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ABSTRACT

This study analyzes the occupational mobility of individuals who hold the Ph.D. degree. Drawing upon data contained in the National Register of Scientific and Technical Personnel compiled by the National Science Foundation, this paper presents the quantitative relationships between educational background, occupational mobility, and salaries. Based on these results, the author then presents and empirically tests an economic theory of Ph.D. occupational mobility. (Author)

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EDUCATIONAL TRAINING AND CAREERS OF PH.D. HOLDERS: AN EXPLORATORY EMPIRICAL STUDY

Jeffrey Morris

Paper P-27

January 1972

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PREFACE

This is one of a continuing series of reports of the Ford Foundation sponsored Research Program in University Administration at the University of California, Berkeley. The guiding purpose of this Program is to undertake quantitative research which will assist university administrators and other individuals seriously concerned with the management of university systems both to understand the basic functions of their complex systems and to utilize effectively the tools of modern management in the allocation of educational resources.

This study analyzes the occupational mobility of individuals who hold the Ph.D. degree. Drawing upon data contained in the National Register of Scientific and Technical Personnel compiled by the National Science Foundation, this paper presents the quantitative relationships between educational background, occupational mobility, and salaries. Based on these results, the author then presents and empirically tests an economic theory of Ph.D. occupational mobility.

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I. DESCRIPTIVE DATA

To begin to analyze education from a broad perspective and to develop somewhat detailed information on the relationship between educational background and lifetime occupation patterns, a sample of data was obtained from the National Register of Scientific and Technical Personnel which is compiled by the National Science Foundation (NSF). This sample contains biographical information and data on educational training, plus career data for the period 1960-66, on 30,168 individuals who received a Ph.D. in some disciplines prior to 1960. For each Ph.D. holder the sample contains the following information on educational background:

(1) Institution, year, major subject and minor subject for the Ph.D. degree.

(2) The same information as for the Ph.D. degree for the second and third most advanced degrees.

(3) Place of secondary school graduation.

The time series information on employment contains the following data for four points in the seven-year time span 1960-66:

(1) Standard Industrial Classification for the Ph.D.'s employer, as well as employer type.

(2) Standard Metropolitan Statistical Area where employed. If employed by an academic institution, that school's name (this information is provided only for the latest two of the four observations).

(3) First and second most important work activities.

(4) Rank and annual salary -- the basic salary associated

with principal professional employment and the gross annual income from all professional activities.

(5) Years of professional experience.

(6) The type of scientific specialty most used in the Ph.D.'s principal professional job.

(7) Four scientific specialties in which the Ph.D. has the most competence.

The specialties are typically categorized even more finely than major and minor subjects for degrees. For example, the Ph.D. could indicate not only that economic statistics is one of his four specialties, but also that econometrics, input-output and programming methods, social accounting, or statistical methods is the specific area of that specialty in economic statistics. Or, if his specialty is solid state physics, he could further indicate in which one of twenty-seven solid state physics specialties he is most competent.

The place and date of birth, sex, and place of residence for each Ph.D. are also listed in the NSF sample, as well as some information on language competence and geographical area studies knowledge.

The remainder of this chapter is devoted to a detailed summary of some of the data contained in the NSF sample of 30,168 Ph.D. holders. Chapter II reports the results of various tests of hypotheses that were carried out on the sample. Some further interpretations of the descriptive data in this chapter are also discussed in that Chapter.

Field of Ph.D. Degree and of Greatest Scientific Competence

Until the decade of the sixties, the NSF's National Register was for the most part restricted to the physical, biological and engineering sciences, and psychology. As indicated in Table 1, the composition of the sample used in this thesis reflects this exclusion of information on holders of Ph.D.'s in the social sciences and humanities. Thus only six of the 30,168 individuals in the NSF sample obtained their Ph.D. in the social sciences or humanities, and all those were in the field of economics.

Almost one-fourth of the people reporting in the NSF sample obtained their Ph.D.'s in chemistry; a significant portion of degrees were also pursued in the biological sciences, psychology and physics. About ten percent of the Ph.D. degrees were in one of the five inter-disciplinary fields -- biochemistry, geochemistry, physical chemistry, biophysics and social psychology.[1] Including these interdisciplinary specialties, the two physical science fields chemistry and physics, the biological sciences and psychology account for over seventy-five percent of the Ph.D.'s in the NSF sample.

In each of the four years for which data was gathered on individuals in the NSF sample, each person was asked to indicate the specialty in which he was most competent at that particular time. This specialized ability of course has a strong correlation with the field in which the Ph.D. was obtained, as indicated by comparison of the distribution of Ph.D. fields with the distribution of fields of greatest competence shown in Table 1. However, the correlation is not perfect because job

[1] Unless otherwise noted, data for these five fields are combined together and reported under the field title "Interdisciplinary" in the analysis and tables in this chapter and Chapter II.

TABLE 1

Field of Ph.D. Degree and Greatest Scientific Competence

	Ph.D. Field		Field of Greatest Competence 1960		Field of Greatest Competence 1966	
Chemistry	6,768	22.7%	5,978	20.0%	5,882	19.7%
Biological Sci.	5,026	16.9	4,658	15.6	4,849	16.3
Psychology	4,119	13.8	3,962	13.3	4,049	13.6
Physics	3,756	12.6	4,017	13.5	3,998	13.4
Earth Sciences	1,801	6.0	1,845	6.2	1,918	6.4
Mathematics	1,600	5.4	1,686	5.7	1,687	5.7
Engineering	916	3.1	1,035	3.5	652	2.2
Agricultural Sci.	661	2.2	853	2.9	667	2.2
Medical Sciences	368	1.2	664	2.2	803	2.7
Prob. & Statistics	156	0.5	314	1.0	335	1.1
Astronomy	155	0.5	173	0.6	189	0.6
Economics	6	-	132	0.4	335	1.1
Anthropology	0	0	6	-	11	-
Education	0	0	42	0.1	48	0.2
Humanities	0	0	18	0.1	23	0.1
Linguistics	0	0	16	0.1	255	0.9
Political Science	0	0	22	0.1	36	0.1
Sociology	0	0	9	-	47	0.2
Interdisciplinary	2,930	9.8	4,350	14.6	4,003	13.4
Other	287	1.0	41	0.1	22	0.1
Unclassifiable[1]	1,272	4.3	0	0	12	-
TOTAL[2]	29,821	100.0%	29,821	100.0%	29,821	100.0%

[1] Degree or specialty field data blank, miscoded, or otherwise not usable.

[2] Total not equal to 30,168 because 347 records on individuals were not usable for the purposes of this study, as a result of factors such as their having received a Ph.D. after 1960, or their having received more than one Ph.D.

SOURCE: NSF Sample.

experience and self-education after the Ph.D. can presumably allow any given person to change the field in which he is most competent. For example, although only six individuals in the NSF sample obtained their Ph.D. in economics, by 1966, 335 (slightly more than one percent) claimed that their greatest scientific competence was in the field of economics. On the other hand, 916 Ph.D.'s were in engineering, but by 1966 only 652 claimed that field as the one in which they were most competent.

There is some difficulty in making any straightforward interpretation of such changes over time in scientific comeptence because these variations are based on individuals' assertions that there had been a change in their competence rather than on a more objective measure of ability. As demand and supply conditions in the various fields change over time, with concomitant rise and fall in salary levels, it would perhaps be advantageous to claim greatest competency in an area in which demand and thus salary was relatively high, even when one's actual ability was greatest in some other field. This would be especially easy to do when the two fields are somewhat similar in the abilities they require, such as would be the case for engineering and economics. A claimed change in competence could also reflect a change in interest rather than a change in ability. To the extent that interest is a leading indicator of ability, the usefulness of data on fields of competence is not destroyed in this case; its interpretation is just somewhat altered. These problems with interpreting the data on competency will be important to bear in mind when the descriptive data of this chapter is being interpreted in the next chapter.

Since it is intended that the NSF sample provide information on the effects of educational background on job salary and mobility, it is im-

portant to develop some notion of the extent to which the sample is representative of the population of Ph.D.'s. As mentioned above, the social science and humanities fields are significantly under-represented. Some idea about the representativeness of the sample in other fields can be gained by comparing it with data in the complete National Register of Scientific and Technical Personnel which is collected biennially by the NSF. The NSF sample used in this study differs from the complete National Register, because to be included an individual had to report to the National Register four consecutive times, and he had to receive his Ph.D. prior to 1960. The NSF sample is thus a subsample of the National Register data for any particular year.

The complete National Register sample is classified by field of greatest scientific competence; Table 2 contains the distribution among fields for Ph.D.'s reporting in 1960 and 1966. Comparison of the distribution for 1960 with the distribution for the NSF sample given in Table 1 shows that the NSF sample is almost identical in relative composition to the larger National Register sample. For 1966, however, there is significant disparity in certain fields, such as economics which represents 6.2% of the National Register sample but only 1.1% of the NSF sample. Chemistry on the other hand comprises 16.2% of the 1966 National Register, but 19.7% of the NSF sample. These sorts of differences in composition are to be expected as a result, for example, of changes in the supply of new Ph.D.'s. The composition of competency in the NSF sample can change due to job experience, self-education and the other factors mentioned previously, but these effects operate much more slowly than the alteration in composition of competency in the total population of Ph.D.'s due to changes in relative supply of new Ph.D.'s. As long as

TABLE 2

Field of Greatest Scientific Competence for Ph.D.'s
Reporting in the National Register, 1960 and 1966

	1960		1966		% Increase
Chemistry	11,978	19.1%	14,638	16.2%	22.2%
Organic	8,108		8,941		10.3
Biological Sciences	10,226	16.3	12,932	14.3	26.5
Psychology	8,461	13.5	11,677	12.9	38.0
Clinical	3,458		4,567		32.1
Physics	7,738	12.4	11,289	12.5	45.9
Economics	*	*	5,593	6.2	-
Business Adm.	*		1,171		-
Earth Sciences	3,810	6.1	5,325	5.9	39.8
Geology	1,174		2,190		86.5
Meteorology	237		668		181.9
Mathematics	3,647	5.9	5,235	5.8	43.5
Sociology	*	*	2,757	3.1	-
Engineering	2,901	4.6	1,969	2.2	-32.2
Medical Sciences	1,409	2.3	1,886	2.1	33.9
Pharmacology	807		1,198		48.5
Agricultural Sciences	1,902	3.0	1,691	1.9	-11.1
Probability & Stats.	673	1.1	1,169	1.3	73.7
Anthropology	*	*	830	0.9	-
Linguistics	*	*	750	0.8	-
Astronomy	338	0.5	561	0.6	66.0
Interdisciplinary	8,701	13.9	10,837	12.0	24.5
Biochemistry	3,408		4,553		33.6
Physical Chemistry	4,078		4,724		15.8
Other[1]	826	1.3	1,165	1.3	41.0
TOTAL REPORTING	62,610	100.0%	90,304	100.0%	44.2%

some attempt is made to take this new Ph.D. supply effect on observed salaries and job changes for Ph.D.'s in the NSF sample into account, there is nothing in the comparison of this sample with the complete National Register sample to suggest that the NSF sample cannot be used as a representative sample of Ph.D. career patterns in the physical, biological, and engineering sciences and in psychology.

However, one additional problem is that, while the NSF sample may be a representative subsample of a portion of the complete National Register, the National Register may not be an unbiased sample of the total population of Ph.D.'s. Data are gathered for the National Register through mailings to the membership of professional associations, such as the American Chemical Society. Ph.D.'s who do not belong to one of these professional societies do not receive any questionnaire. Even if such nonmembers were sampled there is some evidence that their response rate would be significantly different. The response rate of Ph.D.'s employed in academia is also probably higher than for those employed by government or business.[2] Thus, while the NSF sample may be representative of academics who belong to professional associations, conclusions based on such data may not on average apply to those Ph.D.'s who do not belong to professional societies or to those who are not employed by academic institutions.

[2] In a study of sociologists, Sibley [11] mailed out questionnaires to both members and nonmembers of the American Sociology Association. The useable response rate was about 85% for members and less than 40% for nonmembers. Such a systematic difference in response rate could mean the existence of systematic differences in the information being gathered. In a study of political scientists, Somit and Tanenhaus [12] found that the response rate to a mailed survey for members of the American Political Science Association was higher for those employed by academic institutions than for those employed by government or business.

Employment Specialty Field and Associated Salary

To determine the effects of educational background on job mobility and earnings of Ph.D. holders, it is first necessary to have information on the skills actually being used in the Ph.D.'s occupation. Fortunately, the NSF sample contains data that provide this information. Table 3 indicates the distribution of specialty fields used in the Ph.D. holder's job for the years 1960 and 1966; the average annual salary associated with jobs using each skill is also listed.[3]

The average salary data is calculated from the basic annual salary associated with each Ph.D.'s principal professional employment as of January in the two years. The basic salary is annual salary before income tax and social security deductions; it excludes bonuses, overtime, summer teaching, and other payment for professional work not a usual part of principal professional employment. For 1966, Ph.D.'s employed in academia indicated whether their salary was for 9-10 months or 11-12 months. If 9-10 month employment was indicated, the reported salary figure was multiplied by a factor of 6/5 to make it comparable to the salary data for 11-12 month employment in academia, government or business. However, this adjustment could not be made to the 1960 salary data because no information on employment time span was collected that year.

The distribution of employment specialty fields in 1960, as shown in Table 3, is quite similar to the distributions of both Ph.D. degrees

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[3] It should be noted that the data on Ph.D. field, field of greatest scientific competence, and employment specialty have been categorized into only 20 major fields for ease in reporting and manipulating the large NSF sample. This categorization reduces the detail provided in the sample by a factor of between 5 and 500, depending on whether it is degree data or employment and competency data that is being so reduced.

TABLE 3

Specialty Field Used in Current Employment, and Associated Average Annual Salary

Employment Specialty	1960				1966			
			Average Basic Salary	Salary Rank			Average Basic Salary	Salary Rank[1]
Chemistry	5,727	19.2%	$11,880	4	4,643	15.6%	$16,976	12(8)
Biological Sciences	4,743	15.9	9,468	13	4,208	14.1	15,159	17(12)
Psychology	4,072	13.7	9,936	11	3,514	11.8	16,089	14(10)
Physics	3,915	13.1	12,291	3	3,457	11.6	17,960	7(4)
Earth Sciences	1,802	6.1	10,070	10	1,638	5.5	16,089	14(10)
Mathematics	1,723	5.8	10,471	8	1,537	5.1	18,173	6(3)
Engineering	980	3.3	13,711	1	715	2.4	19,544	3(1)
Agricultural Sciences	820	2.7	9,513	12	649	2.2	14,453	18(13)
Medical Sciences	519	1.7	11,458	5	928	3.1	17,838	8(5)
Probability & Statistics	248	0.8	11,297	6	293	1.0	17,417	11(7)
Astronomy	158	0.5	10,142	9	177	0.6	17,557	10(6)
Economics	*	*	--	--	939	3.1	22,271	1
Anthropology	*	*	--	--	10	--	18,878	5
Education	*	*	--	--	227	0.8	15,589	16
Humanities	*	*	--	--	30	0.1	14,453	18
Linguistics	*	*	--	--	955	3.2	14,185	20
Political Science	*	*	--	--	205	0.7	19,880	2
Sociology	*	*	--	--	78	0.3	17,659	9
Inter-disciplinary	4,730	15.9	11,026	7	3,152	10.6	16,263	13(9)
Other	303	1.0	12,476	2	255	0.8	19,083	4(2)
Unclassifiable[2]	81	0.3	10,968		2,211	7.4	17,776	
Total	29,821	100.0%	$10,939		29,821	100.0%	$16,850	

*Not separately classified in the NSF sample data for 1960.

[1]Figures in parentheses give salary rank when the seven fields are omitted for which no data were recorded in 1960.

[2]Specialty field data blank, miscoded or otherwise not usable.

SOURCE: NSF Sample.

and fields of greatest scientific competence for 1960, as shown in Table 1. However, for 1966 the distribution of employment specialty fields is substantially different than the other two distributions. For example, 15.6% of those Ph.D.'s in the NSF sample claimed that their employment specialty field was chemistry in 1966, while 19.7% claimed they were most competent in chemistry and 22.7% had their Ph.D. in that field. In the case of economics and linguistics, each field employed over 3% of the NSF sample in 1966. Only about 1% claimed greatest competence in economics, and another 1% in linguistics; there were no Ph.D.'s in linguistics in the sample, and only 6 in economics.

There are at least two possible reasons for this change between 1960 and 1966. The first is that as demands for the various specialty fields change, and new Ph.D.'s affect manpower supply to each scientific area, it is to be expected that Ph.D.'s who got their degrees before 1960 would want to respond by moving from specialty fields with lower salaries into those areas paying more. Changes in interest could also contribute to the desire to change employment fields. The actual amount of job switching would depend then on the extent to which either their formal educational training, informal learning, or on-the-job training qualified Ph.D.'s in the NSF sample to make these switches. Actual job mobility would also depend on the similarity in skills required in the two fields between which movement was desired.

Table 3 does list some tentative evidence for such effects. For example, between 1960 and 1966 the proportion of Ph.D.'s working in chemistry dropped from 19.2% to 15.6%. At the same time the rank of the average basic salary paid to practicing chemists dropped from being fourth out of thirteen to eighth. Inasmuch as the number of Ph.D.'s

in chemistry grew relatively slowly during this period, as evidenced by the data in Table 2, the drop in number of Ph.D.'s practicing chemistry can be interpreted as a response to a fall in the demand for chemists. The decrease in relative salary caused some Ph.D.'s in the NSF sample to move out of chemistry and into better paying fields.

The effects of changing interests and of responses to continual variations in relative salaries thus could be expected to produce a distribution among employment specialties that diverged more, as time passed, from the distribution among Ph.D. fields. To the extent that the NSF sample is on average composed of Ph.D.'s who got their degree not too many years prior to 1960, the distributions would be very similar in 1960 and somewhat different by 1966.

For these same reasons, the distributions among fields of greatest competence and among Ph.D. fields could also be expected to diverge over time, as discussed above. However, there does not seem to be any reason for the distributions of employment specialties and fields of competence to become either more or less similar over time. If changes in interest do not cause too much distortion in reporting competence, then the competency distribution may simply lag behind the employment distribution until on-the-job learning in a new field enables the Ph.D. with his degree in another specialty to legitimately claim that his experience outweighs his formal training. He would then report greatest competency in the new field, instead of in his Ph.D. field. If the NSF sample is composed mainly of Ph.D.'s who received their degree shortly before 1960, then the operation of this lag between being employable in a field and being most skilled in that field could explain the increased divergence in the two distributions for 1966 as compared with 1960. For

example, Ph.D.'s in chemistry began switching to other fields such as economics and linguistics during the early sixties, but their greatest competency remained in chemistry for some years after they had stopped practicing chemistry and began practicing economics or linguistics.

Although this interpretation is plausible, there is a second possible explanation based on a change in data collection procedures used for the NSF sample, rather than on any substantive change in behavior. For 1966, the Ph.D. holders in the NSF sample were asked to list the specialty field used most often in their current employment. They were also asked to indicate what their professional identification (chemist, economist, etc.) was in 1966. On the other hand, in 1960 there was no question asked about employment specialty, so that professional identification had to be used as a surrogate for employment specialty in that year. Thus all data on employment specialty for 1960 (and 1962) are based on professional identification; while for 1966 (and 1964) they are based on actual information about the specialty field used in current employment.

Some understanding of the effect of these data categorization procedures is provided by the association among Ph.D. field, employment specialty and professional identification in the 1966 data. Table 4 lists percentage data which indicate the strength of association between various combinations of two out of the three specialty categorizations. The first column indicates the percent of the holders of a Ph.D. degree in a given field who also list their professional identification as being in that same field. The second column indicates the proportion of Ph.D. holders in some field who also work in that field. The correspondence between field of Ph.D. and professional identification

TABLE 4

Correspondence Among Field of Ph.D., Employment Specialty and Professional Identification for 1966

	Percent Ph.D.'s with Same Professional Identification	Percent Ph.D.'s with Same Employment Specialty	Percent with Same Professional Identification as Employment Specialty	Percent with Same Employment Specialty as Professional Identification
Chemistry	72%	54%	81%	62%
Biological Sciences	83	70	87	78
Psychology	92	79	94	83
Physics	91	73	85	79
Earth Sciences	87	72	79	77
Mathematics	89	71	77	73
Engineering	18	35	22	41
Agricultural Sciences	64	60	71	69
Medical Sciences	83	75	53	81
Probability & Statistics	82	54	46	56
Astronomy	90	65	63	70
Economics	100	83	21	76
Anthropology	--	--	90	75
Education	--	--	0	--
Humanities	--	--	0	--
Linguistics	--	--	1	77
Political Science	--	--	0	--
Sociology	--	--	29	68
Inter-disciplinary	76	46	79	54
Other	15	2	5	7
Unclassifiable	4	7	6	14

SOURCE: NSF Sample

is much closer than between Ph.D. field and employment specialty in all areas except engineering. In fact, the relatively high percentages indicate that Ph.D. field is a good predictor of professional identification.

The third column in Table 4 gives the proportion of those employed in a field who also have the same professional identification; the fourth column gives the opposite, the percentage of those who claim professional identification with some field who also work in that area. In the physical and biological sciences and in psychology, employment specialty is a better predictor of professional identification than the latter is of employment specialty. The converse relationship holds in the engineering and social sciences.

But the physical and biological sciences and psychology account for over 90% of the Ph.D. degrees in the NSF sample, and over 80% of the jobs. Using either Ph.D. degree or employment specialty to predict professional identification would thus usually yield a correct prediction; however, using professional identification or Ph.D. field to predict employment specialty would give somewhat poorer results. The use of professional identification in 1960 (and 1962) to indicate employment specialty is then likely to cause some inaccuracies, whose possible effects must be borne in mind when examining the interpretations given in the next chapter of the descriptive data presented in this chapter.

Looking again at the salary data in Table 3, it is apparent that average salary varies quite substantially by employment field and that relative rankings can change dramatically over time, as has been discussed above in the case of chemistry. Tables 5 and 6 give a

TABLE 5

Distribution of Employment Specialty Field by Employer Type, and Associated Average Annual Salary

Employment Specialty	Percent of Specialty Field Employed by[1]						Average Basic Salary in Academia		Average Salary as Percent of Academia			
	Academia		Government		Business				Government		Business	
	60	66	60	66	60	66	60	66	60	66	60	66
Chemistry	25.5%	21.8%	7.3%	8.6%	66.7%	69.0%	$ 8,615	$14,910	129%	106%	153%	119%
Biological Sciences	65.3	69.0	22.7	21.2	11.1	9.1	9,002	14,819	107	103	133	117
Psychology	48.3	51.1	34.1	28.3	15.8	18.4	8,855	15,166	106	95	168	144
Physics	39.1	53.3	25.8	13.3	34.6	33.3	9,371	16,567	136	109	163	122
Earth Sciences	54.3	53.2	23.3	24.7	21.3	21.8	8,848	14,984	116	108	149	127
Mathematics	74.3	69.9	8.8	10.8	16.1	18.7	9,092	16,914	141	120	169	128
Engineering	29.3	36.8	6.9	9.1	62.6	54.0	10,641	17,981	122	110	143	115
Agricultural Sciences	66.5	66.9	23.7	23.1	9.0	9.2	9,388	14,402	96	97	127	112
Medical Sciences	52.0	44.6	16.0	24.2	31.8	30.4	10,141	16,868	115	104	134	116
Probability & Stats.	61.3	64.8	18.1	17.1	19.4	17.7	9,912	16,516	124	116	150	115
Astronomy	63.3	63.3	31.6	26.0	3.8	10.7	9,591	17,078	115	106	141	113
Economics	--	24.8	--	13.1	--	61.6	--	19,349	--	102	--	124
Anthropology	--	90.0	--	10.0	--	0	--	19,077	--	90	--	--
Education	--	90.3	--	6.6	--	0.9	--	15,470	--	109	--	130
Humanities	--	76.7	--	10.0	--	10.0	--	14,740	--	89	--	107
Linguistics	--	83.4	--	8.1	--	8.0	--	13,709	--	120	--	125
Political Science	--	19.0	--	30.7	--	49.8	--	18,191	--	106	--	115
Sociology	--	60.3	--	28.2	--	6.4	--	17,116	--	100	--	127
Interdisciplinary	41.8	47.2	21.7	19.6	35.4	32.5	9,273	15,628	114	102	143	111
Other	61.4	50.2	11.6	26.7	25.1	22.4	10,960	18,437	118	106	149	107
Unclassifiable	40.7	40.4	8.6	12.4	39.5	21.9	8,400	16,322	122	108	155	128
Average	46.5%	49.5%	20.0%	17.2%	32.5%	30.7%	$ 9,128	$15,630	116%	104%	151%	123%

[1]Percents do not add across to 100% because some individuals did not indicate employer type. Government includes nonprofit institutions. Business includes self-employed persons.

SOURCE: NSF Sample

TABLE 6

Rank of Average Basic Salary Associated with Distribution of Employment Specialty by Employer Type

	1960			1966[1]		
	Academia	Government	Business	Academia	Government	Business
Chemistry	13	7	11	16(11)	16(10)	14(10)
Biological Sciences	10	11	12	17(12)	17(11)	16(12)
Psychology	11	12	5	14(9)	18(12)	2(1)
Physics	7	4	3	10(6)	8(6)	7(4)
Earth Sciences	12	10	10	15(10)	14(8)	13(9)
Mathematics	9	3	2	8(4)	1(1)	4(2)
Engineering	2	1	4	5(2)	2(2)	6(3)
Agricultural Sciences	6	13	13	19(13)	19(13)	18(13)
Medical Sciences	3	6	7	9(5)	9(7)	10(6)
Probability & Statistics	4	5	6	11(7)	6(4)	12(8)
Astronomy	5	8	8	7(3)	7(5)	11(7)
Economics	--	--	--	1	3	1
Anthropology	--	--	--	2	11	--
Education	--	--	--	13	12	8
Humanities	--	--	--	18	20	19
Linguistics	--	--	--	20	13	17
Political Science	--	--	--	4	5	5
Sociology	--	--	--	6	10	3
Interdisciplinary	8	9	9	12(8)	15(9)	15(11)
Other	1	2	1	3(1)	4(3)	9(5)

[1]Figures in parentheses give salary rank when the seven fields are omitted for which no data were recorded in 1960.

SOURCE: NSF Sample

breakdown on salary averages and ranks by employer type, where employers are classified as being either an academic institution, a government (including nonprofit institutions), or a business (including self-employed persons). Table 5 also indicates the distribution of those in each employment specialty across employer types.

Academic institutions were the largest employer of personnel in the NSF sample; their relative importance increased after 1960, a reflection of the boom in academic jobs that lasted to the end of the decade. By 1966 academia accounted for one out of every two jobs in the NSF sample. Businesses were the second most important employer, providing about 31% of jobs in 1966; while government accounted for about 17%.

There was substantial variation among employment specialty fields in relative importance of the employer types. For example, 70% of those working in mathematics in 1966 were employed in academia, while only 22% of those in chemistry were. Businesses provided almost 70% of the jobs for practicing chemists. Relatively more practicing psychologists were employed by government in 1966 than were reported working for government in most other fields.

Although they were the largest employer of Ph.D.'s in the NSF sample, academic institutions paid the lowest basic salaries. On a twelve month basis, businesses paid 20 percent more than academia in 1966; governments also paid slightly more. This ranking of average salary by employer type held true across all employment specialties in 1966, except that government employers paid less than academic employers in psychology, the agricultural sciences, anthropology and the humanities. The differentials among salaries paid by the three types of

employers varied quite substantially among fields. For example, business psychologists in 1966 were on average paid forty percent more than academic psychologists, or in absolute amounts over $6,700 more; while in the agricultural sciences, businesses paid only ten percent more than academic institutions, or about $1,750 more.

The rankings of average salaries within each employer-type category given in Table 6 reflect such variations in relative salary differentials, because the ranking of any particular employment specialty is not constant across employers. Thus, Ph.D.'s working in mathematics for government institutions in 1966 were paid on average more than the average Ph.D. working for government in any other specialty area; while in academia mathematicians' average salary ranked eighth. Such variations in the rankings of average salary in an employment specialty imply that relative demand and supply conditions for Ph.D.'s are not constant across employer types within any particular specialty area.

Job Mobility

As mentioned in the introduction to this chapter, the NSF sample contains information on the Standard Industrial Classification (SIC) and geographical location of each Ph.D.'s employer, as well as data on employer type. The previous section outlined the kind of information the sample also provides on the specialized skill actually being used in each Ph.D.'s occupation.

To relate job mobility to educational background, it was first necessary to construct some index of actual job mobility from the above data. Counting the number of times a Ph.D. holder reported a change in employer over the 1960-66 period would have given one

such index of actual mobility among jobs, if such detailed information had been available. This type of index would be natural to use for studying attempts by workers to improve their wages or working conditions by changing employers. As just indicated, surrogates for employer name, such as SIC or geographical location of the Ph.D.'s employer, are included in the NSF data; these could have been used to approximate this kind of index, or to calculate indices of industrial and geographical mobility.

However, it is occupational mobility that is of most interest here, because the NSF sample was acquired to help find the effects of educational background on a Ph.D.'s ability to move among occupations (employment specialty fields). Thus job changes that require the Ph.D. to use different kinds of knowledge are what should be measured by the mobility index; changing employers without changing the skill content of the occupation performed for each should not be counted. At the same time, changes in the main employment specialty field used while the Ph.D. remained with the same employer should be counted.

For these reasons, actual job mobility was calculated for each Ph.D. by comparing his Ph.D. specialty, and his job specialties for 1960, 1962, 1964 and 1966.[4] Taking them in chronological pairs, an occupation change was said to have occurred whenever the specialty fields for any pair were different. Each Ph.D.'s mobility index is thus an integer between zero and four. His index would equal zero if his Ph.D. and four successive employment specialties were all in the same area; it would equal four if his 1960 job used a specialty

[4] The reader should recall that, as explained above, employment specialty in 1960 and 1962 was taken to be the same as the Ph.D.'s professional identification in those years.

different than his Ph.D. field, and each succeeding employment specialty was different than the one which the Ph.D. used in his occupation two years prior.

Table 7 lists the average value of the mobility index for holders of Ph.D.'s in the various specialty fields represented in the NSF sample. There is a good deal of variation in average occupational mobility among Ph.D.'s in the different disciplines, ranging from an average of 0.16 occupational changes for those who got their Ph.D. in economics to 1.97 for holders of a Ph.D. in one of the interdisciplinary fields. The average for the whole sample was 0.86 occupation switches out of a possible four.

The table also indicates the average increase in basic salary between 1960 and 1966 for holders of Ph.D.'s in the various disciplines. As with the average index of occupational mobility, average salary increases varied quite widely across the Ph.D. fields. Ph.D.'s in the agricultural sciences received the lowest average increase, slightly over $5,000; while the six Ph.D.'s in economics had an average salary increase of $9,600. The average increase for the whole NSF sample was about $6,000.

The salary increases associated with occupational mobility were included in Table 7 to give an initial test of the hypothesis that observed occupational switching and relative salary increases ought somehow to be related. For example, Ph.D.'s in chemistry were in relatively low demand during the sixties, as discussed above and as indicated by the fact that Ph.D.'s in chemistry obtained an average salary increase between 1960 and 1966 that ranked thirteenth out of fourteen. Other factors being constant, low demand in chemistry should be expected to cause Ph.D.'s in chemistry to look to other fields for better job opportunities, so that the amount of occupational switching by chemists would be rather high. And in fact, the average Ph.D. in

TABLE 7

Average Occupational Mobility by Field of Ph.D., with Associated Basic Salary Differentials

Ph.D. Field	Mobility Index			1966 versus 1960 Average Basic Salary	
	Mean	Standard Deviation	Rank of Mean	Absolute Increase	Rank of Increase
Chemistry	1.01	1.27	6	$5,409	13
Biological Sciences	0.60	1.04	8	5,839	9
Psychology	0.32	0.78	13	6,266	8
Physics	0.43	0.81	11	6,672	6
Earth Sciences	0.51	0.94	9	5,743	11
Mathematics	0.43	0.78	11	7,320	2
Engineering	1.15	1.03	5	6,548	7
Agricultural Sciences	1.89	0.76	2	5,039	14
Medical Sciences	1.84	0.81	3	6,759	5
Probability & Statistics	0.86	0.94	7	7,209	3
Astronomy	0.49	0.78	10	6,929	4
Economics	0.16	0.41	14	9,600	1
Interdisciplinary	1.97	0.70	1	5,748	10
Other	1.62	0.92	4	5,662	12
Unclassifiable	1.34	0.96		6,397	
Average	0.86	1.11		$6,019	

SOURCE: NSF Sample

chemistry switched occupations once, as compared with an average of 0.86 switches for the whole sample.

The chemistry example suggests that one should expect actual mobility to be inversely correlated with observed salary increases. If demand was high in the field in which the Ph.D. degree was earned, then salary increases in that field should be relatively high; while at the same time the temptation to move into other fields should be correspondingly low, and average observed mobility below that in fields for which demand was not so high.

One way to obtain a nonparametric test of this hypothesis is to compute the rank correlation coefficient for the rankings of average mobility and average salary increase given in Table 7. If the calculated coefficient is significantly different from zero, then the hypothesis that mobility and salary change are independent can be rejected. If the coefficient is significantly negative, then the hypothesis of independence can be rejected in favor of the alternative hypothesis of inverse correlation just outlined.

However, while the estimated rank correlation coefficient for job mobility and salary increase is -0.50, this value is not negative enough to allow rejection at a 5% confidence level of the hypothesis that mobility and salary increase are independent. Whether this result is caused by the influence of other factors not being held constant, so that occupational mobility and salary change are in truth inversely correlated, will be discussed in the next chapter where analyses of the relationship between educational background, occupational mobility, and salary are reported in some detail.

To determine whether calculating average mobility by employment field, rather than Ph.D. field, would give a different relative distribution of

observed occupational switching, the data on mobility were rearranged to give the results reported in Table 8. It is apparent that there are some differences in actual job mobility when the data are reclassified according to employment specialties. For example, practicing chemists in 1960 averaged 0.53 job changes and those in chemistry in 1966 averaged 0.62; the corresponding average for those who obtained their Ph.D. in chemistry was 1.01.

However, the variations are not large enough to conclude that the classifications are very different in terms of the relative rankings by field. The three rankings of average mobility do not differ significantly; the rank correlation coefficients for Ph.D. field versus 1960 employment specialty and Ph.D. field versus 1966 employment specialty are both estimated to be about 0.9. This indicates that the three classifications are strongly interdependent in terms of the way each measures relative mobility.

It might have been expected that in low demand fields such as chemistry, the Ph.D. holders (of degrees in all fields) who were still practicing chemistry in 1966 would be those who were relatively immobile. Based on the decline from 6,768 Ph.D. degrees in chemistry to 5,727 practicing chemists in 1960 to 4,643 practicing in 1966, such a hypothesis is reasonable. Moreover, the average mobility for Ph.D.'s in chemistry was 1.01 as compared with 0.62 for those employed in chemistry in 1966. This difference in means is significant; Chapter III will explore this problem somewhat further.

In conclusion, Table 8 gives average mobility in each field by employer type. The data suggest that academics were somewhat less mobile than Ph.D.'s who were employed by government or business in either 1960 or 1966. With certain exceptions, such as psychology, the relationship tended to hold within most specialty areas, in addition to being true for the NSF sample as a whole.

TABLE 8

Average Occupational Mobility, By Field of Employment Specialty and Employer Type for 1960 and 1966

Employment Specialty	1960				1966			
	Academia	Government	Business	All[1]	Academia	Government	Business	All[1]
Chemistry	0.62	0.70	0.47	0.53(9)	0.70	0.87	0.56	0.62(8)
Biological Sciences	0.30	0.42	0.67	0.37(12)	0.41	0.61	0.91	0.50(12)
Psychology	0.24	0.18	0.18	0.21(13)	0.22	0.16	0.16	0.19(13)
Physics	0.33	0.44	0.62	0.46(11)	0.41	0.57	0.72	0.54(10)
Earth Sciences	0.52	0.48	0.36	0.47(10)	0.54	0.64	0.57	0.58(9)
Mathematics	0.46	0.77	0.84	0.54(8)	0.29	1.04	1.00	0.51(11)
Engineering	0.94	1.48	1.24	1.17(5)	0.96	1.06	1.20	1.10(6)
Agricultural Sciences	2.09	2.24	2.18	2.13(3)	1.96	2.02	1.76	1.95(2)
Medical Sciences	2.17	2.08	2.21	2.17(2)	1.99	1.84	1.76	1.88(3)
Probability & Stats.	1.00	1.02	1.22	1.04(6)	1.10	1.12	1.25	1.12(5)
Astronomy	0.45	0.64	1.66	0.55(7)	0.64	0.54	1.15	0.67(7)
Economics	*	*	*	*	1.31	1.62	1.64	1.55
Anthropology	*	*	*	*	1.33	1.00	--	1.30
Education	*	*	*	*	1.60	1.46	2.50	1.60
Humanities	*	*	*	*	1.69	1.00	1.33	1.56
Linguistics	*	*	*	*	1.58	1.61	1.67	1.58
Political Science	*	*	*	*	1.43	1.84	1.50	1.59
Sociology	*	*	*	*	1.78	1.72	1.60	1.74
Interdisciplinary	2.44	2.43	2.38	2.41(1)	2.10	2.11	1.94	2.05(1)
Other	1.41	1.82	2.17	1.66(4)	1.48	1.48	2.10	1.62(4)
Unclassifiable	0.54	0.42	0.71	0.62	0.62	0.63	0.67	0.62
Average	0.81	0.85	0.93	0.86	0.81	0.92	0.92	0.86

[1]Figures in parentheses give rank of mobility index average for those fields on which data was available for both 1960 and 1966.

*Not separately classified in the NSF data for 1960.

SOURCE: NSF Sample

Educational Background

The last type of data which is important in characterizing the NSF sample is information on educational background of Ph.D. degree holders. Table 9 summarizes some of this data; it indicates the percentage of those with a Ph.D. in each field who got their undergraduate degree with a major in the same specialty. The table also shows the type of undergraduate school attended by Ph.D. holders in each field.

The school classification used in Table 9, and in analyzing the effects of educational background on career mobility and salary patterns, is based on grouping the educational institutions into three categories: one containing 106 schools that were rated in a survey of graduate education; one containing 31 liberal arts schools; and the third containing all other educational institutions. The 106 schools were used by Cartter [4] in his 1964 study of American graduate departments in twenty-nine specialty disciplines. His criterion for selection was that the institution had to grant at least ten Ph.D. degrees a year; in the 1930's only forty-five universities satisfied this criterion, but by the 1960's there were 106 that did. This grouping thus contains all the well-known universities and technical schools that grant Ph.D.'s, as well as some that are not so well-known.

Table 10 lists the thirty-one undergraduate liberal arts schools that comprise the second grouping. An institution was selected for this category if it was an undergraduate school offering a liberal arts type of training; <u>and</u> if the school was given a prestige rating of A or B on a scale of A through F by Brown [2] in his study of the labor market for academic personnel, <u>or</u> the school was rated as being highly productive of scientists in studies by Knapp and Goodrich [6] and Knapp and Greenbaum [7]

TABLE 9

Undergraduate Major and School for Ph.D. Fields

Ph.D. Field	Percent with Undergraduate Major Same as Ph.D.	Percentage of Ph.D.'s Attending Indicated Category of Undergraduate Schools		
		106 Graduate Schools	31 Liberal Arts Schools	Other Schools
Chemistry	80.5%	49.5%	5.1%	45.4%
Biological Sciences	62.8	53.8	4.1	42.1
Psychology	54.8	54.6	5.7	39.7
Physics	67.5	56.0	6.9	37.1
Earth Sciences	64.2	61.5	5.2	33.3
Mathematics	67.9	52.3	5.2	42.5
Engineering	80.0	77.0	0.5	22.5
Agricultural Sciences	73.4	66.7	0.9	32.4
Medical Sciences	32.3	48.4	3.0	48.6
Probability & Stats.	3.8	55.8	2.6	41.6
Astronomy	30.3	61.3	12.3	26.4
Economics	66.7	82.4	0	16.6
Interdisciplinary	4.1	55.0	5.3	39.7
Other	33.8	46.0	5.2	48.8
Unclassifiable	12.3	54.0	4.8	41.2
Average	58.4%	54.6%	5.0%	40.4%

SOURCE: NSF Sample.

TABLE 10

31 Liberal Arts Schools

1. Amherst College (A)
2. Antioch College (C)
3. Bowdoin College (B)
4. Carleton College (C)
5. Claremont Men's College (B)
6. Dartmouth College (A)
7. Earlham College (C)
8. Hamilton College (B)
9. Harvey Mudd College (B)
10. Haverford College (A)
11. Kalamazoo College (C)
12. Kenyon College (B)
13. MacMurray College (D)
14. Mt. Holyoke (C)
15. Oberlin College (B)
16. Pomona College (B)
17. The Principia College (B)
18. Queens College (Not Rated)
19. Reed College (B)
20. St. John's College, Maryland (B)
21. Scripps College (B)
22. Smith College (B)
23. Swarthmore College (A)
24. Trinity College (B)
25. Union College (A)
26. University of the South (B)
27. Vassar College (B)
28. Wellesley College (B)
29. Wesleyan University (A)
30. Williams College (A)
31. Woodstock College (B)

of the social and collegiate origins of American scientists. The letters in parentheses after each college's name in Table 10 give Brown's prestige rating; twenty-four of these schools were rated highly by Brown. In contrast only thirty-seven out of the 106 graduate schools in the first category were given a prestige rating of A or B.

The reason for dividing educational institutions into these three categories was to obtain some other measure of the influence of undergraduate education besides the undergraduate major. It is believed that regardless of his undergraduate major, a Ph.D. holder who attended one of the thirty-one liberal arts schools received an undergraduate education that was considerably less specialized than the Ph.D. who got his undergraduate degree from one of the 106 schools that Brown found to be most productive of Ph.D. degrees. Although such a hypothesis was probably not true for the average undergraduate who did not go on to earn a Ph.D., for the student who eventually did obtain the advanced degree, the emphasis on a broad liberal arts education at the thirty-one schools probably had the effect of reducing his opportunities to become as specialized in some discipline, as he would have been if he attended one of the 106 graduate schools. For example, even the number of undergraduate course offerings in any particular discipline is likely to be far less at a small liberal arts school than at a large undergraduate-graduate school offering the Ph.D. degree in that field; this would restrict the student's opportunity for specialization. In addition, the decision to attend a liberal arts college may be indicative of a preference on the part of the student for a more general course of instruction. Whether the two school categories are associated with different career patterns, as a result of different opportunities and preferences, will be examined in the next chapter.

Table 9 does indicate some sizeable variations in the percentage of Ph.D.'s in the various specialty fields who attended one of the three categories of undergraduate schools.[5] For example, in economics, engineering and the agricultural sciences less than one percent of the holders of Ph.D.'s received their bachelor's degree from one of the thirty-one liberal arts schools, as compared with the five percent in the whole sample who went to those schools for their undergraduate degree. In contrast, over twelve percent of Ph.D.'s in astronomy got an undergraduate degree at one of the liberal arts schools.

Table 9 also shows that in some Ph.D. fields it was rather rare to obtain the undergraduate degree in the same specialty; but in most fields well over half the Ph.D. holders had their undergraduate major in the same discipline. Three exceptions--the medical sciences, probability and statistics, and astronomy--are explained by noting that the undergraduate major tended to be in some closely associated field, such as mathematics in the case of probability and statistics, and physics in the case of astronomy. However, as expected, Ph.D.'s in the interdisciplinary fields--biochemistry, biophysics, geochemistry, physical chemistry and social psychology--tended to have more diverse undergraduate majors.

Finally, Table 11 shows the absolute and relative distribution of undergraduate majors in the NSF sample, and the percentage of undergraduate majors that were obtained at schools in each of the three categories for undergraduate institutions. As expected from the close association between

[5] Since over 95% of the Ph.D.'s in the NSF sample were obtained at one of the 106 graduate schools, as opposed to being earned at one of the graduate schools in the "other" category, variation by field in percentage attending the 106 for the Ph.D. degree was not believed to be of significant importance in analyzing the effects of educational background on career patterns.

TABLE 11

School and Field of Undergraduate Major

Ph.D. Field	Undergraduate Major		Undergraduate Major Percentage Attending Indicated Category of Undergraduate Schools		
			106 Graduate Schools	31 Liberal Arts Schools	Other Schools
Chemistry	8,806	29.5%	52.8%	6.2%	41.0%
Biological Sciences	3,730	12.5	56.8	5.0	38.2
Psychology	2,356	7.9	62.2	7.0	30.8
Physics	2,928	9.8	62.0	8.4	29.6
Earth Sciences	1,247	4.2	69.4	5.5	25.1
Mathematics	1,876	6.3	50.1	6.3	43.6
Engineering	1,962	6.6	78.8	0.4	20.8
Agricultural Sciences	1,292	4.3	70.4	0	29.6
Medical Sciences	379	1.3	64.6	2.4	33.0
Probability & Stats.	15	0.1	100.0	0	0
Astronomy	58	0.2	72.4	13.8	13.8
Economics	337	1.1	66.8	5.9	27.3
Anthropology	0	0	--	--	--
Education	0	0	--	--	--
Humanities	0	0	--	--	--
Linguistics	279	1.0	48.4	7.2	44.4
Political Science	0	0	--	--	--
Sociology	134	0.4	58.2	9.0	32.8
Interdisciplinary	241	0.8	80.9	0.9	18.2
Other	1,587	5.3	50.3	4.8	44.9
Unclassifiable	2,594	8.7	9.8	0.7	89.5
Total Sample	29,821	100.0%	54.6%	5.0%	40.4%

SOURCE: NSF Sample

Ph.D. field and undergraduate major shown in Table 9, the concentration of Ph.D.'s in the biological sciences, chemistry, physics and psychology in the NSF sample is reflected by a concentration in those same fields at the undergraduate level. Almost 60% of undergraduate degrees were obtained in one of those four fields. There were very few majors in the social sciences and none in the humanities; also less than 1% of the undergraduates majored in one of the interdisciplinary fields--biochemistry, biophysics, geochemistry, physical chemistry and social psychology. Apparently these interdisciplinary fields are more specialized than the typical undergraduate major, although they are probably less specialized than the typical Ph.D. field.

The distribution among the three categories of undergraduate schools attended, classified according to undergraduate major, shows variation similar to that exhibited when the distribution is classified by Ph.D. field, as is done in Table 9.

II. INTERPRETATIONS OF THE DESCRIPTIVE DATA AND TESTS OF SOME HYPOTHESES

Having described the NSF sample in some detail in the previous chapter, this chapter then applies that data to an analysis of the relationships between educational background, occupational mobility, and salary. After data on, and tests of, the relationship between educational training and mobility are presented, a general theory of Ph.D. occupational mobility that is applicable to the data available in the NSF sample is developed. Tests of that theory as well as data on the relationship between educational training and salary for Ph.D. holders are then presented.

The main analytical technique used in this chapter is to cross-tabulate the data on occupational mobility and salary according to such variables as field of Ph.D. and employment specialty in some year. These cross-tabulations correspond exactly to calculating the regression of salary or mobility data on a series of dummy variables which allow for all interaction effects. As such, the cross-tabulations can be biased by left-out variables, just as estimated regression coefficients may be, if those variables are correlated with any of the factors being controlled in the cross-tabulation. In a cross-section sample this sort of problem is especially critical because personal preferences are one of those left-out variables which are likely to be correlated with such control variables as the Ph.D.'s current occupational specialty. Whenever appropriate, the inability to control for varying preferences will be mentioned below.

The Relationship Between Occupational Mobility and Educational Background

In the past five years there have been at least three major studies of the occupational mobility of Ph.D. degree holders. In the study done

by Brown [3] for the American Council of Education, it was found that the degree of mobility among college professors depended to some extent on the definition of subject matter specialty field. For 13 broadly defined subject matter areas, Brown determined that about 5% of the professors surveyed were teaching in at least two areas, and that about 4% were mainly teaching in a field that was not the same as that in which they obtained their most advanced degree (usually the Ph.D.). But for 73 narrowly defined subject areas, the corresponding figures were both about 21%.[1] The teachers surveyed thus evidenced some mobility among occupations, but the observed movement depended on how finely the subject areas in which they taught were categorized.

A study by the National Research Council of the National Academy of Sciences [10] of a sample of doctorate degree recipients who had their Ph.D. by 1955 provided additional evidence that there is a substantial amount of occupational switching even among such highly trained personnel. In this study a measure of mobility was obtained by comparing the field of Ph.D. with the field in which each Ph.D. holder worked in 1962, based on a categorization of degrees and jobs into 24 specialty areas. This mobility measure indicated that field retention rates (the percentage of Ph.D. holders in some given field working in that field in 1962) were higher in the agricultural, medical, physical and social sciences, ranging from 70% to 90%, than they were in the biological sciences, where retention rates were as low as 41% and only exceeded 56% in one of the eight biological specialties. On the average, by 1962 about 25% of the Ph.D.'s surveyed had switched into a job that made use of a specialty field that was not

[1] Brown [3], p. 64.

the same as their Ph.D. field.[2]

In contrast, the same study found that for the 5 five-year periods between 1935 and 1960, the fields that were high in job changing--where movement among employers instead of among specialty fields is the type of mobility being measured now--across all five periods were psychology, sociology, economics and political science. Physics and mathematics showed moderate job mobility; while the agricultural, biological and medical sciences were low. Chemistry was stable in the physical science group. Apparently for the Ph.D.'s surveyed, job changing was more common among social scientists without a concurrent change in occupation; while in the biological sciences it was more often true that the Ph.D. changed fields (occupations) without changing employers.

The third recent study of Ph.D.'s occupational mobility is part of an unpublished Ph.D. dissertation by Freeman [5]. Using the survey data gathered by the National Research Council for the study just discussed, and beginning with the calculations for retention rates reported in that study, Freeman attempted to determine the importance of economic incentives in explaining observed field switching. He concluded that such incentives were significant. "Post-degree mobility patterns ... can be explained in terms of economic motivation. The average income in fields feeding workers to a specialty is below the income of fields receiving workers from the specialty. The level of mobility appears to be influenced by the relative income among fields and by the 'technological' similarity among fields."[3]

The extent to which Freeman's conclusions on the import of economic

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[2] See National Research Council [10], Appendix 15 for detailed tables of retention rates.

[3] Freeman [5], pp. 4-77.

incentives are borne out by the NSF sample data will be discussed later. However, the lack of a significant negative correlation between mobility and salary increases by Ph.D. field that was discussed in the previous chapter does cause some hesitation in accepting Freeman's analysis.

This section is concerned with the effects of educational background on occupational mobility. For this purpose it is important to note that, as was true of Brown's study, observed occupational mobility reported in the National Research Council study and used by Freeman depends on the classification system used for specialty fields. Lower retention rates in the biological sciences than in physics may be the result of such biological specialties as microbiology and genetics having been classified as separate fields, while all the physics specialties were classified into one field. It would then seem to be somewhat difficult, as Freeman himself indicated, to distinguish the effects of economic incentives from the effects of technological similarities, when the basic data on mobility are so crucially affected by the classification system; because that classification schema can determine the technological similarity of the resulting fields, and thus influence the extent to which economic incentives are free to operate.[4]

The NSF sample data were classified into nineteen main fields in a way that hopefully minimized these problems that could be caused by having some subject matter areas more narrowly defined than others. For example, biological specialties were not separated out as was done in the National Research Council study but were grouped together into one field, the

[4]"Technological similarity" between fields is being used here in the same sense that Freeman used it, that is, to indicate that the amount of knowledge common to two fields will influence actual mobility between those two fields.

biological sciences. The field classifications correspond quite closely to those used by the National Science Foundation in gathering data for the National Register.[5]

Table 12 lists the distribution of holders of Ph.D.'s in the thirteen fields for which data were gathered in the NSF sample among nineteen employment specialties in 1966. Retention rates in the various fields are indicated in parentheses. These retention rates are quite different from those obtained by the National Research Council (NRC). In the first place, the average retention rate is about 61% for the NSF sample as compared with about 75% for the NRC sample.

More importantly, the retention rates for some specialty fields are very different. For example, the biological sciences have a higher than average retention rate (70%) in the NSF sample as compared with the lower than average rates for the biological specialties in the NRC sample. This, of course, is a direct result of having only one biological field here as compared with eight in the NRC study. Engineering had a retention rate of only 35%, while in the NRC sample its retention rate was 87%. In chemistry, only 54% of those with a Ph.D. in that field were employed there in 1966 for the NSF sample, as compared with 76% in the NRC sample.

The fact that the NSF sample retention rates are calculated through 1966 and the NRC rates only through 1962 means that lower average retention in the NSF sample is reasonable. As more time passed, there would probably be more reasons and opportunities for any given Ph.D. to change fields. However, the variations between the two samples in retention rates in the

[5] In my unpublished thesis (Morris [8]) the results are reported of using finer classifications for a subsample of the NSF sample, which is composed only of those who received their Ph.D. in some area of chemistry.

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TABLE 12

Distribution of Ph.D. Fields in 1966 Jobs

1966 Employment Specialty	Number Receiving Ph.D. in Indicated Field															
	1	2	3	4	5	6	7	8	9	10	11	12	19	20	21	Total
1)Chemistry	3,655 (54)	88	0	21	20	2	185	16	11	0	1	0	471	2	171	4,643
2)Biological Sciences	69	3,529 (70)	24	17	19	1	0	144	35	0	0	0	252	6	112	4,208
3)Psychology	18	15	3,264 (79)	3	0	4	2	0	1	2	0	0	25	99	81	3,514
4)Physics	217	7	2	2,751 (73)	19	45	112	0	0	0	22	0	171	21	90	3,457
5)Earth Sciences	33	63	1	133	1,303 (72)	6	14	28	0	0	6	0	17	4	30	1,638
6)Mathematics	25	8	34	121	6	1,133 (71)	64	4	0	48	4	1	10	35	44	1,537
7)Engineering	88	8	6	163	26	31	319 (35)	1	1	1	0	0	46	0	25	715
8)Agricultural Sciences	6	190	0	0	25	0	0	396 (60)	0	0	0	0	2	0	30	649
9)Medical Sciences	61	323	51	8	2	0	2	6	276 (75)	0	0	0	151	3	45	928
10)Probability & Stats.	9	8	47	9	3	99	2	4	0	85 (55)	0	0	2	7	18	293
11)Astronomy	0	0	0	60	2	8	1	0	0	0	100 (64)	0	1	1	4	177
12)Economics	394	15	49	35	20	34	79	4	3	9	1	5 (83)	96	5	190	939
13)Anthropology	1	1	1	0	0	0	0	0	0	0	0	0	0	6	1	10
14)Education	71	18	34	19	10	14	6	0	1	1	5	0	25	13	10	227
15)Humanities	13	1	1	2	1	3	0	0	0	0	0	0	1	6	2	30
16)Linguistics	347	130	95	20	66	115	13	0	5	4	0	0	75	29	56	955
17)Political Science	71	11	53	14	3	8	6	4	1	1	0	0	16	7	10	205
18)Sociology	0	2	31	4	3	1	0	0	0	0	0	0	10	2	25	78
19)Interdisciplinary	1,064	212	120	56	41	0	46	1	13	0	0	0	1,361 (46)	3	234	3,152
20)Other	50	62	9	29	19	21	8	23	0	1	23	0	15	7	10	255
21)Unclassifiable	576	335	297	291	213	74	57	30	21	4	15	0	183	31	84	2,211
TOTAL	6,768	5,026	4,119	3,756	1,801	1,600	916	661	368	156	155	6	2,930	287	1,272	29,821

SOURCE: NSF Sample

various fields cannot be explained satisfactorily by only this difference in the time periods covered. Part of the variation is due to the differing classification schemes, as indicated above.

It seems likely that any measure of mobility would be sensitive to changes in the way specialty fields are categorized. The one to be used here, which was described in the previous chapter, is certainly dependent on the classification schema. However, even if some relative measure based on retention rates, such as the rank of a field according to the size of its retention rate, was independent of the classification system, and rank clearly is not, retention rates would not provide a satisfactory measure of relative occupational mobility for the purposes of this study.

For one thing, retention rates do not measure the amount of switching out and then back into a field that has occurred. Table 13 gives average observed mobility, based on the index defined in the previous chapter, for individuals in the cells of the cross-classification used in Table 12. Fields such as the agricultural and medical sciences with high retention rates according to Table 12, and thus showing, relatively, low mobility according to the retention rate index, have very high average amounts of observed occupational mobility according to Table 13. In fact the Ph.D.'s in those two fields who are employed in their Ph.D. field in 1966 have on average moved out and then back in by 1966 to the occupational field corresponding to their Ph.D. field. Such mobility is nowhere reflected by retention rates.

Also retention rates do not satisfactorily measure mobility for Ph.D.'s no longer employed in the specialty field in which they obtained their Ph.D. Table 13 again indicates that there are substantial variations by Ph.D.

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TABLE 13

Average Occupational Mobility, By Ph.D. Field and 1966 Employment Specialty

1966 Employment Specialty	Ph.D. Field															
	1	2	3	4	5	6	7	8	9	10	11	12	19	20	21	Average
1)Chemistry	0.4	1.6	--	1.5	1.5	1.0	1.2	2.1	2.0	--	1.0	--	1.7	1.5	1.0	0.6
2)Biological Sciences	2.7	0.2	1.2	2.2	1.4	2.0	--	1.8	2.1	--	--	--	2.1	1.0	1.0	0.5
3)Psychology	1.4	1.7	0.1	1.3	--	1.8	3.0	--	3.0	2.0	--	--	1.5	1.4	0.5	0.2
4)Physics	2.5	2.4	2.5	0.2	1.5	1.4	1.7	--	--	--	1.1	--	1.9	1.8	1.4	0.5
5)Earth Sciences	2.3	1.8	1.0	1.3	0.3	2.0	1.4	2.4	--	--	1.5	--	2.4	1.5	1.0	0.6
6)Mathematics	2.2	2.4	1.5	1.3	1.3	0.1	1.8	2.8	--	1.3	1.3	1.0	2.4	1.4	1.4	0.5
7)Engineering	1.9	1.5	1.5	1.3	1.3	1.5	0.6	3.0	3.0	1.0	--	--	2.0	--	1.2	1.1
8)Agricultural Sciences	1.2	2.2	--	--	2.6	--	--	1.9	--	--	--	--	2.5	--	1.7	2.0
9)Medical Sciences	2.3	1.7	1.5	2.5	2.0	--	2.5	2.7	1.8	--	--	--	2.4	2.0	1.7	1.9
0)Probability & Stats.	1.1	1.4	1.5	2.0	2.7	1.3	2.0	1.0	--	0.5	--	--	2.5	2.0	0.6	1.1
1)Astronomy	--	--	--	1.3	0.5	1.0	1.0	--	--	--	0.2	--	3.0	2.0	2.0	0.7
2)Economics	1.5	2.3	1.2	1.4	1.5	1.1	1.5	2.0	2.7	1.1	1.0	0.0	2.4	1.6	1.3	1.6
3)Anthropology	1.0	2.0	2.0	--	--	--	--	--	--	--	--	--	--	1.2	1.0	1.3
4)Education	1.5	1.3	1.2	1.3	1.2	1.0	2.3	--	3.0	1.0	1.4	--	2.6	2.5	1.8	1.6
5)Humanities	1.1	2.0	3.0	1.5	1.0	1.0	--	--	--	--	--	--	2.0	2.8	1.0	1.6
6)Linguistics	1.6	1.2	1.3	1.6	1.4	1.3	1.8	--	3.4	1.5	--	--	2.5	2.2	1.9	1.6
7)Political Science	1.6	1.6	1.2	1.1	1.3	1.3	1.5	2.8	2.0	2.0	--	--	2.3	2.4	2.0	1.6
8)Sociology	--	1.5	1.5	1.5	1.0	1.0	--	--	--	--	--	--	2.4	2.5	2.0	1.7
9)Interdisciplinary	2.2	2.0	2.2	1.7	2.2	--	1.9	3.0	2.4	--	--	--	2.0	2.7	1.9	2.1
0)Other	1.7	1.3	1.6	1.4	1.6	1.2	1.8	2.4	--	2.0	2.4	--	2.2	2.0	2.0	1.6
1)Unclassifiable	0.7	0.5	0.3	0.4	0.2	0.2	0.7	1.4	1.3	1.0	0.4	--	1.6	1.2	0.9	0.6
Average	1.0	0.6	0.3	0.4	0.5	0.4	1.2	1.9	1.8	0.9	0.5	0.2	2.0	1.6	1.3	0.9

Note: A dash (--) indicates there were no persons in this category.

SOURCE: NSF Sample

field and occupational specialty in average amounts of field switching.[6] Retention rates only indicate that a Ph.D. has switched from his Ph.D. field, and give no information on the number of other fields in which he had been employed before he switched into that field of his employment at the point in time used to calculate retention.

It is for these reasons, as well as those discussed in the previous chapter, that the index of mobility used here to measure the effects of educational background is based on the number of switches between Ph.D. field and 1960 employment specialty, 1960 and 1962, 1962 and 1964, and 1964 and 1966 employment specialties for each Ph.D. holder in the NSF sample. Table 14 provides a first indication of the relationship between educational training and actual occupational mobility. It lists average observed mobility for those individuals with a Ph.D. in the same field, for those with undergraduate majors in the same area, for those whose undergraduate major was the same as their Ph.D. field, and for those whose undergraduate major was not the same as their Ph.D. field (classified by field of Ph.D.).

If specialists and non-specialists, or the more narrowly trained and the more broadly trained, can be distinguished solely on the basis of whether their undergraduate and graduate majors were identical or different, then the data in Table 14 can be used to test the hypothesis that specialists are less mobile (inflexible). Alternatively, as is discussed below, these data can be used to estimate what characteristics in a Ph.D. educational background are associated with his being relatively mobile or not.

[6] It should be mentioned that although all off-diagonal entries in Table 13 ought to be greater than or equal to 1.0, the entries in row 21, for occupations that were unclassifiable because of missing or bad data, are sometimes less than one. This is because switches into or out of the unclassifiable field were not counted, in order to avoid counting a switch when, for example, the Ph.D. failed to report employment specialty in some year when he was still employed in the same field as in previous years.

TABLE 14

Average Occupational Mobility,
By Four Educational Background Groupings

	Ph.D. Field		Undergraduate Field		Ph.D. Field and Undergraduate Field Identical		Ph.D. Field and Undergraduate Field Different[1]	
		Rank		Rank		Rank		Rank
Chemistry	1.01	6	1.24	4	0.98	6	1.12	6
Biological Sciences	0.60	8	0.60	8	0.47	7	0.82	8
Psychology	0.32	13	0.36	14	0.32	13	0.32	13
Physics	0.43	11	0.46	12	0.39	9	0.51	11
Earth Sciences	0.51	9	0.42	13	0.36	11	0.80	9
Mathematics	0.43	11	0.57	9	0.40	8	0.49	12
Engineering	1.15	5	1.06	5	1.12	5	1.27	5
Agricultural Sciences	1.89	2	1.41	2	1.87	3	1.95	2
Medical Sciences	1.84	3	1.27	3	1.90	2	1.81	3
Probability & Stats.	0.86	7	0.53	10	0.33	12	0.88	7
Astronomy	0.49	10	0.48	11	0.38	10	0.54	10
Economics	0.16	14	0.76	6	0.25	14	0	14
Anthropology	--	--	--	--	--	--	--	--
Education	--	--	--	--	--	--	--	--
Humanities	--	--	--	--	--	--	--	--
Linguistics	--	--	0.41	--	--	--	--	--
Political Science	--	--	--	--	--	--	--	--
Sociology	--	--	0.58	--	--	--	--	--
Interdisciplinary	1.97	1	1.49	1	1.96	1	1.97	1
Other	1.62	4	0.64	7	1.58	4	1.64	4
Unclassifiable	1.34		0.90		1.23		1.35	
Average	0.86		0.86		0.69		1.12	

[1]Classified according to Ph.D. field.

SOURCE: NSF Sample

Table 14 indicates that on the average, individuals who specialized by taking the same major during both undergraduate and graduate training moved among occupations somewhat less frequently than did those who took different majors for their undergraduate degree and their Ph.D. Also, for ten out of the thirteen specialty areas in which Ph.D. degrees were obtained, observed mobility for those with different undergraduate and graduate majors was greater than it was for those who specialized. Only in economics and the medical sciences was it true that greater specialization was associated with higher occupational mobility.

Assuming that the distributions of mobility indices for these two groups have the same variances by Ph.D. field (but not assuming that the variances are the same for different fields), the average mobility estimates given in the last two columns of Table 14 provide 14 separate tests of the hypothesis that educational specialization has no effect on occupational mobility. Except for Ph.D.'s in psychology, economics and the interdisciplinary specialties, that hypothesis can be rejected at the 0.05 confidence level in all 13 specialty fields in which Ph.D.'s were awarded. It can also be rejected for the average Ph.D. recipient in each of the two groups.[7] Alternatively, the hypothesis that educational specialization is associated with lower occupational mobility could not be rejected for the two groups as a whole or for any of the 13 separate fields, except for the medical sciences where it would be rejected at the 0.025 confidence level.

Table 14 also lists the rankings of specialty fields according to the average mobility indices computed for the four groupings. The six estimated

[7]This test is based on the usual t-test for the difference between sample means. Since the sample size is very large in all fields except economics, the fact that mobility indices only range between 0 and 4 does not invalidate the assumption of normality for the sample means. The t-statistics range from 2.7 to 65.9, except for psychology (0), medical services (-2.1), economics (-0.5), and interdisciplinary (0.8).

rank correlation coefficients are all approximately equal to or greater than 0.8, so that the rankings are highly interdependent. This suggests that the relative effects of specialization are similar for all thirteen Ph.D. specialties; even though the absolute effects, as measured by the usually significant differences in the average mobilities given in the last two columns of the table, differ quite a bit.

Table 15 provides further data on the relationship between educational training and observed mobility. This table exhibits average occupational mobility cross-classified by Ph.D. field and undergraduate major. The row and column averages and the diagonal entries provide the same information as the first three columns of Table 14. The off-diagonal mobility averages represent a disaggregation of the data contained in column 4 of Table 14.

These off-diagonal averages indicate that *educational specialization tends to be associated with lower mobility no matter what other undergraduate major is combined with a Ph.D. in some given field.* Reading across the rows in Table 15 one readily sees that the diagonal entry is usually less than or equal to the off-diagonal entries in each row. In the biological sciences, Ph.D.'s who also got their undergraduate degree in biology had an average mobility that was never greater than the average mobility in any of the other 13 undergraduate fields which were combined with a Ph.D. in the biological sciences. Only in psychology, earth sciences and the interdisciplinary fields did the specialized Ph.D.'s have an average mobility index that was greater than more than 4 out of the possible 14 other average mobility indices for Ph.D.'s with undergraduate majors that differed from their Ph.D. field. Psychology was the extreme with specialized psychologists moving more frequently on average than did psychologists in 6 out of the 13 other undergraduate major-psychology Ph.D. combinations

TABLE 15

Average Occupational Mobility, By Fields of Study

Ph.D. Field	Undergraduate Field 1	2	3	4	5	6	7	8	9	10	11	12	16[1]	18[2]	19	20	21	Average
1) Chemistry	1.0	1.5	--	1.9	0.7	1.4	1.2	1.0	0.9	--	--	1.8	1.7	3.0	1.0	1.0	1.1	1.0
2) Biological Sciences	0.9	0.5	0.5	1.1	1.3	0.6	1.1	0.9	0.7	--	1.0	0.5	0.6	1.5	0.8	0.6	0.7	0.6
3) Psychology	0.6	0.4	0.3	0.2	0	0.5	0.6	0	0.5	0.2	--	0.3	0.2	0.3	0.1	0.2	0.4	0.3
4) Physics	0.7	0.7	0	0.4	0.6	0.4	0.6	0	1.3	--	1.7	0	0.3	--	1.0	0.5	0.5	0.4
5) Earth Sciences	1.2	0.7	0.5	0.6	0.4	0.2	0.7	1.8	--	0	0	0.2	0.4	0.3	1.0	0.2	0.4	0.5
6) Mathematics	0.6	0.3	0	0.5	0	0.4	0.7	1.0	--	1.5	0	0.7	0.4	--	--	0.5	0.3	0.4
7) Engineering	1.1	0	1.0	1.6	2.0	1.7	1.1	0.5	--	--	2.0	0.3	--	--	--	1.9	1.3	1.2
8) Agricultural Sciences	2.3	1.9	1.0	3.0	2.1	1.4	--	1.9	--	--	--	3.0	0	--	2.0	1.9	2.0	1.9
9) Medical Sciences	1.9	1.9	2.0	--	2.0	2.0	1.5	3.0	1.9	--	--	2.0	--	2.0	1.9	1.9	1.6	1.8
10) Probability and Stats.	1.0	3.0	0.5	0	0	1.0	0.6	0.8	--	0.3	--	0.5	--	2.0	--	1.0	0.4	0.9
11) Astronomy	--	--	2.0	0.4	--	0.6	0.8	0	--	--	0.4	--	1.5	--	--	0.3	0.6	0.5
12) Economics	--	--	--	--	--	--	--	--	--	--	--	0.3	--	--	--	--	0	0.2
19) Interdisciplinary	2.0	1.9	2.0	1.8	1.5	2.0	2.0	1.8	2.0	--	--	1.8	2.3	2.0	2.0	1.8	2.0	2.0
20) Other	2.0	1.3	1.2	2.0	1.0	1.8	2.0	3.0	1.5	--	1.0	1.2	1.2	0.5	1.0	1.6	1.4	1.6
21) Unclassifiable	1.6	1.4	1.0	1.2	0.9	1.2	1.4	1.4	1.0	2.0	--	1.2	1.3	1.3	1.9	1.1	1.2	1.3
Average	1.2	0.6	0.4	0.5	0.4	0.6	1.0	1.4	1.3	0.5	0.5	0.8	0.4	0.6	1.5	0.6	0.9	0.9

Note: A dash (--) indicates there were no persons in this category.

[1]Linguistics

[2]Sociology

SOURCE: NSF Sample

which were observed in the NSF sample. The data of Table 15 thus lend additional support to the hypothesis that specialized educational training is associated with, and indeed may cause, lower occupational mobility.

What about the effects of the school at which the undergraduate degree was obtained? As explained in the previous chapter, there is some basis for believing that undergraduate training at a liberal arts college is considerably less specialized for those students who go on to obtain a Ph.D. than it is at one of the private or public universities that provide graduate education in addition to their undergraduate curricula. Table 16 summarizes some data that can be used to test this hypothesis.

But first it is important to note that subdividing the specialist and non-specialist groups according to undergraduate school categories does not affect the conclusion reached above, that in the NSF sample specialization is associated with less observed switching among occupations. At the 0.025 confidence level, the hypothesis that educational specialization is associated with lower occupational mobility could only be rejected in three out of the thirty-six significance tests (three on group averages and thirty-three on the thirteen Ph.D. fields; six Ph.D. fields had at most one observation) given by the data in Table 16. In chemistry and mathematics for undergraduates at the 31 liberal arts schools, and in the medical sciences for undergraduates at schools in the "other" category, specialization was associated with higher mobility.

In terms of the hypothesis that liberal arts training is associated with greater occupational mobility, the NSF sample provides some seemingly surprising results. For the sample as a whole, observed occupational mobility averaged 0.86 for both those who went to undergraduate school at one of the institutions in the "106 graduate schools" category and those

TABLE 16

Average Occupational Mobility, By Undergraduate School Categories

	Ph.D. Field and Undergraduate Field Identical			Ph.D. Field and Undergraduate Field Different		
Ph.D. Field	106 Graduate Schools	31 Liberal Arts Schools	Other Schools	106 Graduate Schools	31 Liberal Arts Schools	Other Schools
Chemistry	0.99	1.11	0.94	1.18	0.82	1.13
Biological Sciences	0.50	0.28	0.45	0.88	0.97	0.77
Psychology	0.32	0.42	0.30	0.35	0.42	0.30
Physics	0.38	0.36	0.42	0.57	0.42	0.44
Earth Sciences	0.39	0.24	0.33	0.82	0.44	0.70
Mathematics	0.39	0.29	0.43	0.53	0.13	0.46
Engineering	1.09	3.00	1.26	1.36	1.50	1.12
Agricultural Sciences	1.87	--	1.85	2.07	1.33	1.88
Medical Sciences	1.90	1.33	1.95	1.80	1.87	1.80
Probability and Stats.	0.33	--	--	0.91	1.25	0.83
Astronomy	0.37	0.50	0.33	0.43	0.29	0.80
Economics	0.25	--	--	0	--	--
Interdisciplinary	1.96	1.00	2.05	1.97	1.99	1.98
Other	1.51	1.85	1.62	1.66	1.76	1.60
Unclassifiable	1.16	1.33	1.23	1.30	1.40	1.44
Average	0.69	0.61	0.69	1.14	1.16	1.04

SOURCE: NSF Sample

who went to a school in the "other" category. For those attending one of the 31 liberal arts schools, actual mobility averaged only 0.78. Thus, a liberal arts school training was associated with significantly less occupational mobility, contrary to the predicted direction of this association.[8]

The data in Table 16 allows some further analysis of this result. These data show that the association between undergraduate school and mobility depends on whether the Ph.D. was a specialist. If he took an undergraduate major in his Ph.D. field, then attending one of the 31 liberal arts schools meant that his observed mobility was on average significantly less than if he had gone to a school in either one of the other categories. On the other hand, if he was not a specialist, then attending a liberal arts undergraduate school did result in his switching fields more often than if he had gotten his undergraduate degree elsewhere. However, compared with the 106 graduate schools group, the additional occupational changing averaged just 0.02 moves out of a possible 4; this difference only becomes significant at about a 7% confidence level.

It appears from the results just given that specialization and undergraduate school attended interacted with each other in relation to observed mobility. So rather than trying to examine the data of Table 16 by Ph.D. field, these interaction effects were calculated and listed in Table 17. For the average Ph.D. in the sample, his choice of school did not interact with his choice to specialize; but, as expected, it did if the Ph.D. took an undergraduate major different than his Ph.D. field. This interaction effect on occupational mobility was largest for those who attended one of the liberal arts schools.

One might conclude that those Ph.D.'s who attended a liberal arts

[8] Unless otherwise noted, significance is being measured at the .01 confidence level for a one-tail t-test.

school and took an undergraduate major in their Ph.D. field ended up being the most narrowly trained, perhaps because the typical liberal arts school allowed and encouraged more independent study courses in the major field than did the typical public or private university, partly because of the increased student-faculty contact at the smaller liberal arts colleges. But this also meant that those Ph.D.'s who were not committed to their Ph.D. specialty during their undergraduate days at a liberal arts school ended up being the most broadly trained, because lack of commitment to the field in which he would later obtain a Ph.D. would most often be manifested by the Ph.D.'s taking an undergraduate major outside his Ph.D. speciality. Thus *those Ph.D.'s who were not specialized and went to a liberal arts college were most mobile in the NSF sample, as a result of their being rather intensively trained in some field in addition to their Ph.D. major.*

It would have been interesting to check whether this hypothesis held true in each Ph.D. field also. However, like the data of Table 16, the data in Table 17 for the separate fields do not lend themselves to such a test. This was to be expected, because there are many other factors, such as employment demand in the various occupations, which affect occupational mobility that are not being held constant so as to isolate the separate influence of educational background. The extent to which these other variables could be confounding the association between educational training and mobility is considered in the next section.

A Theory of Ph.D. Occupational Mobility

Ideally, the NSF sample was to have been used to determine the effects of the amount of specialization during undergraduate and graduate training on a Ph.D. holder's potential mobility among occupations. It was believed

TABLE 17

Effect of Educational Training on Occupational Mobility

	UG-GT		UGS			Interaction Effects					
	S	NS	106	31	Oth	S,106	S,31	S,oth	NS,106	NS,31	NS,oth
Chemistry	-.03	.11	.01	.09	-.02	0	.04	-.02	.05	-.39	.03
Biological Sciences	-.13	.22	.03	-.20	-.01	0	.01	-.01	.03	.35	-.04
Psychology	0	0	.01	.10	-.02	-.01	0	0	.02	0	0
Physics	-.04	.08	0	-.06	0	-.01	.03	.03	.06	-.03	-.07
Earth Sciences	-.15	.29	0	-.21	.01	.03	.09	-.04	.02	-.15	-.11
Mathematics	-.03	.06	0	-.17	.01	-.01	.06	.02	.04	-.19	-.04
Engineering	-.03	.12	-.02	.65	.06	-.01	1.23	.08	.11	-.42	-.21
Agricultural Sciences	-.02	.06	.02	-.56	-.03	-.02	--	--	.10	-.06	-.04
Medical Sciences	.06	-.03	0	-.12	0	0	-.45	.05	-.01	.18	-.01
Probability & Stats.	-.53	.02	.01	.39	-.03	-.01	--	--	.02	-.02	-.02
Astronomy	-.11	.05	-.08	-.13	.24	.07	.25	-.29	-.03	-.12	.02
Economics	.09	-.16	.04	--	-.16	-.04	--	--	-.04	--	--
Interdisciplinary	-.01	0	0	.01	.01	0	-.97	.08	0	.01	0
Average	-.17	.26	0	-.08	0	0	0	0	.02	.12	-.08

Key to Abbreviations:

UG-GT = Undergraduate-graduate training.
S = Specialized (undergraduate, graduate majors identical).
NS = Not specialized (undergraduate, graduate majors different).
UGS = Undergraduate school category.
106 = 106 graduate schools.
31 = 31 liberal arts schools.
oth = Other schools.

SOURCE: NSF Sample

a priori that greater specialization would reduce the Ph.D.'s potential mobility. However, actually testing this hypothesis on the NSF sample is difficult because of the many variables in addition to educational background which can be expected to affect mobility, and because the sample only contains data on actual, as opposed to potential, mobility.

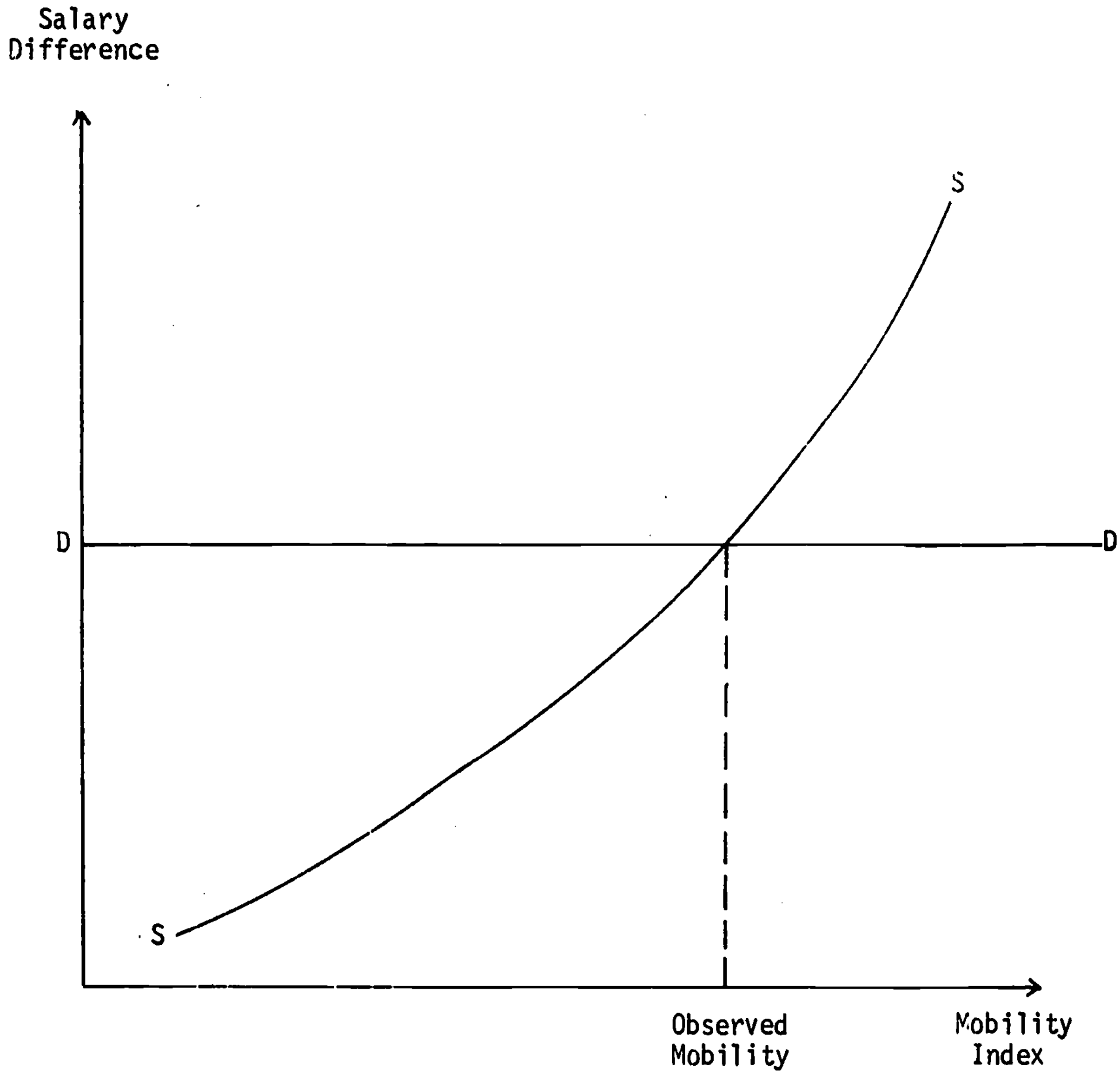
Now it may be that having data only on actual mobility is not a major problem, if the difference between actual and potential mobility can be said to be reasonably analogous to the difference between the actual quantity of some good purchased on a market, and potential sales and purchases which are represented by supply and demand schedules.

In Figure 1 the curve labeled SS represents the propensity for a given Ph.D. holder to change occupations, as a function of the difference between the average salary he could get in other fields and the salary he is being paid in his current occupation. The SS curve slopes upward because it is reasonable to expect the Ph.D.'s desire to change occupations to increase as the opportunity cost of remaining in his present job rises.

Given the Ph.D.'s abilities, experience and educational training, the salary increase that employers would be willing to pay is fixed at the level given in Figure 1 by the intersection of the perfectly elastic demand curve DD with the vertical axis. If propensity to change occupations can be measured by an index of occupational mobility like that used in this study, then actual or observed mobility for each Ph.D. would be given by the intersection of the supply and demand schedules for mobility.

Using this analysis, it is possible to re-interpret the hypothesis that greater specialization reduces potential mobility. In fact, that hypotheses should be restated because potential mobility depends on the Ph.D.'s preference for his current occupation as opposed to other potential

FIGURE 1



occupations; these preferences are summarized by his supply schedule, his potential mobility schedule. If it can be assumed that this supply schedule is independent of the degree of specialization in educational training, the hypothesis should then be that specialization reduces actual mobility because it shifts the demand for mobility down. Specialization reduces the desire of employers in other occupations to hire the Ph.D. away from his "home" occupation, the employment specialty that corresponds to his Ph.D. field.

Notice that this hypothesis really depends on the truth of two assertions. The first is that the relationship between salary differences and potential or desired mobility is positive. The second is that employers as a rule are willing to pay less of a salary differential to induce the specialist to leave his specialty than they would pay to a less narrowly trained Ph.D. who is also working in the specialty in which both got their Ph.D. Testing the hypothesis that specialization reduces mobility thus provides an indirect test of both of these assertions.

However, testing the hypothesis on the NSF sample then requires that the characteristics of a specialized educational program be known in advance; for example, it might be assumed that having the same undergraduate and graduate major is a characteristic of a narrower educational background. Rather than assuming that such characteristics are known *a priori*, one could alternatively take the two assertions about supply and demand schedules, assume them to be true, and then use the NSF sample to determine what those characteristics are by regressing observed mobility on various measures of the properties of educational programs, while holding constant all other factors that might shift the supply and demand curves in Figure 1. Those properties with negative estimated coefficients would then be the ones that made the Ph.D. specialized; those with positive coefficients

would define a more general educational program.

Therefore, for whatever use the NSF data is put, some strong assumptions are necessary, and these results may be interpreted as having tested the hypothesis that specialization reduced mobility, or as having provided an estimate of the effects of the two characteristics on observed mobility.[9] Either way, what must be noted now is that no obvious attempt was made to hold other variables constant. If these other variables are independent of the two characteristics of the Ph.D.'s educational background, then leaving them out does not change the results. However, it is not likely that they are independent.

For one thing, each Ph.D.'s preferences determined his supply schedule; his preferences were also important in his deciding what school to attend and which major to take. If those Ph.D.'s who chose to major in the same specialty at both the undergraduate and graduate level are the same in the NSF sample as the ones who had lower desired mobility at any given salary differential, then the strong association in the sample between choosing the same major (specializing) and lower mobility could be mainly a manifestation of different preferences, rather than of degree of specialization. The association between specialization and actual mobility still holds true, but the implication of that correlation is no longer that specializing causes lower mobility. Since the problem of having people with different preference structures always exists in cross-section analysis, an attempt was made to describe relationships in the text above by saying that specialization was associated with less mobility, rather than stating that the former causes the latter.

[9]The reader should recall that the cross-tabulations which were summarized in the tables of the last section correspond exactly to regressions using a series of dummy variables on the right-hand side.

What about factors that affect demand? First, there are the varying abilities of the Ph.D.'s in the NSF sample. If ability was correlated with choice of school or with the choice to take the same major, then the effects of educational background on mobility would be estimated incorrectly. However, any very strong correlation would probably be reflected in the relationship of undergraduate school category to mobility. This would follow because it is reasonable to assume that the most able Ph.D.'s--where ability was defined by the labor market for Ph.D.'s--probably attended undergraduate school at one of the 106 graduate institutions, or one of the 31 liberal arts schools. Because of the upward shift in mobility demand that would then be correlated with these two school categories, one would expect to see them associated with greater mobility relative to the other school category. As Table 17 indicated, this association did not materialize. Also, in their study, Ashenfelter and Mooney [1] found that in a sample of highly educated people, the inclusion of an ability variable only marginally affected estimates of the effects of other education-related variables. For these reasons, not controlling for ability in the results reported above probably did not seriously bias estimates of the effects of educational background on career mobility.

Second, the experience of Ph.D.'s in the NSF sample probably varied widely. There are data in the sample that could have been used to measure experience, such as the number of years since obtaining the Ph.D., and this could be included in further research. The NRC study mentioned above does show that relative field retention rates do not differ substantially for the different Ph.D.-degree-year cohorts contained in their sample. Leaving out controls for experience thus is probably not a serious problem.

Finally, the general level of employment demand in each employment specialty can be expected to affect the level of the demand for a given

Ph.D. to switch fields. For Ph.D.'s working in occupations that are in relatively low demand, and have correspondingly low salaries, the salary difference that employers would be willing to pay to induce them to change occupations should tend to be higher than the differential they would pay someone in a high demand occupation. This is just another way of saying that the inducements to actually move out of low paying occupations are greater because the gain in salary from such a move is likely to be higher than if the Ph.D. is in a high demand, high paying occupation.

Based on the ranking of demand in 1964 for the various academic specialties reported in Brown [2] and reproduced as Table 18, and on the analysis by Freeman [5] of demand in the early sixties, engineering, mathematics (including statistics), physics, economics and the medical sciences were high demand specialties during the 1960-66 period covered by the NSF sample. The agricultural, earth sciences and biological sciences were relatively low demand fields. Psychology, chemistry and astronomy were fields in which employment demand was moderate.

Using this description of demand in the various fields, Table 19 gives some data on the relationship between employment demand and observed mobility for Ph.D.'s classified three different ways--according to their Ph.D. field, their 1960 employment specialty (occupation) and their 1966 employment specialty. For the high demand fields one would expect that, other things being constant, the inducement for Ph.D.'s in those fields to switch out would be lower than the inducement for those with Ph.D.'s in other areas to switch in. This would imply lower observed mobility for those with Ph.D.'s in a high demand field than the average Ph.D. employed in that field as of 1966, some of whom were induced to switch into the high demand field. For five out of the six high demand fields, this relationship held.

TABLE 18

Brown's Ranking of 23 Disciplines by Excess Demand,[1] 1964

Discipline	Rank
Electrical Engineering	1
Educational Services and Administration	2
Mechanical Engineering	3
Mathematics	4
Physics	5
Economics	6
Civil Engineering	7
Chemistry	8
Counseling and Guidance	9
Clinical Psychology	10
Sociology	11
Art	12
Secondary Education	13
Political Science	14
Earth Sciences and Geology	15
General Biology	16
Biochemistry	17
Physical Education and Health	18
Music	19
General Zoology	20
English and Literature	21
History	22
French	23

[1]Rank of 1 means excess demand greatest in that discipline.

SOURCE: David Brown, Academic Labor Markets [2].

TABLE 19

Average Occupational Mobility, by Ph.D. Field,
1960 Employment Field and 1966 Employment Field

	Average Mobility Classified By		
High Demand Fields	Ph.D.	1960 Job	1966 Job
Physics	0.43	0.46	0.54
Mathematics	0.43	0.54	0.51
Engineering	1.15	1.17	1.10
Medical Sciences	1.84	2.17	1.88
Probability & Statistics	0.86	1.04	1.12
Economics	0.16	--	1.55
Moderate Demand Fields			
Chemistry	1.01	0.53	0.62
Psychology	0.32	0.21	0.19
Astronomy	0.49	0.55	0.67
Low Demand Fields			
Biological Sciences	0.60	0.37	0.50
Earth Sciences	0.51	0.47	0.58
Agricultural Sciences	1.89	2.13	1.95

SOURCE: NSF Sample

Similarly, the opposite relationship should hold in low demand fields. It does for the biological sciences, but not for the agricultural and earth sciences. Including chemistry and psychology, which Freeman would characterize as having weaker demand than Brown did, makes the result true in three out of five relatively low demand fields.

To the extent that the classification of fields by employment demand for the early sixties held true in the late fifties, or if demand changes were anticipated by job changing up to 1960, the same relationships should be true between Ph.D. field mobility and 1960 employment specialty mobility. In this case it turns out that all but one of the differences in average mobility have the expected sign. The data of Table 19 thus imply that the effects of employment demand on job mobility are important in the NSF sample, although as noted in Tables 7 and 8, the demand effects were not strong enough to change the rankings of the specialty fields in terms of average mobility, when the fields were changed from being classified by Ph.D. to employment specialty. All three classification methods exhibited in Table 19 yield virtually identical rankings. This is partly due to the fact that in 1960 about 80% and by 1966 about 60% of the Ph.D.'s in the NSF sample were still employed in the field in which they got their degree.

Then does the lack of controls for demand suggest that the estimates of the effects of educational background on occupational mobility are biased? And if so, in which direction? If the specialists tended to work in high demand fields, then part of the association between specialized training and lower observed mobility for the sample as a whole would be caused by this correlation between employment demand and educational background.

However, the percentage of Ph.D.'s in each field who specialized by getting their undergraduate degree in the same field is not correlated to

any extent with the strength of employment demand, as comparison of the data in Table 9 and Table 19 above makes clear. The specialists would then have had to switch into the high demand fields without this change being measured by the mobility index, in order to bias the association between observed mobility and specialization. But the mobility index counts any change that persists until 1960, by comparing Ph.D. field and 1960 employment specialty. Correlation between employment demand and educational specialization for this reason is not a problem in the mobility results for the NSF sample as a whole.

Furthermore, calculating the effects of educational training on mobility by field of Ph.D., as was done in the previous section, does provide some adjustment for employment demand's varying among fields. In fact the data given in Table 17 can be interpreted as showing the interaction of demand and specialization (taking the same major at undergraduate and graduate school) on actual mobility. The association between specialization (or non-specialization) and mobility was much stronger in two of the low demand fields--the biological and earth sciences--than it was in the average high demand specialty. Apparently low employment demand interacts with educational background to make the specialization decision more important. This may be the result of desired mobility's being more sensitive to shifts in mobility demand about high salary differential levels than it is to shifts in demand when the salary differential being offered to induce mobility is low.

The conclusion from this analysis would be that the measured associations between specialization and occupational mobility that were reported in the previous section probably are relatively unbiased. They can be said to have behavioral or causal implications if it is assumed that preferences for different jobs are approximately constant among the Ph.D.'s

in the NSF sample.

The effects of the left-out demand variable on the association between undergraduate school and mobility are also not likely to be very great, as the distribution of Ph.D.'s among the three school categories is fairly random (see Table 9). The results reported on the association between undergraduate school and occupational mobility are thus relatively unbiased; but those data are difficult to interpret. Perhaps a liberal arts college offers both the possibility of becoming very specialized, and the very flexible alternative of being well-trained in two fields instead of just one.

The Relationship Between Salary and Educational Background

The theory outlined in the previous section justified the procedure used to estimate the association between occupational mobility and educational training. That theory contained two important assertions:

a. There is a positive relationship between salary differentials and potential mobility. (The mobility supply curve slopes upward.)

b. Employers offer lower salary differentials to induce the specialist to change occupations than they do to the Ph.D. who is more broadly trained. (The perfectly elastic demand curve for mobility shifts downward if the Ph.D. has specialized in his undergraduate and graduate training.)

Suppose it can be assumed that for each Ph.D. holder in the NSF sample, the difference between his basic annual salaries for 1966 and 1960 gives an adequate relative measure of the average salary differential he was offered by employers who wanted him to change occupations. This

method of measuring salary differentials is justifiable on the basis that the Ph.D. holder accepts an offer and changes occupations if the salary increase obtained is large enough; otherwise he remains in the same occupation and gets the usual life cycle salary increase. In either case, the 1966-60 differential should be related to average mobility in the same way that the annual increments are to occupational switching on a year-to-year basis.

Then both of these assertions can be tested on the sample salary data, the first by looking at the relationship between observed mobility and salary changes, the second by examining the association between educational training and salary changes, where that association is to be calculated in the same way as the relationship between education and mobility was determined.

Table 20 provides data that can be used to test the first assertion. It shows the average increase in basic salary between 1960 and 1966, cross-classified by field of Ph.D. degree and number of changes in occupation. For the total sample, the number of changes in occupation is an increasing function of the average salary change. The same is true for seven out of the thirteen Ph.D. fields. Only in three of the fields--mathematics, astronomy and economics--is the relationship decreasing.

Formally these data allowed 27 tests of the hypothesis that salary changes and actual mobility are positively associated. That hypothesis could be rejected in only 5 of the 27 cases. Alternatively, the hypothesis that salary increase is inversely related to occupational mobility, could be rejected for 12 of the 27 relations.

These data in Table 20 also support the contention by Freeman [5] that economic motivations are important in explaining post-degree mobility.

TABLE 20

Average Salary Differentials, by Ph.D. Field
and Amount of Occupational Mobility

Ph.D. Field	Salary Differential for Indicated Number of Occupational Changes 0 (000)	1 or 2 (000)	3 or 4 (000)	Average (000)	Rank
Chemistry	$5.2	$5.5*	$5.9*	$5.4	13
Biological Sciences	5.8	6.0*	6.0	5.8	9
Psychology	6.2	6.5*	7.2*	6.3	8
Physics	6.6	6.8*	7.0	6.7	6
Earth Sciences	5.8	5.5*	6.2*	5.7	11
Mathematics	7.4	7.1*	6.4*	7.3	2
Engineering	6.3	6.5	7.2*	6.5	7
Agricultural Sciences	4.5	5.0*	5.6*	5.0	14
Medical Sciences	6.6	6.8	6.8	6.8	5
Probability & Stats.	6.8	7.5*	8.0	7.2	3
Astronomy	7.0	6.9	4.4*	6.9	4
Economics	10.2	6.8	--	9.6	1
Interdisciplinary	6.3	5.7*	5.8	5.7	10
Other	6.7	5.5	6.2	5.7	12
Unclassifiable	6.2	6.6	5.7	6.4	
Sample Average	$6.0	$6.0	$6.1*	$6.0	

*Difference between this average increase and average increase in the column to the left is significant at 0.01 confidence level.

SOURCE: NSF Sample

It was stated above that the data in Table 7 suggested some doubt about Freeman's hypothesis, because the expected negative relationship between average salary increase and average mobility for Ph.D.'s in each field was not particularly evident in the data of Table 7. Based on the theoretical analysis of the previous section and the data in Table 20, it is now rather easy to see why it was incorrect to expect negative correlation. For while it still might be true that fields in which demand was low had more occupational mobility than did those in which it was high (the previous theoretical analysis would imply such a relationship), the average salary increase for Ph.D.'s in each field is not a particularly good measure of relative demand, precisely because that average depends on what proportion of Ph.D.'s have changed occupations to gain higher salary increases. If all the Ph.D.'s in a low demand field switched occupations, then their average mobility and average salary change would both tend to be high relative to those averages for Ph.D.'s in other fields.

Cross-classifying by undergraduate school category and whether the undergraduate major was the same as the Ph.D. field, so as to hold some characteristics of the Ph.D.'s educational background constant, does not change the general conclusion that salary increases over the 1960-66 period were positively correlated with occupational mobility. For example, Table 21 gives the relationship when specialists are separated from non-specialists in terms of the undergraduate-graduate major combination. For the specialists, occupational changes were an increasing function of salary increases in 9 out of 13 fields, and for all specialists combined. The result is somewhat weaker for non-specialists, inasmuch as the relationship was increasing in only 5 out of the 12 fields for which data were available. However, it was decreasing only for non-specialists with Ph.D.'s in engineering. In the other six Ph.D. fields and for all non-specialists

TABLE 21

Average Salary Differentials for Specialists and Nonspecialists, By Ph.D. Field and Amount of Occupational Mobility

Ph.D. Field	Salary Differential for Indicated Number of Occupational Changes									
	Ph.D. - Undergraduate Majors Same					Ph.D. - Undergraduate Majors Different				
	0 (000)	1 to 2 (000)	3 to 4 (000)	Average (000)	Rank	0 (000)	1 to 2 (000)	3 to 4 (000)	Average (000)	Rank
Chemistry	$5.2	$5.5	$6.0	$5.4	11	$5.1	$5.4	$5.8	$5.4	12
Biological Sciences	5.8	6.1	6.3	5.9	8	5.6	5.9	5.8	5.7	9
Psychology	6.4	6.5	7.3	6.4	7	6.0	6.4	7.0	6.1	7
Physics	6.7	6.8	6.9	6.8	3	6.4	6.8	7.0	6.5	6
Earth Sciences	5.8	6.0	6.3	5.9	8	5.6	5.1	6.1	5.5	11
Mathematics	7.4	7.2	5.8	7.3	2	7.6	6.7	7.1	7.3	2
Engineering	6.3	6.7	7.7	6.7	4	6.3	5.8	5.6	5.9	8
Agricultural Sciences	4.5	4.9	5.6	5.0	13	4.7	5.1	5.3	5.1	13
Medical Sciences	6.2	6.4	7.5	6.6	6	6.8	6.9	6.4	6.9	5
Probability & Stats.	6.1	3.6	--	5.1	12	6.8	7.6	8.0	7.3	2
Astronomy	7.0	6.2	1.4	6.7	4	7.0	7.2	5.4	7.0	4
Economics	8.5	6.8	--	8.1	1	12.6	--	--	12.6	1
Interdisciplinary	4.8	5.7	6.4	5.8	10	6.3	5.7	5.8	5.7	9
Other	6.9	5.4	6.3	5.6		6.6	5.6	6.2	5.7	
Unclassifiable	6.0	7.3	6.8	6.9		6.2	6.5	5.6	6.3	
Sample Average	$6.0	$6.0	$6.3	$6.1		$6.0	$6.0	$5.9	$6.0	

SOURCE: NSF Sample

combined, the association was mixed.

Table 21 also provides some initial information on the empirical validity of the second assertion of the theory--the assertion that lower salary differentials are offered to specialists as opposed to non-specialists in trying to induce the former to change occupations. For the average specialized Ph.D., the salary increase he obtained over the six years from 1960 to 1966 was greater than the average increase for non-specialists in six out of the thirteen Ph.D. fields, and for the average across all fields. His increase was the same in two, and less than the average non-specialist's increase in five of the Ph.D. majors. Only in economics and statistics did the differential between the increases that specialists and non-specialists received exceed $1,000; and the results for economics are not reliable as there are only 6 Ph.D.'s in economics in the NSF sample. At any rate, the data of Table 21 do not provide much support for the assertion that salary increases are inversely related to the degree of educational specialization. Nor do they suggest very strongly that it is false.

But this should not be surprising, for in order to test the second assertion it is necessary to compare salary increases for two groups whose mobility demand curves differ only because one group contains specialists and the other non-specialists. Other demand side factors such as ability, experience and employment demand must be constant on average for the two.

For the comparisons between Ph.D.'s in the same field, employment demand was held approximately constant, because in 1960 from 76 to 94 percent of the Ph.D.'s in each field were still working in their "home" field. For the NSF sample as a whole 81% were working in the field of their Ph.D. as of 1960; by 1966 that figure had dropped to 61%. This

meant that it was unlikely that in some field, say chemistry, most of the non-specialists had switched to higher demand fields by 1960, while most specialists had not. In that situation the non-specialists would be in relatively high employment demand jobs, so that the salary increase they could get after 1960 by moving would be lower on average than that which specialists could get. This would, of course, obscure the relative demand effect of being specialized, in comparisons between the two groups.

Another piece of evidence that suggests employment demand was constant in each Ph.D. field for the two groups, is that the ranks given in Table 21 for salary increases by field do not differ significantly. Only in statistics are the two rankings very different; inasmuch as just 6 out of the 156 Ph.D.'s in statistics also had their undergraduate degree in statistics, the low average salary increase estimated to be representative of specialized statisticians is not very reliable. The ranks given in Tables 22 through 24 are also reasonably stable across the specialist versus non-specialist groupings.

This is consistent with employment demand being constant. Because if all non-specialized chemists, for example, were in high demand jobs by 1960, their 1960-66 salary increase could be expected to rank much lower than would the increase for specialists--assuming that the specialization effect on salaries is small compared to the occupational demand effect, so that the specialized chemists could capture both the usual life cycle increment and the relatively large employment demand differential by changing occupations, while the non-specialists could only obtain the life cycle increment during the 1960-66 time span. It is also being assumed that such a movement by non-specialists out of one field, say chemistry, could not be duplicated simultaneously in all the moderate or low demand

fields. Otherwise similar rankings provide no indication of the constancy of employment demand.

Although employment demand then was probably constant for the two groups, it is clear from the data of Table 21 that other demand side factors were not constant within the two groups, and thus were probably not constant on average between the two. If mobility demand had been constant within each group, then the salary increases associated with each classification for number of occupation changes in any given Ph.D. field would have been constant and equal to the group average. For both specialists and non-specialists, salary increases were not constant in any of the thirteen Ph.D. fields listed in Table 21.

The same is true for the average salary increase data when it is subclassified by undergraduate school category, as in Tables 22 through 24, except for non-specialists in the biological sciences who get their undergraduate degrees at one of the institutions in the 106 graduate schools category. For that group with Ph.D.'s in biological sciences, an average salary increase of $5,600 was received regardless of the number of occupational changes. In this case it is only the fact that preferences were not constant in the group that explains why different people chose to move different numbers of times.

But for the specialists in the biological sciences who went to one of the 106 graduate schools, such mobility demand variables as ability and experience did vary, and it would only be fortuitous if for the average specialist they were equal to their constant level for non-specialists. This provides a rather clear indication of the difficulty involved in testing the specialization effect on salary increases by looking at group averages, as was done with the data in Table 21.

TABLE 22

Average Salary Differentials for Specialists and Nonspecialists in the 106 Graduate Schools Category, by Ph.D. Field and Amount of Occupational Mobility

Ph.D. Field	Salary Differential for Indicated Number of Occupational Changes									
	Specialists					Nonspecialists				
	0 (000)	1 to 2 (000)	3 to 4 (000)	Average (000)	Rank	0 (000)	1 to 2 (000)	3 to 4 (000)	Average (000)	Rank
Chemistry	$5.2	$5.5	$6.1	$5.5	11	$5.4	$5.3	$6.1	$5.5	12
Biological Sciences	5.8	6.1	6.3	5.9	8	5.6	5.6	5.6	5.6	10
Psychology	6.6	6.3	6.9	6.6	6	6.2	6.8	6.0	6.3	7
Physics	6.9	7.0	6.7	6.9	4	6.5	7.0	6.7	6.7	5
Earth Sciences	5.8	6.1	6.5	5.9	8	5.6	5.2	6.2	5.6	10
Mathematics	7.7	7.9	6.9	7.8	2	8.1	7.5	7.0	7.9	1
Engineering	6.2	6.7	7.9	6.7	5	6.7	5.7	5.7	6.0	8
Agricultural Sciences	4.4	4.9	5.7	5.0	13	5.3	5.0	5.1	5.1	13
Medical Sciences	5.6	6.4	7.3	6.5	7	4.5	6.9	5.6	6.5	6
Probability & Stats.	6.1	3.6	--	5.1	12	6.9	7.1	7.8	7.1	4
Astronomy	7.4	6.4	1.4	7.0	3	7.2	8.1	6.4	7.4	3
Economics	8.5	6.8	--	8.1	1	7.8	--	--	7.9	1
Interdisciplinary	4.0	5.7	6.5	5.9	8	5.9	5.6	6.0	5.7	9
Sample Average	$6.2	$6.1	$6.3	$6.2		$6.1	$6.0	$5.9	$6.0	

SOURCE: NSF Sample

TABLE 23

Average Salary Differentials for Specialists and Nonspecialists in the 31 Liberal Arts Schools Category, by Ph.D. Field and Amount of Occupational Mobility

Ph.D. Field	Salary Differential for Indicated Number of Occupational Changes									
	Specialists					Nonspecialists				
	0 (000)	1 to 2 (000)	3 to 4 (000)	Average (000)	Rank	0 (000)	1 to 2 (000)	3 to 4 (000)	Average (000)	Rank
Chemistry	$5.8	$5.3	$6.9	$5.9	8	$4.7	$2.5	$5.4	$4.2	12
Biological Sciences	5.8	6.9	6.1	6.0	7	5.3	5.5	6.2	5.5	8
Psychology	5.6	7.8	6.9	6.1	5	6.1	6.1	6.8	6.2	4
Physics	6.7	6.6	7.2	6.7	3	6.4	7.6	--	6.7	2
Earth Sciences	6.0	5.2	4.8	5.9	8	4.7	6.4	1.0	5.0	10
Mathematics	7.3	7.9	1.6	7.3	2	5.8	7.9	--	6.1	5
Engineering	--	--	9.2	9.2	1	--	4.7	9.0	5.8	6
Agricultural Sciences	--	--	--	--		5.1	4.6	--	4.7	11
Medical Sciences	6.0	6.5	--	6.3	4	7.0	4.9	6.2	5.5	8
Probability & Stats.	--	--	--	--		--	8.9	--	8.9	1
Astronomy	6.4	5.8	--	6.1	5	5.9	7.8	--	6.6	3
Economics	--	--	--	--		--	--	--	--	
Interdisciplinary	5.5	4.4	--	5.0	10	6.9	5.6	5.4	5.6	7
Sample Average	$6.1	$6.2	$6.8	$6.2		$6.1	$5.8	$6.1	$5.9	

SOURCE: NSF Sample

TABLE 24

Average Salary Differentials for Specialists and Nonspecialists in the Other Schools Category, by Ph.D. Field and Amount of Occupational Mobility

	Salary Differential for Indicated Number of Occupational Changes									
	Specialists					Nonspecialists				
Ph.D. Field	0 (000)	1 to 2 (000)	3 to 4 (000)	Average (000)	Rank	0 (000)	1 to 2 (000)	3 to 4 (000)	Average (000)	Rank
Chemistry	$5.1	$5.5	$5.6	$5.3	9	$5.0	$5.5	$5.6	$5.3	12
Biological Sciences	5.8	5.9	6.5	5.9	6	5.6	6.2	5.9	5.8	8
Psychology	6.1	6.7	8.5	6.3	5	5.7	6.0	8.1	5.8	8
Physics	6.4	6.6	7.4	6.5	4	6.2	6.5	7.6	6.3	6
Earth Sciences	5.8	5.9	5.5	5.8	7	5.7	4.8	6.2	5.5	10
Mathematics	6.9	6.1	5.7	6.7	1	7.3	6.1	7.2	6.9	4
Engineering	6.6	6.6	7.2	6.7	1	5.8	6.1	5.0	5.9	7
Agricultural Sciences	4.7	4.9	5.5	5.0	11	3.1	5.1	6.0	5.2	13
Medical Sciences	7.5	6.4	8.1	6.7	1	9.0	7.0	7.3	7.2	3
Probability & Stats.	--	--	--	--		6.7	8.2	8.1	7.5	2
Astronomy	5.3	--	--	5.3	9	6.8	6.2	4.9	6.5	5
Economics	--	--	--	--		17.4	--	--	17.4	1
Interdisciplinary	--	5.7	5.5	5.8	7	6.9	5.8	5.6	5.5	10
Sample Average	$5.8	$5.9	$6.0	$5.8		$5.8	$6.0	$5.9	$5.9	

SOURCE: NSF Sample

There is an additional reason for being suspicious of the test performed on the group average data in Table 21. That is that even though most Ph.D.'s were still working in their "home" fields in 1960, some were not. For the 19% who had switched out of their Ph.D. field by 1960, the increase in average salary from 1960 to 1966 is not a particularly accurate measure of the relative inducement necessary to cause them to stop working in the field in which they got their Ph.D. And it is the level of this initial inducement that is supposed to be depressed by specialization, according to the second important assertion of the theory of Ph.D. occupational mobility.

An alternative test of the specialization effect probably does take the difficulty just mentioned into account. This test involves comparing the salary increase for specialists and non-specialists who only changed occupations once or twice. Since about 11% of the Ph.D.'s in the NSF sample changed jobs 3 or 4 times, and since most of those probably had changed out of their Ph.D. field by 1960, it is probable that most Ph.D.'s who only changed fields once or twice, had not changed at all by 1960. For that category the 1960-66 salary increase is thus a very accurate relative measure of the inducement necessary to result in a move out of the "home" employment specialty.

The results of this comparison are disappointing. The non-specialists who changed jobs only once or twice had an average salary increase greater than the corresponding group of specialists in only 4 out of the 12 fields for which a comparison was possible based on the data of Table 21; specialists obtained a larger increase in 6 of the Ph.D. fields.

The average 1966 salary was $17,005 for those who attended undergraduate school at one of the 106 graduate institutions, while it was

$16,972 for the 31 liberal arts schools category, and $16,623 for the other schools; average salary increases over the 1960-66 period ranked in this same order by undergraduate school category. It was thus thought that subclassifying the data of Table 21 by school category might hold constant any important variations in ability that could be biasing the outcome of this test of the specialization effect. However, based on the data in Tables 22-24, non-specialists received a larger increase than specialists in only 13 out of 31 comparisons between the two groups of Ph.D.'s who switched occupations one or two times. Specialists' increases were larger in 14 cases.

The conclusions are that either the specialization effect was very weak or nonexistent in the NSF sample, or uncontrolled variables such as ability and experience acted so as to make its effect unidentifiable, or the characterization of specialists only on the basis of their having identical undergraduate and graduate majors is incorrect. Whichever is true, the data showed no very strong and unambiguous association between specialization and salary increases over the 1960-66 period. On the other hand, the data did show a fairly strong positive correlation between the size of the salary increase and observed mobility, as predicted by the first important assertion of the theory of Ph.D. occupational mobility.

Before closing this section some remarks on the association between salary levels, educational background and mobility are in order, inasmuch as the discussion up to this point has dealt solely with salary increases over the observation period 1960-66. Table 25 summarizes available data on average basic salaries for 1966 for specialists and non-specialists, cross-classified by Ph.D. field and amount of observed occupational switching.

TABLE 25

Average 1966 Salary for Specialists and Nonspecialists, by Ph.D. Field and Amount of Occupational Mobility

Ph.D. Field	1966 Salary for Indicated Number of Occupational Changes									
	Specialists					Nonspecialists				
	0 (000)	1 to 2 (000)	3 to 4 (000)	Average (000)	Rank	0 (000)	1 to 2 (000)	3 to 4 (000)	Average (000)	Rank
Chemistry	$16.7	$17.2	$17.5	$17.0	6	$17.7	$17.9	$17.4	$17.7	7
Biological Sciences	14.8	15.5	16.7	15.1	12	15.4	16.0	16.1	15.7	11
Psychology	16.0	16.5	16.5	16.1	9	16.0	17.2	17.1	16.2	10
Physics	17.9	20.7	19.7	18.5	3	18.3	20.1	19.7	18.9	3
Earth Sciences	15.8	15.5	17.3	15.8	11	16.0	14.9	16.4	15.7	11
Mathematics	17.3	18.0	18.8	17.5	4	17.7	18.1	20.0	17.9	6
Engineering	18.6	20.2	21.7	19.9	2	19.0	19.8	18.2	19.3	2
Agricultural Sciences	15.1	14.1	15.0	14.3	13	17.2	14.3	15.4	14.7	13
Medical Sciences	17.3	15.5	17.6	16.0	10	20.0	18.3	18.2	18.5	4
Probability & Stats.	16.4	16.1	--	16.3	8	17.6	19.0	19.6	18.4	5
Astronomy	17.6	14.1	--	17.2	5	16.6	14.3	17.1	17.3	8
Economics	25.2	18.8	--	23.6	1	27.6	--	--	27.6	1
Interdisciplinary	12.3	17.1	16.6	16.9	7	17.7	16.8	17.2	16.9	9
Sample Average	$16.4	$17.3	$17.5	$16.8		$16.7	$17.2	$17.0	$17.0	

SOURCE: NSF Sample

As was the case for salary increases, 1966 average salaries in each field tend to be positively correlated with the amount of actual changing from one occupation to another that has occurred over the Ph.D.'s career up to 1966. This is further evidence that economic incentives have something to do with career decisions by Ph.D. holders. Of course, the important question is how significant are they? Would a salary increase of a few hundred dollars really cause someone to change occupations, as the data in Table 25 might suggest? Or do salary and mobility just move together because both are determined by a third variable such as the economic and social class in which the Ph.D. grew up?

Whatever is assumed about the causal significance of these data, one other interesting association revealed in Table 25 is that those Ph.D.'s who took undergraduate majors outside their Ph.D. field had higher average salaries in 1966 both in the sample as a whole, and when classified into Ph.D. fields. Only in engineering and the earth sciences did the specialized Ph.D.'s receive higher salaries on average. Thus specialization was rather consistently associated with a negative salary level effect, unlike the mixed association between specialization and the differential in salary changes discussed above. The negative salary level effect also held true in the three categories for number of occupational changes, except that in the NSF sample as a whole the more mobile specialists were better paid than the more mobile non-specialists.

This relationship between specialization and salary level is consistent with the theory that those who obtain a less-specialized education are expected to have more opportunity to respond to changing labor market conditions. By being more flexible, their range of choice is expanded with the result that their money incomes tend to be larger. Both the data

in Table 25 and the negative correlation between specialization and observed mobility reported previously suggest that an education concentrated in one field has costs in terms of future salary and mobility.

In general one would assume that the specialist would be better paid than the non-specialist if both were employed in their Ph.D. field. However, those specialists who were employed in their "home" field throughout their career to 1966 had lower average salaries in every field than did the immobile non-specialists, except in astronomy. The same was true for 1960 average salaries, again with the exception of astronomy. Nor did salary increases for specialists consistently exceed those for non-specialists when both remained employed in their Ph.D. fields over the 1960-66 period, as the data in Tables 21-24 show.

So not only does specialization as defined for the NSF sample have costs if the Ph.D. wants to move to another occupation, it also is costly if he remains employed in his field of specialization.

Perhaps the immobile specialists have stronger preferences for the work in their "home" field and so need not be paid as much as the immobile non-specialists to prevent their switching occupations. As mentioned several times above, it requires some strong assumptions about preferences to make causal conclusions from cross-section correlations. There is a good deal of evidence that preferences vary widely in the NSF sample, as one would expect *a priori*. Some of that evidence was mentioned with reference to the data in Table 22.

Also, suppose average salaries for 1966 are cross-classified by Ph.D. field and 1966 employment specialty, where the latter are grouped into 4 categories--one for the "home" employment field, one for high employment demand fields, one for moderate employment demand fields, and one for those

areas of low demand. Then for every Ph.D. field except engineering more of those who have switched out of their "home" field are employed n one of the five low demand fields than are employed in one of the seven moderate demand specialties, despite the fact that the average salary for such movers is only $15,425 in the low demand fields as compared with $17,352 in the moderate demand fields.

Upon noting that the new field of linguistics had low employment demand and that over 40% of those switching into low demand areas moved into linguistics (an absolute number greater than the amount by which total switches into low demand exceeds the number of switches into moderate demand areas), the anomaly becomes explicable. The mobile Ph.D.'s preferred to work in what they believed would be an exciting new field, and were willing to pay some substantial salary costs to do so. Thus, caution is suggested in making causal conclusions about the results reported in this section.

Ph.D. Employer Mobility: Down a One-Way Street?

The discussion up to this point has been concerned with the relationships among educational training, occupational mobility, and salary. However, another important type of mobility in a Ph.D.'s career is his movement between employers--for example, from one academic institution to another or from a job in academia to one in business. In fact when mobility of Ph.D.'s is being discussed, it is the employer or job type of mobility which is usually meant.

There are many hypotheses about employer mobility, but not so many attempts have been made to actually test these theories.[10] For example,

[10] See Brown [2,3] for a discussion with some supporting data of many of these theories.

it is often asserted that movements among academic institutions take place in only the downward direction; very seldom does a Ph.D. move from a less prestigious institution to one having substantially greater prestige. Or it is asserted that there is more mobility among the high prestige schools than among the low, because the status gaining practices for the individual Ph.D. at a high prestige institution are disciplinary, such as publishing in academic journals. While at low prestige schools, the status gaining practices, such as being a good teacher, are mainly institutional specific, and do not increase the Ph.D.'s status in his specialty discipline.

The NSF sample contains data relevant to both these assertions, but research resources did not permit these data to be analyzed at this time. However, there is a form of the downward mobility hypothesis that could be tested without much additional expenditure of time and money on data retrieval and computation. That is the assertion that employer mobility is also one directional among the three employer types--academic institutions, government institutions and businesses. The prestige ranking for these employer type categories that is assumed in this assertion is that academia is most prestigious, government next, and business the least prestigious.

The previous chapter presented data that are relevant to the employer-type downward mobility hypothesis. For example, Table 5 showed that average salaries for Ph.D.'s were lowest in academia, highest in business, and that government salaries were somewhere in between. This ranking is the opposite of the prestige ranking, as could be expected. Also, Table 8 indicated that occupational mobility was lower in academia than it was in government or business. If occupation changing and employer switching

are highly correlated, as they probably are, then the downward mobility hypothesis would lead one to expect less occupational mobility among those Ph.D.'s who remain in academia. This would be because some of those who change jobs move out of academia, and once out cannot get back in. Since most Ph.D.'s start out in academic jobs, downward mobility leaves relatively more of the job changers in government and business as their careers unfold.

Furthermore, there are two kinds of data in the NSF sample that are more directly relevant to testing whether Ph.D. mobility among employer types is down a one-way street. One is the numbers who actually moved between the employer-type categories over the period from 1960 to 1966. The other is the average salary change associated with these moves. Table 26 shows such figures for the NSF sample. The data in the table show average 1960-66 salary changes cross-classified by 1960 and 1966 employer-type categories. It also lists the percentage of Ph.D.'s working for a given employer type in 1960 who went to work for each of the three types by 1966.

If the employer-type downward mobility hypothesis is true, then the average salary change for those who move up the hierarchy ought to be lower than if they had not moved up. Also, movements down the hierarchy ought to yield higher salary increases than changes within the same employer-type category; otherwise the Ph.D.'s would not be induced to accept a job with a lower status employer.

The data in Table 26 reveal that both these effects did occur in the NSF sample. For Ph.D.'s working in academia in 1960, their salary increase on average was inversely correlated with the prestige of the employer type by whom they were employed by 1966. Ph.D.'s who stayed in academia

TABLE 26

1960-66 Salary Increase, by Employer Type

1960 Employer Type	1966 Employer Type[1] Academic (000)	Government (000)	Business (000)	Average (000)
Academic	$6.5 (89%)	$7.1 (5%)	$9.1 (5%)	$6.5 (100%)
Government	5.6 (25%)	5.7 (64%)	7.7 (8%)	5.8 (100%)
Business	3.6 (8%)	5.1 (5%)	5.7 (84%)	5.5 (100%)
Average	6.3 (50%)	5.8 (17%)	6.0 (31%)	6.0 (100%)

[1]The percentage data in parentheses under each salary change figure indicate the proportion of Ph.D.'s working for a given employer type in 1960 that were working for the various employer types in 1966. The percentages do not all add across to 100% because some Ph.D.'s did not indicate their specific employer type.

SOURCE: NSF Sample

received the lowest increase in salary, while those who moved into business received the highest. The differential was over $2,500, so the salary inducement to move from academia into business was quite large.

On the other hand, the Ph.D.'s employed in academia in 1966 who were working for a business in 1960 received a salary increase that was $2,100 less than those who stayed in business. This is a rather large penalty to pay for moving from bottom to top in the employer-type hierarchy; as a result only 8% of those employed by business in 1960 moved into academia, while 84% stayed in business.

Also as was predicted, the salary increase for those employed by government in 1966 fell in the middle of the salary increases for Ph.D.'s in academia and business, regardless of which employer type they were working for in 1960. However, despite the fact that their salary increase was $2,100 less, 25% of the 1960 government employees moved into academia while only 8% went into business. Mobility was thus downward in the sense that moving up the employer-type hierarchy had rather severe salary costs associated with the move, but it was not true that Ph.D.'s only moved down and never up the hierarchy. In fact, many did so, even moving from bottom to top by going from business to academia.

The data in Table 26 on the diagonal of the cross-classification also reveal some information about the general state of employment demand by employer type for the period 1960-66. Those Ph.D.'s who stayed in academia had salary increases that averaged $800 more than did the Ph.D.'s who stayed in government or business. This differential reflected the high employment demand in academia that lasted nearly until 1970.

However, one problem with basing any strong conclusions on the data shown in Table 26 is that there is no way of being sure that the favorable results for the NSF sample as a whole are not just accidental and due to

the way demand varied by specialty field rather than to the influence of downward mobility. In order to check how variations in the level of employment demand by field might influence the results seemingly by Table 26, similar data were computed for those Ph.D.'s who were in the same occupation (employment specialty) for 1960 and 1966. It was assumed that the number of Ph.D.'s switching out of an occupation after 1960 and then back in would not be large in proportion to the number who remained in the same occupation throughout the period, and further that those who did switch out and back in were not concentrated in the categories of Ph.D.'s who switched employer types. If these two conditions are true, and the data in Table 11 tend to support the first condition, then computing salary changes by employment specialty yields data on both the downward mobility hypothesis and relative demand among employer types, while holding constant the general level of employment demand.

Table 27 reports the data on salary changes associated with employer switching for Ph.D.'s working in a high demand field, physics, and for those working in a low demand field, the biological sciences. In both cases average salary changes were higher for movements to an employer type lower on the prestige hierarchy than for job switches to one higher, no matter what the employer type category was in 1960. Or, another way of looking at the results is to say that a given employer type in 1966 paid a salary increase to the average Ph.D. that was positively correlated with the prestige of his employer type in 1960. So the salary data in Table 27 are all consistent with the employer-type downward mobility hypothesis. However, as was the case for the whole sample, many Ph.D.'s were able to move up the employer-type hierarchy by paying the cost of having lower salary increases over the 1960-66 period.

TABLE 27

1960-66 Salary Increase for Those Working in Physics and the Biological Sciences, by Employer Type

Salary Increase for Ph.D.'s Working in Physics in 1960 and 1966				
1960 Employer Type	1966 Employer Type[1]			
	Academic (000)	Government (000)	Business (000)	Average (000)
Academic	$7.1 (91%)	$8.2 (4%)	$11.9 (4%)	$7.4 (100%)
Government	5.4 (49%)	6.6 (36%)	6.8 (15%)	6.0 (100%)
Business	3.8 (15%)	5.4 (6%)	6.6 (79%)	6.1 (100%)
Average	6.5 (56%)	6.7 (13%)	6.9 (31%)	6.6 (100%)

Salary Increases for Ph.D.'s Working in the Biological Sciences in 1960 & 1966				
1960 Employer Type	1966 Employer Type[1]			
	Academic (000)	Government (000)	Business (000)	Average (000)
Academic	$5.9 (94%)	$6.4 (4%)	$7.5 (1%)	$5.9 (100%)
Government	5.6 (22%)	5.8 (74%)	6.9 (3%)	5.8 (100%)
Business	3.6 (14%)	5.0 (9%)	5.2 (76%)	5.0 (100%)
Average	5.8 (71%)	5.8 (20%)	5.5 (8%)	5.8 (100%)

[1]The percentage data in parentheses under each salary change figure indicate the proportion of Ph.D.'s working for a given employer type in 1960 that were working for the various employer types in 1966. The percentages do not all add across to 100% because some Ph.D.'s did not indicate their specific employer type.

SOURCE: NSF Sample

The average salary increases for Ph.D.'s remaining in the same employer-type category again provide an indication of relative employment demand by employer type. For practicing physicists, demand was highest in academia and equal in government and business. The same was true for practicing biological scientists except that business employment demand ranked below demand in government. These demand rankings are consistent with the data in Table 6 which show rankings of average salaries by employment specialty and employer type for 1960 and 1966, i.e., the ranks for the two fields do not vary significantly across employer types for the two years. Thus one would expect demand in academia to rank first, just as it did for the average Ph.D. without regard to his employment.

As the data in Table 6 indicate, psychology was one field in which average salary rankings did vary substantially by employer type and year. Academic and government salaries ranked from 9th to 12th in both years, but business salaries ranked 5th in 1960 and 1st in 1966, out of the thirteen fields (including other) for which data were recorded in both 1960 and 1966. As expected, Ph.D.'s working for businesses in 1960 and 1966 received an average salary increase of about $8,500, compared with $6,400 for those in academia and $4,900 for those in government in both years.

However, these variations in demand by employer type did not alter the fact that in psychology, as in physics and the biological sciences, salary changes on average were higher for switches to an employer type lower on the prestige hierarchy, no matter what employer type the Ph.D. worked for in 1960; except in the case of those employed by government in 1960, where the switch to academia paid $300 more than did remaining in government. This was probably because relative employment demand rose in

academia over the 1960-66 period, while it remained constant in government.

For the other large employment specialties, the salary change data were also in general consistent with the downward mobility hypothesis; while the number of Ph.D.'s switching employer types revealed that many were willing to accept the costs of upward mobility. In the earth sciences and the interdisciplinary fields, salary changes increased down 1966 employer types for a given 1960 employer type, and decreased down 1960 employer types for a given 1966 employer category, both without exception. In chemistry, engineering and mathematics there were three exceptions each to this increasing-decreasing pattern, out of the twelve pairwise comparisons. Most of these were less than $500 in magnitude. In agricultural sciences, there were six exceptions; but two of the cells in this cross-classification had only one observation, so three of these are not significant.

In conclusion, this section has demonstrated that there is much evidence in the NSF sample which is consistent with the hypothesis that movements down the employer type hierarchy are much easier than moves up, in terms of the effect of such switches on Ph.D.'s salaries. Despite the salary costs, however, many Ph.D.'s still have moved from lower prestige employer types to an employer higher up the prestige hierarchy.

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