ACCOUNTING FOR THE DIFFERENCES IN PH.D. CREATION RATES ACROSS LIBERAL ARTS COLLEGES

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Introduction

Liberal arts colleges are an important source of Ph.D. students. While awarding about eleven percent of all undergraduate degrees in the United States, liberal arts colleges account for almost seventeen percent of all Ph.D.'s awarded to American students. The most recent data suggest that about 5.3 percent of all graduates from the best liberal arts colleges eventually earn a Ph.D., while only 2.2 percent of all graduates from the best universities do. There is also a substantial difference across liberal arts colleges with the best colleges producing Ph.D.'s at three times the rate of lower ranked colleges.

How is it that some liberal arts colleges are consistently more successful than other institutions at producing graduates who go on to earn a Ph.D.? The answers to this question are inherently complex and difficult to isolate. This chapter is a first attempt to unravel parts of the story.

The social benefits provided by institutions of higher education in the form of having a highly educated citizenry are well understood. Society benefits from scientific discoveries, creative works of art, and informative policy analyses as well as from having a more knowledgeable electorate. Institutions of higher education, however, vary greatly in their approach toward education. At liberal arts colleges, where graduate degrees are seldom awarded, the primary mission is focused on educating undergraduates. Even though creating students who will eventually earn a Ph.D. is not the sole objective (and maybe not even a primary objective) of liberal arts colleges, the graduate school success of their students is important to liberal arts colleges. As socially conscious institutions, colleges value education and the benefits that a graduate education offers. Many faculty members at liberal arts colleges measure their contribution to society in part by the students they produce, including future Ph.D.'s who go on to

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undertake meaningful research of their own. More locally, the rate at which an institution's students pursue graduate study indicates generally how successful the institution is at fostering growth in students to enjoy learning and a desire to pursue their own path toward understanding and discovery after college. Liberal arts colleges also have a preference, at least marginally, for hiring faculty with a liberal arts background. This suggests there is some consensus, at least among college Deans, that liberal arts college graduates may have a greater appreciation, if not a greater affinity, for teaching (Astin, 1999; Warch, 2001). And more selfishly, college rankings, the accreditation process, and granting agencies such as the NSF all consider the graduate school success of alumni when evaluating institutions of higher education.

This chapter also provides insight into the effect faculty scholarship has on graduate school choices of students. Whether faculty scholarship should be required at liberal arts colleges has long been debated. Through the 1950s, college faculty were not expected to be engaged in research. Over the last 40 years, however, scholarship expectations have changed. Presently, the most elite colleges require their faculty to be deeply engaged in research. Most lower-ranked colleges also consider scholarship in tenure decisions, though the quantity and quality of the scholarship requirements are less than at the top institutions and vary considerably across institutions (McCaughey, 1994).

Some argue that imposing unnecessary research expectations on faculty detracts from high quality teaching, the foremost stated mission of liberal arts colleges, as research competes for scarce funds and faculty time. In terms of Ph.D. creation, faculty who spend more of their time engaged in research will have less time to devote to teaching and advising, persuading fewer students to pursue a Ph.D.[2] In contrast, others maintain that engagement in scholarship, at least at the very best liberal arts colleges, helps faculty become better teachers (McCaughey, 1994). In terms of Ph.D. creation, faculty research can engage students directly and foster excellent teaching. As a result, students are more likely

[2] Boyer (1990) argued that the traditional definition of scholarship is too limiting, especially in a liberal arts setting, and should be thought of as any activity that strengthens and contributes to one's teaching.

to pursue a Ph.D.[3] The results presented later suggest that both effects exist, with the positive effects of faculty scholarship being strongest at the best colleges.

Ph.D. Creation

For purposes here, ***Ph.D. creation*** refers to the ***undergraduate*** institution of the student who received a Ph.D. in the United States. Every year since 1970, American universities and colleges have created between 20,000 and 24,000 and between 3,600 and 4,900 Ph.D.'s respectively.[4]

The National Center of Education's Higher Education General Information Survey (HEGIS) and Integrated Postsecondary Education Data System (IPEDS) *Completions Survey* provides the number of undergraduate degrees awarded by each institution each year, while the National Science Foundation's *Survey of Earned Doctorates* reports the number of Ph.D.'s earned each year by alumni of each institution. The data for both surveys can be found at www.webcaspar.org. Although the surveys contain information on thousands of institutions of higher education, the 1994 Carnegie Classification system is used to focus on liberal arts colleges (institutions designated BA I or II) and universities (institutions designated Research I or II, Doctoral I or II, or Masters I or II). According to these definitions, there are 604 colleges and 732 universities. Much attention, however, will be restricted to the "top" institutions in each group. There are 165 colleges designated as BA I and 87 universities designated as Research I. While the top universities and colleges alike account for about one-third of all undergraduate degrees awarded, the top universities consistently account for just under half of all Ph.D.'s created by universities, while the top colleges account for more than two-thirds of all Ph.D.'s created by liberal arts colleges.

Using data from the *Survey of Earned Doctorates* and the *Completions Survey*, Ph.D. creation rates can be calculated for each institution or for each type of institution. Two issues, however, are worth mentioning. First, the *Survey of Earned Degrees* does not report when the Ph.D. recipient received his or

[3] Ehrenberg (2005) suggests such interaction as a means to encourage undergraduates at research universities to consider pursuing a Ph.D.

[4] While Ph.D. creation has changed modestly for American universities and colleges, foreign institutions have witnessed a huge increase in Ph.D. creation since 1980 (Ehrenberg, 1991; Bound et al., this volume).

her undergraduate degree. Thus, a five-year rolling window between undergraduate and graduate degrees is used.[5] Second, to smooth the data year-to-year, the yearly Ph.D. creation rate is calculated as all Ph.D.'s awarded within two years as a fraction of all undergraduate degrees awarded within two years. For example, the 1975 Ph.D. creation rate for liberal arts colleges is calculated as all Ph.D.'s received from 1973 through 1977 by graduates of liberal arts colleges measured as a fraction of all undergraduate degrees awarded by liberal arts colleges from 1968 through 1972.

Figure 1 shows yearly Ph.D. creation rates for the top liberal arts colleges vs. the top universities (diamond lines: dark solid vs. light dashed) and for all liberal arts colleges vs. all universities (smooth lines: dark solid vs. light dashed). Ph.D. creation rates fell following the Vietnam War for all types of institutions. Since 1985, however, only the top liberal arts colleges have experienced an increase in creation rates – from just under 4.7 in 1987 to over 5 percent by 1992 and in excess of 5.3 percent since 2000. Comparatively, the Ph.D. creation rate for top universities fell below 2.5 percent by 1980, and has hovered between 2.2 and 2.5 percent since. A similarly persistent gap, though not as large, exists between all colleges and all universities. Whereas the Ph.D. creation rate for all colleges fell from just over 3 percent in 1980 to 2.4 percent in 2000, the Ph.D. creation rate for all universities fell from 1.8 percent in 1980 to under 1.6 percent in 2000.

These differences in Ph.D. creation rates are substantial. Throughout the 1990s, for example, whereas liberal arts colleges graduated one person for almost every eight university graduates, liberal arts graduates earned one Ph.D. for every five earned by university graduates. The ratios are even more striking for the top institutions. From 1985 to 1995, the top liberal arts colleges consistently produced Ph.D.'s at twice the rate of the top universities. By 2000, as they had in the mid 1970s, the top liberal arts colleges were producing Ph.D.'s at a rate two and a half times greater than the top universities.

[5] The results are qualitatively unchanged if a seven-year rolling window is used. Fuller (1986) also allows for a five-year window.

Choosing to Pursue a Ph.D.

There are many possible explanations for why liberal arts colleges create Ph.D.'s at a greater rate than their university counterparts. Liberal arts colleges might be more attractive to students who will later be drawn to a Ph.D. Students at liberal arts colleges also interact frequently with their professors, and typically at a deeper level than do students at universities. This closer relationship may lend itself to faculty members encouraging students to go on to graduate school more often (or that graduate school advice is more frequently followed). It may be that the occupation students at liberal arts colleges are most familiar with, apart from that of their parents, is that of college professor. This familiarity may lead students to graduate school.[6]

Others argue that it is not so much advice given and received but rather that the experiences afforded by liberal arts colleges naturally foster a desire to further one's education. Warch (2001), for example, argues that the one-on-one undergraduate research experiences offered to students at liberal arts colleges are not only transforming, but such opportunities are rare to non-existent at universities where graduate students have first claim to laboratories, equipment, and the professor's time. Astin (1999), Bourque (1999), Warch (2001) and others claim that it is only natural that one-on-one research experiences are likely to have a transformative effect on students and that liberal arts faculty are particularly suited to lead such experiences. Quantitative evidence to this point, however, is lacking.

To try to begin to fill this void, a survey was sent to 850 current full-time faculty members at liberal arts colleges asking when they knew they wanted to go to graduate school and what factor was most responsible for that decision. Surveys were returned by 358 faculty members for a response rate of 42 percent. Of those returned, 152 were from faculty who attended a liberal arts college, while 206

[6] With particular emphasis on the role forming expectations play in the decision, Ehrenberg (1991) discusses factors that likely influence one's decision to pursue a Ph.D., including the pecuniary and non-pecuniary benefits, time to complete the degree, cost of graduate school, etc. Given the close relationship between students and professors at liberal arts colleges, these students arguably can form fairly good expectations of the non-pecuniary benefits of being a professor at such an institution.

attended a research university. The tabulation of responses is given in Table 1.[7]

The question of timing is addressed in panel A. Roughly 50 percent decided on graduate school during their last two years of college regardless of type of undergraduate institution. Graduates from universities were more likely to make the decision before entering college or early in college, while liberal arts college graduates were more likely to make the decision after working for some time. None of these differences, however, are statistically significant at the 5 percent level.

The question of who or what most influenced the decision to go to graduate school is reported in panel B. The responses are broadly grouped into four categories – family, undergraduate institution (including a professor, classmates, a research experience, or a particular class), employment goals (including frustration with one's job, needing a Ph.D. to do interesting research, or wanting to teach at the collegiate level), and self-motivation. Although much more research should be done on the motives underlying the decision to go to graduate school, this simple survey provides some evidence that liberal arts colleges connect with their students in a way that universities do not. Whereas 48 percent of graduates of universities attribute the primary factor to their pursuit of a Ph.D. to something concerning their undergraduate institution, 58 percent of graduates from liberal arts colleges do. (The difference is statistically significant with a *p*-value of 0.032.)

The other statistically significant difference in Table 1 concerns self-motivation. Whereas ten percent of graduates from universities attribute their pursuit of a Ph.D. to self-motivation, only three percent of graduates from a liberal arts college do (with a *p*-value of 0.005). This difference might be attributable to the difference in how students and professors interact on university campuses or simply to the number of students on university campuses. For a student to be an academic standout on a university campus, he or she must rise above thousands, not hundreds. To do this undoubtedly requires an inner desire for academic success. Whereas this desire no doubt exists in the standouts at liberal arts colleges, it may be more necessary on university campuses, and thus is more frequently noted by such graduates.

[7] To what extent the selection issues regarding one's choice of undergraduate institution, reasons for going to graduate school, and the decision to work at a liberal arts college affect the results are unclear.

Cautious of the small sample sizes and rudimentary survey method, it appears that liberal arts colleges deliver on their promise to interact closely with students. More research in this area, however, would be well worthwhile. In particular, how engaging students in undergraduate research projects likely affects future decisions concerning Ph.D. pursuits remains largely unknown. If liberal arts colleges have an advantage in this area, then calls for further funding, such as from NSF grants, to expand such opportunities at liberal arts colleges should be explored (Warch, 2001).[8]

Quantitative Analysis

Attention now turns from comparing liberal arts colleges to universities to that of exploring empirically why some colleges have higher Ph.D. creation rates than others. In order to carry out the analysis, attention was restricted to the BA I colleges as defined by the Carnegie Classification in 1994. Using the number of graduates from each college from 1989 through 1998 and the number of doctorates earned by alumni of each college between 1994 and 2003, each college's overall Ph.D. creation rate was calculated. The average college in the sample saw 4.2 percent of its graduates go on to earn a Ph.D.

To carry out a statistical analysis of Ph.D. creation, additional data was collected from two sources. The 1994 edition of U.S. News and World Reports' *America's Best Colleges* lists 161 top liberal arts colleges and provides data on the 75th percentile SAT score of incoming freshmen (average of 1235) and per student expenditures.[9] Expenditures per student ranged from a low of $4,510 to a high of $23,715, with the average college spending $13,420 per student. Barron's 1995 *Profiles of American Colleges* reports enrollment, percent of students who are female, student-faculty ratio, and the percent of incoming students who scored above a 700 on the verbal/math sections of the SAT.

Lastly, the Web of Science database was used to determine the number of articles attributed to each college in the Arts and Humanities Citation Index (A&HIS), the Social Science Citation Index

[8] Boylan (this volume) finds there is general empirical support that research experiences for undergraduates (REUs) are positive influences on student decisions to pursue a graduate degree.
[9] When ACT scores were reported, they were converted to the SAT scale using the College Board's conversion table. To limit missing observations, data for some colleges was obtained from other sources.

(SSCI), and the Science Citation Index Expanded (SCI-EXPANDED) from 1989 through 1998. Using each college's enrollment and student-faculty ratio, the number of articles per college was transformed into the number of articles per faculty member over the ten-year period. The average school had 0.3, 0.4, and 0.6 articles in A&HIS, SSCI, and SCI-EXPANDED respectively per faculty member for the entire ten years. These low rates reflect that they are calculated per faculty member and not per faculty member in each division. Combining the three indexes, the average college had almost 2.5 entries of any kind, not just journal articles, per faculty member over the ten years; put differently, the average faculty member contributed an entry to the index once every four years. Whereas the least prolific college had almost no entries, the most prolific college averaged just under one publication per faculty member per year.

When attention is restricted to only BA I colleges with an enrollment of between 500 and 3,500 students for which there is no missing data, there are 148 colleges in the sample. Table 2 lists all of the colleges used in the analysis, along with their overall Ph.D. creation rate of students who graduated between 1989 and 1998.

Explaining Overall Ph.D. Creation Rates

Using these data, the relationship certain factors have with Ph.D. creation can be estimated. To do this, two models were estimated using ordinary least squares regression – one for the 81 colleges in the top two tiers and one for the 67 colleges in the third and fourth tiers according to U.S. News.[10] The dependent variable is each college's overall Ph.D. creation rate as reported in Table 2. The explanatory variables included are the college's 75 percentile SAT score, log of enrollment, percent of students who are female (measured 0 to 100), per student expenditures (measured in $1,000s), whether the college

[10] The sample was separated according to tier to partially account for student quality differences across colleges. Each college's 75th percentile SAT score is also included in the analysis to further account for these quality differences. While U.S. News classified Reed College as tier four in 1994 because Reed refused to complete its survey, Reed is classified as a tier two college here to better reflect its reputation.

offered a business degree in the 1990s, whether the college is located in the northeast,[11] and the number of WebScience citations per faculty member from 1989 to 1998.[12] Offering a business degree was included for two reasons. First, offering a business degree might indicate that the college attracts students who are more inclined to pursue professional degrees or who have more immediate job expectations after graduation. Second, a business major may compete with the more traditional liberal arts majors, which in turn may limit student options for a Ph.D. after graduation. Location has also been included because of the historical presence of many elite colleges, and clusters of elite colleges, in the northeast. Kaufman and Woglom (2005) also account for location.

The results from both models are reported in Table 3. The percent of students scoring in the top quartile of the SAT is positively related to Ph.D. creation for both groups of colleges, though the magnitude of the effect is much greater for tier one and two colleges than for tier three and four colleges. While neither enrollment nor the percent of students who are female is statistically significant in either regression, the most important take-away point from Table 3 is how different Ph.D. creation is for the colleges in the top two tiers than it is for the colleges in the next two tiers. There are meaningful differences between the creation of Ph.D.'s and college expenditures, offering a business degree, college location, and faculty scholarship. Each of these is discussed in turn below.[13]

While expenditures per student are not statistically significant in the creation of Ph.D.'s at tier one or two colleges, they are statistically significant at the 5 percent level at tier three and four colleges. The magnitude of the effect, however, is very small. A $1,000 increase in per student spending is

[11] To be considered as offering a business degree, it was required that the college had awarded at least 100 degrees in the area of business between 1989 and 1998 according to the IPEDS/HEGIS data. Colleges located in CT, MA, ME, NH, NJ, NY, RI, or VT are considered to be in the northeast.

[12] Siegfried and Stock (2005) and Townsend (2005) study the undergraduate origins of future Ph.D. students in Economics and History respectively. Kaufman and Woglom (2005) and Lemke et al. (2005) conduct econometric analyses concerning the Ph.D. creation rates at liberal arts colleges in general and in economics respectively.

[13] A dummy variable for tier two colleges is insignificant in the first model; a dummy variable for tier four colleges is statistically significant at the 10 percent level in the second model. The coefficient estimates, however, are insensitive to the inclusion of these dummy variables. The results are also qualitatively unchanged if one includes per student expenditures (as is done here) or the log of per student expenditures as Kaufman and Woglom (2005) do.

associated with less than a 0.15 percentage point increase in Ph.D. creation. For the typical college, this suggest that increasing the annual budget by over $1 million annually would be associated with one additional graduate going on to eventually earn a Ph.D. every other year

Among colleges in the top two tiers, those that offer a business degree create Ph.D.'s at a rate that is almost 2 percentage points less than those that do not offer a business degree. Offering a business degree by colleges in the bottom two tiers, however, is not statistically associated with Ph.D. creation. One interpretation of this finding is that not only are good students at the best colleges attracted to non traditional liberal arts majors like business, but also that students who choose these majors develop less interest in graduate school or find it more difficult to pursue a graduate degree.

Tier one and two colleges located in the northeast are predicted to create Ph.D.'s at a rate that is 3 percentage points less than comparable colleges not located in the northeast. In contrast, tier three and four colleges in the northeast are predicted to create Ph.D.'s at a rate that is almost 1 percentage point higher than comparable colleges not in the northeast. Wall Street and the U.S. financial/banking industry could explain this pattern if the financial sector of the U.S., which is located predominantly in the Northeast, has a preference for hiring the best students from the best regional colleges.

Finally, the relationship between Ph.D. creation and faculty scholarship also varies by tier. Among tier one and two colleges, faculty scholarship is positively related to Ph.D. creation, while faculty scholarship is unrelated to Ph.D. creation at tier three and four colleges. This suggests that both arguments mentioned earlier – that increased faculty scholarship might detract from a professors time to advise and teach or it might add to faculty interactions with students – hold, but that they are realized to varying degrees at different colleges. Faculty at the best colleges who are engaged in scholarship may affect their students positively toward graduate school. At lower ranked colleges, however, faculty scholarship does not appear to be a catalyst for encouraging students to pursue a Ph.D.[14]

[14] Although there is a measurable difference in average student ability between the colleges in the top two tiers and the bottom two tiers, there is also likely to be a difference in the research abilities of the professors across the colleges. To what extent these findings on faculty scholarship and Ph.D. creation

Explaining Ph.D. Creation Rates Across Disciplines

Using the same data as above, the relationship certain factors have with Ph.D. creation within each division was estimated. To do this, the previous models were estimated using seemingly unrelated regression (SUR), which allows for better estimation of parameters when error terms may be correlated across equations. Each model estimates three equations with the dependent variables being each college's Ph.D. creation rates in the humanities, social sciences, and natural sciences.[15] The explanatory variables are identical as in Table 3 except that each equation includes division-specific faculty citations.[16]

The regression results strongly suggest that Ph.D. creation rates are correlated across academic divisions. The correlations of the error terms are greater than one-half and are positively correlated at the one percent level. Moreover, if the errors were randomly distributed, one would expect roughly one in every eight colleges to have a positive (negative) error in all three equations. Instead, 21 (28) of the 81 tier one and tier two colleges have positive (negative) errors in all three equations. Similarly, 14 (22) of the 67 tier three and tier four colleges have positive (negative) errors in all three equations.

The estimated relationships between Ph.D. creation and enrollment, per student expenditures, offering a business degree, being located in the northeast, and faculty scholarship largely support the results from Table 3. A notable difference, however, concerns the percent of female students. Although the percent of a college's student body that is female was unrelated to overall Ph.D. creation rates originally, having a greater percentage of female students on campus is associated with greater Ph.D. creation rates in the humanities and social sciences compared to the natural sciences.

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are due to the students or are due to the faculty remains unknown, and would be worthwhile future research.

[15] The division-specific creation rates were calculated as a percent of all college graduates. They are not measured as a percent of college graduates from within the division as the *Completions Survey* does not allow for accurate calculation of this sort. Division-specific Ph.D. creation rates averaged 1.0 percent in the humanities, 1.3 percent in the social sciences, and 1.9 percent in the natural sciences. The humanities include art, art history, communications/librarianship, English, foreign and modern languages, history, philosophy, and religion; the social sciences include anthropology, economics, government, political science, psychology, and sociology; the natural sciences include biology, bio-chemistry, chemistry, mathematics, physics, and all engineering programs. Omitted from the analysis are doctoral programs in education, social service professions, vocation studies, and home economics.

[16] A full set of empirical results is available from the author upon request.

The results concerning test scores are roughly the same under the SUR model as they were in Table 3. A college's 75th percentile SAT score is positively associated with Ph.D. creation rates for both groups of colleges, but a 100 point increase is associated with between a 0.6 and 0.9 percentage point increase, depending on discipline, for the top two tiers while a 100 point increase is associated with only a 0.1 percentage point increase for the bottom two tiers. The model can be expanded by replacing the 75th percentile SAT score with the percent of students who scored above a 700 on each subject test of the SAT. Almost twenty percent of the colleges, however, fail to report these variables. Consequently, many estimated coefficients are statistically insignificant as they are associated with large standard errors given the smaller sample sizes. That said, the results suggest that student abilities matter in their choices of major and graduate study. The percent of students who score above a 700 on the verbal portion of the SAT is positively associated with Ph.D. creation in the humanities and social sciences but is unassociated with Ph.D. creation in the natural sciences. Conversely, the percent of students who score above a 700 on the math portion of the SAT is positively associated with Ph.D. creation in the natural sciences but is unassociated with Ph.D. creation in the humanities or social sciences.

A final test of robustness is also worth mentioning. The *Completions Survey* data are not disaggregated enough to calculate the number of graduates in each academic division for each college. When a student double majors, for example, only one of his or her majors is recorded in the data. Accurate division-specific Ph.D. creation rates can be calculated, therefore, only if every double major always double majored in the same division. Making the heroic assumption that the *Completions Survey* data accurately reflects the distribution of undergraduate degrees, division-specific Ph.D. creation rates were calculated along with division-specific shares of undergraduate degrees. The model was re-estimated, once using the division-specific creation rates as dependent variables and once including each division's share of undergraduate degrees as an explanatory variable in that division's equation. Both sets of results qualitatively match the original SUR results, but estimates are much less stable across equations and models, and standard errors are larger.

Discussion

The creation of Ph.D.'s from elite liberal arts colleges remains a mysterious process, but this chapter has begun to shine some light on the differences across colleges. First, within colleges, Ph.D. creation rates are highly correlated across academic divisions. Second, college characteristics and student traits matter. Most important is student ability (as measured by test scores) when they enter college, but location, the percent of students who are female (positively related to Ph.D. creation in the humanities and social sciences; negatively related in the natural sciences), and curriculum (colleges that offer a business major are associated with lower rates of Ph.D. creation) also matter. Third, faculty research plays an important but selective role: Ph.D. creation is positively related to faculty scholarship, especially in the social and natural sciences, but only among the top 80 or so colleges.

Although the above mentioned factors are important, they do not tell the entire story. The regressions only explain about 50 percent of the variation in Ph.D. creation rates among the top two tiers of colleges, and even less in the next two tiers. To try to understand more of the Ph.D. creation process, the regression results were used to identify 21 colleges that consistently over-produce Ph.D.'s in all three academic divisions and 26 colleges that consistently under-produce Ph.D.'s. Using these two groups of colleges, a search was undertaken regarding each college's Career Center webpage and the services offered pertaining to graduate school. Under the assumption that colleges with career centers in the 1990s that focused attention on student applications to graduate school would continue to do so, a present-day comparison between the over-producing and under-producing colleges' career centers could be fruitful. Although quantitatively comparing webpages across colleges is difficult, the overall assessment shows that career centers at colleges that over-produce Ph.D.'s are about twice as likely to offer a large amount of information and provide access to multiple resources on the web to students who are interested in graduate school than are the career centers at colleges that under-produce Ph.D.'s.

The directors of the career centers of the over-producing colleges were also asked their opinion concerning how their center meets student needs. The over-riding theme told by directors of career centers is that they do not focus on funneling students toward graduate school; rather, when students

come to them for advice, the approach is to present the student with many options – job, graduate school, professional school, volunteering. Although graduate school is not the focus, it is discussed and presented as a viable option. All of the centers also had resources available to students to help with the process of applying to graduate school – from providing practice GRE tests to offering a list of alumni to talk to at various graduate programs to helping write a personal statement. Of course, it is unclear if the mission of career centers and the services provided result in greater interest in graduate school or if the students at colleges that create many Ph.D.'s require the career center to serve their needs.

In addition to career centers, the set of over- and under-producing colleges can also be used with the previously discussed faculty survey. Of the 358 responses to the faculty survey, 31 attended one of the over-producing colleges and 17 attended one of the under-producing colleges. Although the sample size is very small, some interesting patterns emerge. Compared to students from the under-producing colleges, students from the over-producing colleges were more likely to make the decision to go to graduate school in their last two years of college (61 vs. 47 percent) and were less likely to make the decision early in college or even before college (16 vs. 35 percent). There are also notable differences to what the respondents most attributed their decision to go to graduate school. Compared to students from the under-producing colleges, students from the over-producing colleges were more likely to attribute the decision to a professor (36 vs. 24 percent) and less likely to attribute the decision to a particular class (7 vs. 18 percent) or not enjoying work (3 vs. 18 percent). Response rates were more equal in attributing the decision to an undergraduate research project (7 vs. 6 percent) or not wanting to stop with schooling or having a love of learning (7 vs. 12 percent).

Finally, it is interesting to hear from the colleges directly as to what they think the source of their college's success is. The Dean of Faculty (or equivalent) at each of the over-producing colleges was asked: "Please describe why you think it is that your college is successful at having its students go on the earn Ph.D.'s." The common theme from all Deans concerned curriculum. Although the abilities and talents of incoming freshmen matter in terms of which colleges are most likely to produce future Ph.D.'s, the academic experiences of students while at college also play a role. Providing a serious curriculum,

encouraging students to take on challenges, and developing a campus environment that respects intellectual curiosity all contribute to the development of students. The idea of a campus culture in which graduate school is well-thought of was articulated by many Deans. Two examples stand out: Kalamazoo College and Scripps College.

Kalamazoo College has long been successful at producing future Ph.D.'s. Its creation rate was 9.2 percent in the 1970s, 10.6 percent in the 1980s, and 12.2 percent in the 1990s. It is also at or near the top in per capita volunteers to the Peace Corps. In the 1960s, Kalamazoo undertook a substantial curriculum change, called the K-Plan, that frames each student's entire four years of college. All students participate in a Freshmen Seminar and an off-campus internship in the second year. Study abroad is strongly encouraged in the third year, with over 80 percent of students participating. And all students are required to complete an individual research project during their senior year, many of which are year-long endeavors. For more information regarding the K-Plan, see www.kzoo.edu/about_kplan.htm.

Scripps College is the only all-women's college in the consortium of Claremont Colleges. Scripps has long offered a humanities focus to it students, but it intentionally widened its curriculum and recruited students to match in the 1980s. The required humanities curriculum was developed into the Core Program (www.scrippscollege.edu/dept/cor/about/index.html), in which all faculty are expected to teach regularly. The Core is a three-course sequence with the shared theme of "Culture, Knowledge and Representation." In addition to a more interdisciplinary curriculum, a new science building opened in 1990, and the number of science faculty was substantially increased. The number of science majors increased from just a few each year in the 1970s to presently graduating between 30 and 40 science majors each year. These developments, however, have helped to vastly increase Scripps' Ph.D. creation rate across all academic fields not just in the sciences. Scripps' Ph.D. creation rate was 2.4 percent in the 1970s and 4.2 percent in the 1980s. It has since increased even more, averaging 5.7 percent in the 1990s.

This chapter has begun to explore why some colleges are better than others at producing future Ph.D.'s. Much more research is needed. In particular, a careful analysis of why individuals choose to go to graduate school would be fruitful. Do the best colleges create future Ph.D. students or are they simply

the best at recruiting future Ph.D. students to campus? Do undergraduate research experiences push students toward graduate school? If so, are these experiences different at colleges than at universities? Is the academic lifestyle at liberal arts colleges appealing to its students so that this exposure explains why graduates of liberal arts colleges pursue Ph.D.'s at about twice the rate of graduates from large universities? The answer to these and many other questions would help us better understand the connections between an individual's undergraduate experience and his or her decision to go on to graduate school, possibly helping colleges better target this outcome.

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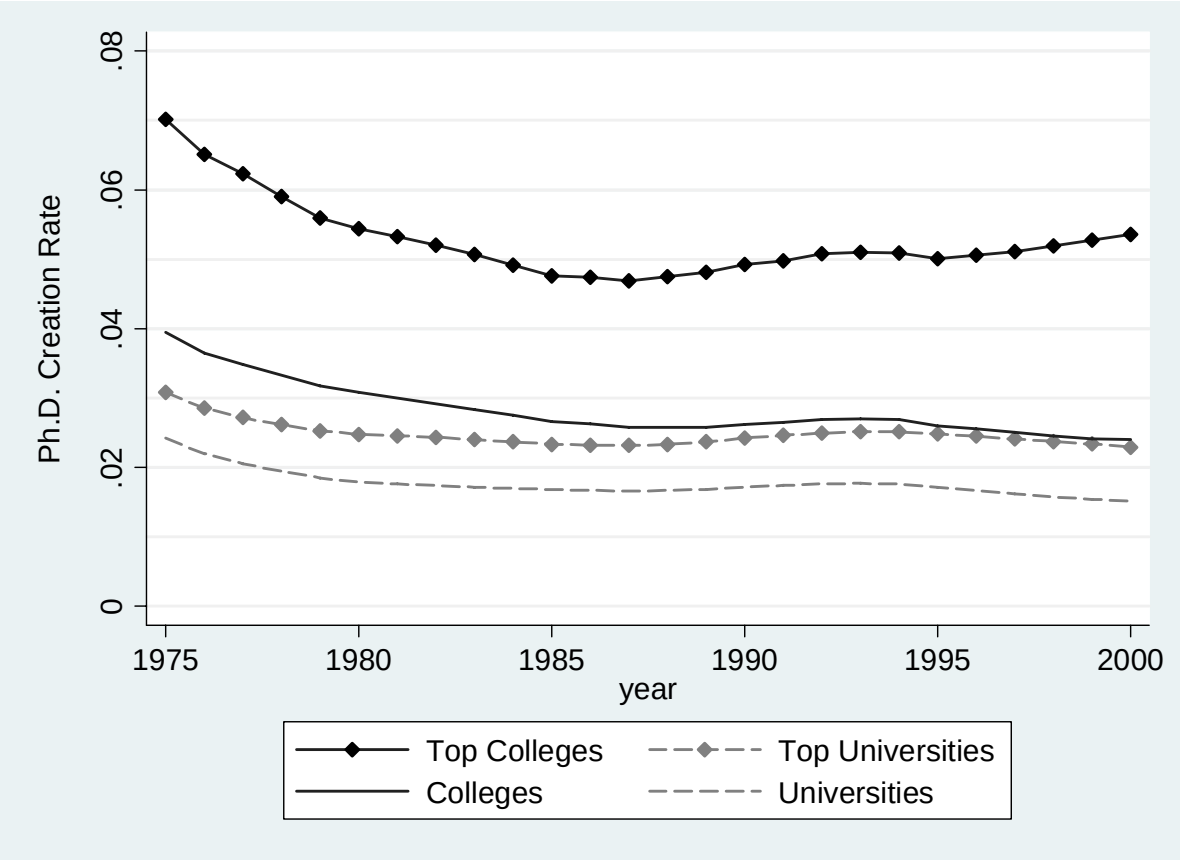
Figure 1. Ph.D. Creation Rates by Type of Institution



Source: Author's calculations using the NSF's Survey of Earned Doctorates and HEGIS/IPEDS Completion Survey. Colleges are all BA I and II Carnegie classified institutions in 1994. Universities are all Research I and II, Doctoral I and II, and Masters I and II Carnegie classified institutions in 1994. Top colleges are the BA I institutions, while top universities are the Research I institutions.

Table 1. The Timing and Motivation of Graduate School by Undergraduate Institution

Type of Undergraduate Institution	Liberal Arts College (N=152)			Research University (N=206)	
A. When did you know you were going to go to graduate school?					
Before College	14	9%		30	15%
Fresh/Soph Year of College	14	9%		30	15%
Junior/Senior Year of College	83	55%		102	49%
After College	41	27%		44	21%
B. To what factor would you most attribute your decision to go to graduate school?					
Family	16	11%		15	7%
Undergraduate Institution	89	58%		97	47%
Employment Goals	43	28%		73	36%
Self Motivation	4	3%		21	10%

Source: Author's survey. In the summer of 2006, the author sent the survey to 850 randomly chosen faculty members of elite liberal arts colleges, of which 358 were returned for a response rate of 42 percent.

Table 2. List of Colleges and 1989-98 Ph.D. Creation Rates

Rate	College	Rate	College	Rate	College
4.8	Agnes Scott College	2.3	Guilford College	18.4	Reed College
2.8	Albion College	2.9	Gustavus Adolphus Col	5.9	Rhodes College
3.2	Albright College	4.5	Hamilton College	5.1	Ripon College
5.9	Allegheny College	1.5	Hamline University	1.0	Salem College
3.1	Alma College	1.9	Hampden-Sydney Col	3.3	Sarah Lawrence College
9.3	Amherst College	6.6	Hampshire College	4.7	Scripps College
1.8	Antioch University	3.3	Hanover College	0.6	Shepherd College
3.2	Augustana College (IL)	2.1	Hartwick College	1.1	Siena College (NY)
3.1	Austin College	2.9	Hastings College	2.2	Skidmore College
4.1	Bard College	12.1	Haverford College	5.3	Smith College
7.4	Barnard College	6.4	Hendrix College	2.8	Southwestern University
5.4	Bates College	3.7	Hiram College	2.6	Spelman College
7.5	Beloit College	3.2	Hobart &William Smith	2.5	St. Andrews Presbyterian
2.1	Bethany College (WV)	1.8	Hollins College	4.0	St. John's University (MN)
2.5	Birmingham Southern Col	4.7	Hope College	3.3	St. Lawrence University
6.5	Bowdoin College	3.5	Houghton College	1.4	St. Mary's College of MD
7.5	Bryn Mawr College	1.9	Huntingdon College	7.1	St. Olaf College
4.1	Bucknell University	1.2	Illinois College	18.0	Swarthmore College
14.6	Carleton College	3.5	Illinois Wesleyan Univ	1.9	Sweet Briar College
2.6	Central College (IA)	5.1	Juniata College	2.5	Transylvania University
4.5	Centre College	11.2	Kalamazoo College	3.8	Trinity College (CT)
3.4	Chatham College	5.1	Kenyon College	3.4	Union College (NY)
2.2	Claremont McKenna Col	7.5	Knox College	1.6	University of Dallas
2.7	Coe College	4.1	Lafayette College	1.3	UNC at Asheville
4.5	Colby College	2.6	Lake Forest College	1.7	University of Puget Sound
4.3	Colgate University	7.7	Lawrence University	4.5	University of the South
1.7	Col of St. Benedict (MN)	1.6	Lewis and Clark College	2.4	Ursinus College
7.7	College of Wooster	3.4	Luther College	6.8	Vassar College
3.6	College of the Holy Cross	7.3	Macalester College	2.0	Virginia Military Institute
5.0	Colorado College	1.8	Manhattanville College	1.1	Virginia Wesleyan College
2.3	Concordia College (MN)	1.5	McDaniel College	7.9	Wabash College
3.5	Connecticut College	4.3	Middlebury College	2.2	Wartburg College
3.2	Cornell College	2.1	Mills College	1.8	Washington College
7.0	Davidson College	2.7	Millsaps College	2.2	Washington & Jefferson Col
3.4	DePauw University	2.7	Monmouth College	2.0	Washington and Lee Univ
3.5	Denison University	1.9	Moravian College	8.2	Wellesley College
3.5	Dickinson College	1.2	Morehouse College	6.9	Wesleyan University
2.6	Drew University	7.4	Mount Holyoke College	2.4	Westminster College (MO)
8.3	Earlham College	3.6	Muhlenberg College	1.7	Westminster College (PA)
2.5	Eckerd College	2.6	Nebraska Wesleyan U.	2.5	Westmont College
2.0	Erskine College	13.4	Oberlin College	2.4	Wheaton College (MA)
1.0	Franklin College Indiana	7.0	Occidental College	5.1	Wheaton College (IL)
5.7	Franklin and Marshall Col	1.2	Oglethorpe University	6.3	Whitman College
4.3	Furman University	3.8	Ohio Wesleyan Univ	1.4	Whittier College
1.3	Georgetown College	3.9	Pitzer College	1.5	Willamette University
3.0	Gettysburg College	11.4	Pomona College	1.7	William Jewell College
3.5	Gordon College (MA)	1.6	Presbyterian College	8.2	Williams College
4.6	Goshen College	2.3	Randolph-Macon College	3.5	Wittenberg University
4.4	Goucher College	4.0	Randolph-Macon Wom's	2.5	Wofford College
11.1	Grinnell College				

Table 3. OLS Regression Results

	Tier 1 & 2 Colleges	Tier 3 & 4 College
SAT 75th percentile score.	0.0203***	0.0037**
	0.0049	0.0017
Ln(enrollment).	0.3578	-0.0782
	0.8361	0.3464
Percent students who are female (0 to 100).	0.0048	-0.0069
	0.0172	0.0066
Per student expenditures in $1,000.	0.0721	0.1484**
	0.1271	0.0673
College offers a business degree (0/1).	-1.9485***	0.2123
	0.6893	0.3922
College is located in the northeast (0/1).	-3.0178***	0.8110*
	0.6677	0.4451
Citations per faculty member 1989-98	0.4497**	-0.0161
	0.2289	0.1856
Constant	-24.3854	-2.8280
	8.6792	3.6664
Number of Observations	81	67
R-squared	0.5615	0.2482
Adjusted R-squared	0.5195	0.1590

Note: The dependent variable is each college's overall Ph.D. creation rate measured 0 to 100 and is calculated as the number of Ph.D.'s earned by alumni of the college from 1994 – 2003 measured as a percent of the college's graduates from 1989 – 1998.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.