been granted immigrant status or permission to stay in the United States permanently. Temporary residents, or, more precisely, nonimmigrants, are people who have been admitted to the United States for specified purposes (e.g., tourist, student, exchange visitor) for a fixed period of time. As discussed in Chapter 10, temporary residents sometimes subsequently become permanent residents.

3. An important qualification about these time-to-degree data (first recognized by Bowen, Lord, and Sosa, in press) is in order here. The data in Table 7.4 are grouped by year of completion of degree, not by year of entry into doctoral programs. As a result, even if the distribution of times to degree in each entering cohort remains constant over time, these reported average times to degree by year of completion will change if the sizes of entering cohorts are systematically changing over time. In particular, if entering cohorts are increasing in size, average time to degree by year of completion will spuriously appear to decrease, while, if entering cohorts are declining in size, average time to degree by year of completion will spuriously appear to increase. This would occur because, in the former case, those completing degrees in a given year would disproportionately come from "fast" completers from relatively large cohorts, while, in the latter case, those completing degrees in a given year would disproportionately come from "slow" completers from relatively large cohorts.

A simple numerical example illustrates this point. Suppose that all entering students receive degrees, that (unrealistically) half of each year's entering doctoral cohort complete in one year, and the other half complete in two years. Average time to degree by year of entering cohort is thus

Table 7.3 **Share of New Doctorates Going to U.S. Citizens and Permanent Residents**

	Total Doctorates	Physical Sciences	Engineering	Life Sciences	Social Sciences	Humanities	Education	Professional/Other
1960	.907	.896	.836	.852	.910	.970	.953	.898
1964	.896	.886	.837	.822	.907	.962	.949	.871
1968	.899	.888	.850	.840	.909	.955	.954	.871
1972	.923	.886	.845	.874	.914	.959	.960	.903
1973	.904	.869	.850	.872	.908	.953	.959	.887
1976	.894	.840	.813	.863	.909	.951	.954	.885
1980	.879	.829	.705	.867	.914	.945	.931	.880
1984	.839	.770	.646	.853	.887	.925	.918	.826
1988	.801	.702	.654	.815	.865	.895	.919	.801

Source: *Summary Report 1988: Doctorate Recipients from United States Universities* (Washington, D.C.: National Academy Press, 1989), table C.

Understanding the causes of the lengthening of registered time to degree is important because longer times to degree probably discourage people from entering doctoral study, may increase the likelihood that initial enrollees fail to complete their programs, and increase the length of time it takes new graduate students to enter the academic labor market. Indeed, even if time to degree had no effect at all on the number of people electing graduate study or their completion rates, a reduction in time to degree of one year would create a doubling for one year in the number of doctorates produced and thus contribute to increased academic labor supply.[4]

Data are also presented in Table 7.4 on *total time* to degree, the total length of time between an individual's receipt of the bachelor's degree and his or her receipt of a doctoral degree. Median total time to degree has risen by 2.4 years

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constant at 1.5 years. Suppose that, in years 0 and 1 (and all previous years), entering cohort size is 100. The top half of the table below shows that reported time to degree by year of completion will decrease from 1.5 to 1.476 years if, starting in year 3, entering cohort size increases by 10 percent per year. Similarly, the bottom half shows that reported time to degree by year of completion will increase from 1.5 to 1.526 years if starting in year 3, entering cohort size decreases by 10 percent per year:

Year	Entering Cohort Size	No. Who Will Complete in t + 1	No. Who Will Complete in t + 2	Average Time to Degree of Completers in the Year
0	100	50	50	1.5 ([50 × 1] + [50 × 2])
1	100	50	50	1.5 ([50 × 1] + [50 × 2])
2	110	550	55	1.5 ([50 × 1] + [50 × 2])
3	121	60.5	60.5	1.476 ([55 × 1] + (50 × 2])
4	133.1	66.55	66.55	1.476 ([60.5 × 1] + [55 × 2])
0	100	50	50	1.5 ([50 × 1] + [50 × 2])
1	100	50	50	1.5 ([50 × 1] + (50 × 2])
2	90	45	45	1.5 ([50 × 1] + [50 × 2])
3	81	40.5	40.5	1.526 ([45 × 1] + [50 × 2])
4	72.9	36.45	36.45	1.526 ([40.5 × 1] + [45 × 2])

While the total number of doctorates awarded in the United States remained roughly constant over the period 1970–88 (Table 6.4), the share and hence the absolute number awarded in the humanities fell substantially (Table 7.2). One can infer from these data that entering cohorts of humanities doctoral students were declining. Bowen, Lord, and Sosa (in press) compute that slightly over half the reported increase in time to degree, reported in Table 7.4, is spuriously due to the declining humanities cohort sizes. This line of reasoning suggests that, while time to degree has increased in the humanities, the increase is not as large is suggested by Tables 7.4 and 7.5 below. Similar studies of how changing cohort sizes affect reported times to degree in other fields have yet to be undertaken.

4. A numerical example illustrates this point. Suppose that it initially takes six years to complete a degree, that 100 students enter the program, and that all complete their degrees. Then, in steady state, there will be 100 first-year, 100 second-year, 100 third-year, 100 fourth-year, 100 fifth-year, and 100 sixth-year students enrolled each year. If time to degree could be reduced to five years in year *t*, both the fifth- and the sixth-year cohorts would receive degrees that year. Hence, there would be 200 doctorates produced in year *t*, and median time to degree would be 5.5 years. In year *t* + 1 and all subsequent years, only the fifth-year cohort would receive degrees. Thus, median time to degree would drop to, and thereafter remain at, five years, and doctorate production would return to 100 a year.

Table 7.4 **Median Years to Degree for Doctorate Recipients by Broad Field, 1968–88**

	All Fields	Physical Sciences	Engineering	Life Sciences	Social Sciences	Humanities	Education	Professional/Other
Registered time:								
1968	5.5	5.1	5.1	5.3	5.1	5.5	5.8	5.1
1970	5.5	5.3	5.2	5.3	5.5	6.1	6.2	5.4
1972	5.7	5.6	5.5	5.5	5.6	6.2	6.1	5.6
1974	5.9	5.6	5.6	5.5	5.7	6.6	6.3	6.0
1976	6.0	5.6	5.6	5.6	5.8	6.9	6.3	6.1
1978	6.1	5.8	5.6	5.7	6.0	7.3	6.5	6.2
1980	6.3	5.8	5.6	5.8	6.4	7.7	6.9	6.4
1982	6.5	5.8	5.7	6.0	6.7	8.0	7.2	6.7
1984	6.8	6.0	5.7	6.3	7.1	8.2	7.6	7.1
1986	6.8	6.0	5.9	6.4	7.2	8.2	7.8	7.3
1988	6.9	6.1	5.9	6.5	7.4	8.5	8.1	7.3
Total time:								
1968	8.1	6.0	7.1	7.1	7.7	9.5	13.9	10.9
1970	7.9	6.1	6.9	6.6	7.3	9.1	12.7	10.2
1972	8.2	6.5	7.5	7.0	7.5	9.0	12.5	9.7
1974	8.5	6.8	7.6	7.2	7.7	9.3	12.4	9.8
1976	8.6	6.7	7.5	7.3	7.8	9.7	12.7	10.3
1978	8.9	7.0	7.5	7.3	8.1	10.2	12.7	10.3
1980	9.3	6.9	7.6	7.4	8.6	10.6	13.2	11.1
1982	9.6	6.9	8.0	7.6	9.2	11.2	13.6	11.6
1984	10.0	7.2	8.0	8.2	9.7	11.5	14.6	12.3
1986	10.4	7.3	8.1	8.7	10.1	12.1	15.7	12.8
1988	10.5	7.4	8.1	8.9	10.5	12.2	16.9	13.0

Source: *Summary Report 1988: Doctorate Recipients from United States Universities* (Washington, D.C.: National Academy Press, 1989), table I.

Table 7.5 Mean Number of Years between Receipt of Baccalaureate Degree and Taking of the GREs for Students Planning Doctoral Study[a]

	Field of Planned Graduate Study											
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1976	2.2	2.1	6.3	2.5	2.0	1.1	1.8	.8	1.8	1.5	1.1	2.2
1977	2.4	2.2	6.2	2.8	2.0	1.2	2.0	1.0	1.8	1.7	1.0	2.3
1978	2.7	2.4	6.8	3.0	2.1	1.3	2.5	1.1	2.0	2.0	.9	2.6
1979	2.9	2.5	7.2	3.2	2.3	1.8	2.7	1.4	2.0	2.1	1.0	2.8
1980	2.8	2.7	7.4	3.3	2.3	1.6	3.1	1.4	2.0	2.2	1.1	2.9
1981	3.2	2.9	8.0	3.9	2.6	1.6	3.2	1.6	2.1	2.5	1.2	3.1
1982	2.8	3.2	8.5	3.5	2.6	1.7	3.6	1.6	2.2	2.6	1.3	3.1
1983	2.9	3.1	8.6	4.1	2.6	1.8	3.6	1.8	2.3	2.7	1.2	3.2
1984	3.3	3.2	8.8	4.4	2.7	2.0	3.8	2.2	2.3	2.8	1.2	3.3
1985	3.9	3.2	9.1	4.6	2.7	2.0	3.9	2.2	2.4	2.8	1.4	3.4
1986	4.3	3.5	9.2	4.7	3.0	2.2	4.4	2.5	2.8	3.0	1.6	3.7
1987	4.5	3.5	9.4	5.0	2.9	2.3	4.5	2.5	2.8	3.0	1.7	3.7

Source: Author's computations from Educational Testing Service (1988), table 42, and the comparable table from the prior years' reports.

[a]Year student took the GRE (e.g., the 1986–87 academic year is treated as 1987 since most students would enter doctoral study in the fall of 1987) minus the year the student reported receiving the bachelor's degree. The fields are as follows: (1) arts; (2) other humanities; (3) education; (4) other social sciences; (5) behavioral sciences; (6) biological sciences; (7) health; (8) applied biology; (9) engineering; (10) mathematical sciences; (11) physical sciences; and (12) total (including fields not reported separately above and intended field not reported by the student).

from 8.1 to 10.5 years; again, much smaller increases are observed for the sciences and engineering, with larger increases for other fields. Total time to degree will be larger than registered time to degree if students delay entry to graduate programs, if they start study in one field and then switch to another at a later date, or if they spend some time not enrolled in graduate study after their initial entry. Evidence presented from the Educational Testing Service in Table 7.5 on the mean number of years between the time students planning doctoral study first take the Graduate Record Examination (which is required for admission by many institutions) and when they received their bachelor's degrees suggests that college graduates are increasingly delaying entry to doctoral study. On average, test takers waited a year and a half longer in 1987 than they did in 1976 (col. 12).

Completion rates for entrants into doctoral programs vary widely across fields and institutions. Data for a set of selected major research universities for periods during the 1970s and early 1980s appear in Table 7.6. These data suggest that completion rates tend to be higher in the sciences than in the humanities and that in most of these programs doctoral completion rates lie in the 40–70 percent range.[5] Even the very best science graduate students, those

5. The rates reported in Table 7.6 may understate the true completion rates slightly because some people who were noncompleters as of the survey dates will ultimately complete their degrees and because one school (University D) reports only those who completed degrees within seven years of their first enrollment.

Table 7.6 **Doctoral Completion Rates at Selected Major Research Universities**

	Entering Class Years											
	University A (1975–77)		University B (1975–80)		University C (1970–82)		University D (1974–80)		University E (1975–77)		University F (1975–77)	
Field	No. of Observations	Completion Rate (%)	No. of Observations	Completion Rate (%)	No. of Observations	Completion Rate (%)	No. of Observations	Completion Rate (%)	No. of Observations	Completion Rate (%)	No. of Observations	Completion Rate (%)
Anthropology	66	43.9	49	43.0	152	39.0	30	33.3	31	51.0	69	55.1
Architecture	24	37.5					28	39.3			25	44.0
Astronomy	15	60.0			65	72.0					10	70.0
Biochemistry and molecular biology	68	77.9			134	75.0	59	64.4			60	75.0
Biology							67	73.1	57	63.0		
Business administration	59	54.2			103	62.0					56	66.1
Chemical engineering	42	83.3			90	53.0	88	85.2			35	60.0
Chemistry	213	83.1	93	87.0	424	68.0	157	75.8	84	60.0	66	74.2
City regional planning	21	42.9			141	51.0					34	61.8
Civil engineering	152	55.9			235	57.0	53	73.6			38	57.9
Classics	28	25.0	23	61.0	47	51.0	41	36.6			21	52.4
Comparative literature	66	19.7	21	71.0	50	52.0	61	50.8			14	50.0
Dramatic art	24	25.0			38	39.0					14	78.6
Economics	97	59.8	66	48.0	247	51.0	41	36.6			21	52.4
Education	230	43.9			385	64.0					707	50.9
Electrical engineering and computer science	211	50.2	26	46.0	502	55.7	102	89.2			106	53.8
English	109	34.9	94	46.0	211	57.0	102	60.8	82	49.0	90	55.6

French	20	35.0	23	52.0					34	50.0		
Genetics	23	82.6			59	52.0					18	50.0
Geology & geography	43	60.5	51	61.0	118	45.0	65	72.3			14	71.4
German	27	33.3	6	17.0	68	37.0	39	48.7			11	36.4
History	105	19.0	54	31.0	153	41.0	111	32.4	61	52.0	88	42.1
Industrial engineer-ing / operational research	51	39.2			152	58.0						
Linguistics	36	47.2	22	55.0	160	47.0	6	100.0			49	40.8
Material science and engineering	57	66.7			137	64.0					9	44.4
Mathematics	199	46.7	47	72.0	169	54.0	116	77.6			68	50.0
Mechanical engineering	122	58.2			123	35.0	70	75.7			35	62.9
Music	24	75.0	6	50.0	84	54.0	64	37.5			111	54.1
Near East studies	26	23.1					55	45.4			31	45.2
Nuclear engineering	32	50.0			25	68.0					49	73.5
Philosophy	30	43.3	37	49.0	80	46.0	64	40.6	42	40.0	35	28.6
Physics	147	67.3	102	70.0	400	60.0	141	79.4	56	71.0	51	58.9
Physiology	21	71.4			44	59.0			7	86.0	15	66.7
Political science	92	51.1			210	45.0	110	29.1			74	40.5
Psychology	72	68.1	31	90.0	165	64.0	76	67.1	57	56.0	165	73.3
Romance language and literature	6				152	50.0	75	38.7			42	42.9
Slavic language and literature	23	21.7	23	52.0	60	32.0					18	33.3
Sociology	70	41.4	63	65.0	135	59.0	63	41.3			72	52.8
Statistics	45	62.2			32	63.0	39	69.2			14	14.3

Source: Unpublished tabulations prepared by the University of California, Berkeley, Graduate Division, dated 3 May 1989.

Note: University A: Completion rate as of May 1988. University C: Completion rate as of May 1988. University D: Completion rate after seven years following the first enrollment for each cohort. University E: Completion rate as of December 1987. University F: Completion rate as of January 1988.

who win prestigious National Science Foundation Graduate Fellowships, had completion rates of 80 percent or less during the period 1962–76 (Harmon 1977, table 1; J. Snyder 1988). These completion rates should be contrasted with completion rates of over 98 percent in the top 20 American law schools, of over 90 percent in major American medical schools, and of 80–95 percent for top MBA programs in the United States.[6] Doctoral study is considerably riskier than its alternatives.

7.2.2 Initial Postdegree Experiences of New Doctorates

Each year, when doctoral candidates submit their dissertations to their graduate schools for final approval, they are asked to respond to the Survey of Earned Doctorates (SED), which is administered by the National Research Council. Among the questions asked in the SED are whether respondents have made definite employment plans in the United States and, if so, whether their employment is in the academic or the nonacademic sector.[7] Data on the sectoral distribution of employment for U.S. citizen and permanent resident new doctorates from the SED are reported in Table 7.7 for 1968, 1978, and 1988. Quite strikingly, the share of these employed new doctorates finding employment in academe has declined in the aggregate from two-thirds in 1968 to about half in 1988. With the exception of the health sciences and business and management fields, the academic share declined in all fields. Indeed, while almost 94 percent of employed new doctorate humanists were employed in academe in 1968, by 1988 slightly less than 80 percent were initially so employed.

Of crucial concern for public policy is whether the declining academic share of employed new doctorates is due to an increasing demand and higher relative salaries for new doctorates in the nonacademic sector or simply due to a scarcity of job openings in the academic sector during the period. While the answer will likely vary across fields, if the former is the case, it will be necessary to increase academic salaries vis-à-vis nonacademic salaries to attract a greater share of new doctorates into academe. If the latter is the case, an expansion of academic job opportunities in itself (without any increase in academic salaries) may lead a greater share of new doctorates to enter aca-

6. The law school data come from *Barrons' Guide to Law Schools* and are for the mid-1980s. The American Medical Association (1988) reports a net attrition rate of 2.6 percent of 1986–87 enrollments at AMA approved medical schools. Since most medical schools have a four-year curriculum, this implies that completion rates exceed 90 percent. Finally, while completion rates of MBA programs are not collected, James Schmotter, associate dean at Cornell's Johnson School of Management, reports that Cornell's MBA completion rate is 98 percent, and other top MBA program rates are also greater than 90 percent, save perhaps Harvard and Virginia. This latter two use the case-study method, and, apparently, test scores and undergraduate records cannot predict which applicants will succeed in these programs, at least not as well as they do for other programs.

7. It is rare for the U.S. citizens holding doctorates to have definite employment plans outside the United States. For example, of those U.S. citizen new doctorates whose future location was known when they returned the SED, 97.6 percent (15,778 of 16,182) had plans in the United States in 1988 (see National Science Foundation 1989e, table 15).

Table 7.7 **Sector of Employment of U.S. Citizen and Permanent Resident Doctorate Recipients with Employment Commitments in the United States, 1968, 1978, and 1988 (%)**

	Employment Sector											
	Academe			Industry			Government			Other		
Field	1968	1978	1988	1968	1978	1988	1968	1978	1988	1968	1978	1988
Total all fields	66.6	56.4	49.8	14.8	15.3	20.4	7.4	12.5	10.8	11.2	15.9	19.1
Physical sciences	50.1	37.9	36.2	34.6	45.2	50.0	9.4	14.4	11.8	5.9	2.4	1.9
Physics/astronomy	52.1	25.9	26.1	25.0	46.9	48.2	16.1	24.1	23.4	6.7	3.1	2.3
Chemistry	29.5	18.4	15.3	58.9	71.4	77.7	4.9	7.7	5.0	6.7	2.5	2.0
Earth, atmospheric, marine	50.7	33.2	39.3	25.9	36.1	30.4	17.8	27.9	29.5	5.6	2.9	.9
Mathematics	79.9	70.8	75.9	12.6	19.1	19.0	3.7	8.2	2.3	3.9	1.9	2.8
Computer sciences	*	58.2	56.6	*	35.8	32.7	*	6.0	8.8	*	.0	1.8
Engineering	33.3	23.5	28.5	47.0	57.1	55.5	10.6	17.5	15.0	9.1	2.0	.9
Life sciences	65.9	59.0	51.9	11.8	20.4	23.7	14.0	16.3	16.8	8.4	4.3	7.6
Biological sciences	68.0	60.9	47.7	9.0	17.7	27.1	13.0	16.4	18.0	9.9	5.0	7.2
Health sciences	56.8	62.9	63.1	23.7	17.2	13.8	6.8	14.5	12.5	12.7	5.5	10.6
Agricultural sciences	62.2	53.7	44.3	16.1	26.7	30.8	19.3	17.3	20.4	2.4	2.4	4.4
Social sciences (including psychology)	75.3	58.5	45.1	4.8	9.6	19.4	10.6	16.0	14.2	9.2	16.0	21.3
Psychology	61.0	40.0	29.6	6.5	12.4	24.6	17.0	20.7	16.5	15.6	26.9	29.3
Other social sciences	85.1	76.2	66.2	3.7	6.9	12.3	6.3	11.4	11.1	4.9	5.5	10.4
Humanities	93.9	82.6	79.3	6.0	4.9	5.8	1.4	3.8	3.7	4.3	8.7	11.2
Education	68.1	51.9	43.8	1.0	3.4	7.3	3.9	12.5	9.0	26.9	32.2	39.8
Professional/other	80.9	74.1	73.8	8.9	7.0	8.2	3.9	7.2	6.4	6.3	11.8	11.6
Business and management	84.6	87.0	90.0	9.1	7.9	7.0	1.9	4.3	2.6	4.4	.8	.4
Communications	88.9	83.9	81.9	8.3	9.3	8.1	.0	4.1	2.0	2.8	2.6	8.1

Source: *Summary Report 1988: Doctorate Recipients from United States Universities* (Washington, D.C.: National Academy Press, 1989), table R. "Other" includes elementary/secondary schools, nonprofit institutions, self-employment, and other employers.

*Not available.

demic life and may also induce some doctorates currently employed in the nonacademic sector to enter or reenter academe.

Table 7.7 may present a misleading picture of the proportion of new doctorates entering academic careers directly because it focuses on those new doctorates who have accepted employment and ignores the increasing share of new doctorates accepting one- or two-year postdoctoral appointments (postdocs). These positions, found in universities, government, and the private sector, offer doctorates additional opportunities to develop their research skills before moving on to more permanent employment.

Table 7.8 contains data on the share of new doctorates with definite plans in the United States going on to postdocs and academic employment between 1970 and 1988. During this period, the share of new science/engineering U.S. citizen doctorates with definite plans who were starting postdocs rose from 0.22 to 0.39, which was almost equal to the decline from 0.44 to 0.24 in the share accepting academic employment.[8] The trends for permanent residents were very similar. In contrast, in the nonscience/nonengineering fields, very few students accept postdocs, and the small increase that occurred over the last 20 years cannot "explain" the large decline in the share of new doctorates with definite plans accepting academic employment.

When one examines more narrowly defined science/engineering fields, one finds variations in behavior across them. In some of the specific fields listed in Table 7.8, the increase in the share accepting postdocs between 1970 and 1988 was approximately equal to, or greater than, the decrease in the share accepting academic employment (physical sciences, earth and material sciences, life sciences, mathematical sciences, engineering). In other fields, such as the social and psychological sciences, the decline in the share accepting academic employment far exceeded the increase in the postdoc share.

These trends suggest a number of policy issues. Is the increasing share of postdocs in most fields caused by a deepening of knowledge and hence a required longer training period before faculty appointments can be obtained? Or does it represent a response to a relatively loose academic labor market and attempts by doctorates to enhance their attractiveness in the search for permanent academic positions by accepting these lower-paying training positions?[9] Are differences in the growth of postdocs across fields caused at least partially by differences in the strength of the nonacademic labor market across fields? Do postdocs eventually wind up in academic positions so that the net effect on the academic labor supply is simply to lengthen the pipeline? Is the increasing "need" for a postdoc partially responsible for the decline in the

8. In Table 7.8, the social sciences and psychology are included as sciences, and the nonscience/nonengineering fields include the humanities, education, and other professional doctoral fields.

9. As of 1979, the median postdoc stipend was, on average, less than 60 percent of the median salary of full-time-employed new doctorates, although this percentage varied across fields (see National Research Council 1981, table 53).

share of college graduates seeking doctorates? If the increased use of postdocs is a result of a "loose" academic labor market, would a "tight" market lead to an increase in the number of new doctorates directly accepting academic employment? If this occurs, would the decline in the probability that a postdoc is required for academic employment make doctoral study more attractive and increase the flow of college graduates into doctoral programs?

Table 7.8 also contains data on temporary resident (foreign) new doctorates who reported having definite plans in the United States. Although temporary resident new doctorates with definite plans are less likely to remain in the United States than U.S. citizen and permanent resident new doctorates, the share of the former doing so has increased from 0.42 to 0.55 in the total sciences/engineering fields and from 0.22 to 0.30 in the nonscience/nonengineering areas over the period 1970–88. Of those who do stay, a much greater proportion obtain postdocs than do citizen or permanent resident degree holders. Moreover, in 1988, in the total science/engineering area, the share of temporary resident doctorates who stay and find academic appointments was actually as high as the comparable shares of U.S. citizen new doctorates finding academic employment, and, in the nonscience/nonengineering area, it was greater. In part, this may be because temporary resident doctorates may have difficulty obtaining visas to work in the U.S. nonacademic sector. Whether an expansion of temporary resident U.S. academic employment is possible, or desirable, will be discussed in a later chapter.

What do postdocs actually do on completion of their appointments? Every two years, the Office of Scientific and Engineering Personnel of the National Research Council conducts a national probability survey of all doctorates residing in the United States. The Survey of Doctoral Recipients (SDR) is longitudinal in design and allows one to track individuals' changes in status over two-year periods if they respond to the survey in two consecutive periods.

Special tabulations from the SDR presented in Table 7.9 indicate that the percentage of those doctorates who held postdoctoral appointments in 1985 that were employed in the U.S. academic sector in 1987. In the aggregate, 63.6 percent of U.S. citizen and permanent resident postdocs in 1985 were employed in academe in 1987, and over 50 percent were employed in faculty positions. Both these percentages exceed the 49.8 percent of all employed new doctorates in 1988 who were employed in academe (Table 7.7). Indeed, contrasting the percentages of 1985 postdocs employed in the academic sector in 1987 in the physical sciences (54.0), life sciences (67.7), and social sciences and engineering (61.7) with the comparable percentages of new doctorates employed in academe in 1988 (Table 7.7), it is clear that in each field postdocs *are* more likely to enter academe than are new doctorates who accept employment immediately on graduation.

It is somewhat more difficult to use the SDR to draws conclusions about temporary residents because nonresponse rates for temporary residents increase substantially in the SDR with time since degree. Partially, this reflects

Table 7.8 Share of New Doctorates with Definite Plans in the United States Going on to Postdoctorate and Academic Appointments

	Total		U.S. Citizen		Permanent Resident		Temporary Resident		
	SPDOC	SACAD	SPDOC	SACAD	SPDOC	SACAD	SPDOC	SACAD	SDEFU
Total science/engineering:									
1970	.24	.43	.22	.44	.28	.36	.51	.31	.42
1975	.28	.37	.26	.39	.35	.23	.50	.22	.40
1980	.33	.29	.32	.30	.27	.21	.50	.21	.45
1985	.36	.26	.35	.26	.28	.27	.50	.28	.49
1988	.42	.24	.39	.24	.35	.28	.58	.25	.55
Total nonscience/nonengineering:									
1970	.02	.79	.02	.79	.06	.86	.15	.75	.22
1975	.02	.66	.02	.65	.07	.73	.22	.64	.20
1980	.03	.58	.03	.58	.07	.67	.25	.61	.15
1985	.03	.55	.03	.55	.08	.77	.11	.72	.21
1988	.05	.56	.04	.56	.05	.70	.15	.76	.30
Selected fields:									
Physical science (physics/astronomy and chemistry):									
1970	.38	.21	.35	.23	.51	.13	.72	.15	.63
1988	.61	.07	.54	.08	.59	.09	.89	.03	.70

Earth and material sciences:									
1970	.21	.43	.18	.45	.26	.31	.70	.25	.36
1988	.39	.23	.35	.26	.50	.08	.88	.04	.33
Life sciences:									
1970	.46	.37	.43	.39	.57	.26	.81	.14	.35
1988	.74	.12	.72	.13	.76	.09	.92	.06	.47
Social sciences:									
1970	.04	.82	.04	.82	.05	.90	.09	.75	.25
1988	.09	.65	.08	.64	.05	.64	.12	.74	.38
Psychological sciences:									
1970	.14	.52	.14	.52	.35	.42	.25	.56	.35
1988	.21	.24	.21	.24	.14	.32	.52	.32	.60
Mathematical sciences:									
1970	.06	.75	.06	.76	.06	.66	.20	.73	.52
1988	.20	.65	.15	.65	.23	.55	.30	.67	.51
Engineering:									
1970	.07	.27	.05	.27	.12	.21	.27	.28	.48
1988	.20	.26	.11	.26	.12	.29	.40	.27	.59

Source: National Science Foundation (1989e, table 15).

Note: SPDOC = share of doctorates with definite plans in the United States going on to postdoctoral appointments; SACAD = share of doctorates with definite plans in the United States going on to academic appointments; and SDEFU = share of those with definite plans with plans in the United States.

Table 7.9 Percentage of Postdocs in 1985 Who Were Employed in the U.S. Academic Sector in 1987[a]

		Field		
	Total	Physical Sciences	Life Sciences	Social Sciences and Engineering
U.S. citizens and permanent residents:				
Total number of postdocs in 1985	6,722	1,551	4,176	965
% in academe in 1987	63.6	54.0	67.7	61.7
% in faculty positions	50.3	41.0	53.1	53.4
% in nonfaculty positions	7.9	9.6	8.6	2.3
% faculty status not reported	5.4	3.4	5.9	6.0
Temporary residents:				
Total number of postdocs in 1985	924	451	277	196
% in academe in 1987	27.3–58.0	23.1–52.0	53.8–92.0	[b]
% in faculty positions	20.2–42.9	21.7–49.0	32.1–54.9	[b]
% in nonfaculty positions	2.2– 4.6	.7– 1.5	6.1–10.5	[b]
% faculty status not reported	5.0–10.6	.7– 1.5	15.5–26.5	[b]

Source: Special tabulations prepared from the *Survey of Doctorate Recipients* by the Office of Scientific and Engineering Personnel, National Research Council.

[a]Based on respondents to the 1985 *Survey of Doctoral Recipients* who received their doctorates in 1980–84. The figures for U.S. citizens and permanent residents assume that nonrespondents to the 1987 *Survey* were distributed across employment categories in an analogous manner to respondents. The upper-bound estimates for temporary residents similarly assume this, while the lower-bound estimates assume that all temporary resident nonrespondents in 1987 were employed abroad or outside the U.S. academic sector in 1987.

[b]Sample was too small to compute percentages.

a tendency, based on both immigration law and their desires, for temporary resident doctorates to leave the United States and return to their home countries. If one assumes that all nonrespondents in 1987 returned to their home countries, one can compute a lower-bound estimate of the proportion of temporary resident postdocs in 1985 employed in the U.S. academic sector in 1987. If instead one assumes that all nonrespondents in 1987 in fact remained in the United States and were distributed across employment categories in a manner similar to 1987 respondents, one can compute an upper-bound estimate.

Both these estimates are presented in the bottom half of Table 7.9. In both the physical and the life sciences, even the lower-bound estimates of the proportion of 1985 temporary resident postdocs employed in the U.S. academic sector in 1987 exceed the proportion of 1985 and 1988 temporary resident new doctorates directly entering employment in the U.S. academic sector (Table 7.8). While this provides evidence that temporary resident new doctorates contribute to academic labor supply in the United States, both directly on receipt of their doctorates and subsequently to postdoc appointments, no evidence is available on their expected length of academic careers here. However, since their immigration status does directly affect their ability to remain in the United States, one suspects that this expected length is shorter than that of otherwise comparable citizen and permanent resident new academics.

7.2.3 Stocks and Flows of Experienced Doctorates

The age distribution of doctorates employed in academe at a point in time depends on patterns of growth of positions in the past and decisions by experienced doctorates to enter or leave academe and retire from the work force. Over the period 1977–87, the age distribution of doctoral scientists, social scientists, and engineers employed by educational institutions shifted to the right as relatively few new faculty positions were created during the 1980s.[10] As a result, the proportion of these faculty below age 35 fell from 21.7 to 12.2 percent, while the proportion of faculty age 55 and over rose from 15.0 to 21.6 percent (Table 7.10).

As the share of faculty who are age 55 and older increases, so does concern over the impending growth in retirements and thus the increased replacement demand for faculty that will occur. As of 1994, faculty will no longer be subject to mandatory retirement, and concern over whether research and teaching productivity decline, on average, with age leads to discussion of policies that might be pursued to "encourage" older faculty to retire. Alternatively, given projections of future faculty shortages, some wonder whether encouraging older faculty to postpone retirement will have a substantive effect on the magnitude of these shortages.

The changing age distribution also has implications for the mobility pattern of experienced doctorates between the academic and the nonacademic sectors. Table 7.11 presents data (for three age groups) on the share of doctorates employed in either the academic or the nonacademic sector in 1985 who moved to the other sector by 1987. These data, which come from analyses of the SDR, make clear that on average the proportion of faculty who move to the nonacademic sector declines substantially with age while the proportion that move from the nonacademic to the academic sector is much less dependent on age.

There are also substantial differences in these proportions across fields, relating presumably to differences in the relative availability and attractiveness of employment opportunities in the two sectors. In most fields, the proportion of academics moving to the nonacademic sector is greater than the proportion of nonacademics moving to the academic sector for the two age groups under 50, but the inequality is reversed for the older cohorts. A notable exception is the humanities, where for all age groups the proportion of nonacadem-

10. Similar trends have been observed in the age distribution of all humanities doctorates (see National Research Council 1989b, tables 2, 9; National Research Council 1986, table 3; National Research Council 1982, table 2.3; and National Research Council 1978, table 2.3).

Table 7.10 Age Distribution of Doctoral Scientists, Social Scientists, and Engineers Employed by Educational Institutions

	% in:					
Category	1977	1979	1981	1983	1985	1987
Under 30	3.3	2.6	2.4	1.8	1.5	1.2
30–34	18.4	16.3	14.9	12.4	12.0	11.0
35–39	22.7	22.8	20.5	18.7	18.1	16.3
40–44	15.8	16.9	19.2	20.9	20.1	18.9
45–49	13.7	13.6	13.1	14.1	15.7	18.5
50–54	11.0	11.2	11.5	11.9	11.6	12.4
55–59	8.1	8.9	9.3	9.7	9.5	10.0
60–64	4.8	5.3	6.0	6.8	7.4	7.5
65 and over	2.1	2.5	3.2	3.6	4.0	4.1
No report	.1	.0	.0	.1	.1	.2

Source: National Science Foundation (1988a, table 3).

Table 7.11 Shares of Doctorates Employed in Both 1985 and 1987 Who Changed Sectors between 1985 and 1987, by Field and 1987 Age

	Age 35 and Under		Age 35–50		Age 50 and Over	
	AN	NA	AN	NA	AN	NA
All fields	.107	.078	.052	.043	.024	.047
Physical sciences	.206	.030	.052	.019	.014	.034
Mathematical sciences	.074	.059	.018	.039	.006	.046
Computer sciences	.064	.000	.071	.025	.000	.267
Environmental sciences	.026	.084	.062	.026	.043	.052
Life sciences	.122	.144	.068	.063	.025	.053
Psychology	.152	.084	.090	.032	.047	.032
Social sciences	.029	.116	.044	.093	.035	.089
Engineering	.069	.038	.041	.023	.032	.030
Humanities	.065	.191	.036	.074	.013	.081

Source: Special tabulations prepared by the Office of Scientific and Engineering Personnel, National Research Council, from the *Survey of Doctorate Recipients*. These computations assume that nonrespondents in 1987 are distributed across sectors in an identical manner to respondents.

Note: AN = share of those employed in the academic sector in 1985 who were employed in the nonacademic sector in 1987; and NA = share of those employed in the nonacademic sector in 1985 who were employed in the academic sector in 1987.

ics moving to academe is substantially greater than the proportion of academics moving to the nonacademic sector.

Of course, the number of people moving from each sector depends not only on the proportions of people leaving the sector but also on the number of people initially in the sector. Table 7.12 presents estimates from the SDR on the number of experienced doctorates (by field in 1985) employed in the academic and nonacademic sectors. On average, the number employed in the

Table 7.12 Estimated Number of Doctorates by Field, Sector of Employment, and Age in 1985

	Age 35 and Under		Age 35–50		Age 50 and Over	
	A	N	A	N	A	N
All fields	30,740	27,697	146,266	134,513	79,673	51,795
Physical sciences	4,062	7,137	17,015	28,673	10,718	13,915
Mathematical sciences	1,822	565	8,378	4,138	3,751	975
Computer sciences	567	351	792	1,267	61	62
Environmental sciences	738	809	3,413	4,642	1,818	1,764
Life sciences	9,699	6,009	33,195	24,462	16,850	9,841
Psychology	3,471	5,005	13,126	19,472	5,630	7,642
Social sciences	4,276	2,050	24,093	12,299	13,088	4,401
Engineering	2,872	4,671	11,964	25,407	6,637	8,322
Humanities	3,233	1,100	34,290	14,153	21,120	4,873

Source: Special tabulations prepared by the Office of Scientific and Engineering Personnel, National Research Council, from the *Survey of Doctorate Recipients*. Approximately 0.1 percent of doctorates did not report their ages and are excluded from these totals.

Note: A = employed in academic sector; and N = employed in nonacademic sector.

academic sector exceeds the number employed in the nonacademic sector, and, on balance, the net flow of experienced doctorates is from the academic to the nonacademic sector, rather than vice versa, except for the age 50 and over group. There are, of course, substantial differences by field. However, even for the humanities (because of the greater proportion of doctorates employed in the academic sector), the net flow is from the academic to the nonacademic sector. Later chapters will discuss whether the potential exists for these net flows to be reversed and for experienced doctorates currently employed in the nonacademic sector to help avert projected shortages of doctorates.