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ABSTRACT

The use of a modified training opportunities approach for predicting the number of graduate enrollments and degrees at the University of Illinois at Urbana-Champaign is considered. Data concerning graduate assistantships and faculty staffing levels were used to predict, with a high level of accuracy, the number of graduate enrollments and degrees. Predictions were based on the multiple regression technique. Possible impacts upon institutional, regional, and national policy are discussed, as are the other major theories of graduate manpower planning: the market, demographic, and credentialist approaches. From a theoretical perspective the study tends to support the notion that the training opportunities approach can be used as a proxy for the demographic, market, and credentialist approaches in analyzing scientific manpower supply and demand. The basic assumption of the approach was that the availability of financial aid to students in scientific fields, as well as the faculty staffing levels in those same fields, ought to serve as a useful predictor of enrollments and degrees produced. (Author/SW)

A "Training Opportunities" Model for Predicting Advanced Degrees in the Sciences

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Mary Corcoran
University of Minnesota
(Editor, AIR Forum Publications)

Abstract

This study shows how a modified "training opportunities" approach to the prediction of number of graduate enrollments and degrees at a large university can be employed using multiple regression. Readily available data concerning graduate assistantships and faculty staffing levels were utilized to predict, with a high level of accuracy, the number of graduate enrollments and degrees. Possible impacts upon institutional, regional, and national policy are discussed, as are the other major theories of graduate manpower planning: the market, demographic, and credentialist approaches.

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Review of the Literature

The problems associated with the seeming over- and under-supply of doctorates over the past twenty years have received quite a bit of attention both in the popular and scholarly media. Allan Cartter was one of the first people to call attention to the shift from shortage to surplus among supply of doctorates in the 1960's (Cartter, 1965), particularly among those doctorate holders seeking teaching positions in colleges and universities. He has continued to update his original estimates (1971, 1974, 1976), which have generally proven to be accurate in light of their assumptions.

At least two problems emerge from Cartter's research, however. First, Cartter tends to focus his efforts on the academic marketplace, i.e., employment opportunities in postsecondary education. This focus seems natural, since traditionally many holders of doctorates have become college faculty. The demand for these faculty can also be estimated more accurately than total doctoral demand, as demographics make it possible to estimate the number of people in the "traditional" college age group (18-22 years old). Cartter also tends to treat doctoral production in the aggregate, lumping all doctorates together in a total supply/demand relationship. In fact some fields will be impacted more by the decline in academic employment than others, for less than half of all doctorates in chemistry and engineering teach while over ninety percent of those in the humanities have traditionally done so (Cartter, 1976:225). Cartter's research is consequently quite useful, though also limited, as far as policy makers are concerned.

Moffat (1978) characterizes Cartter's work as being primarily demographic in nature; that is, demographics are the driving force behind doctoral supply and demand. Besides this demographic approach, she has identified three other models to explain the study of doctoral supply and demand: the market, credentialist, and training opportunities approaches. The market approach is represented by Freeman (1971, 1975) and Freeman and Breneman (1974). Freeman focuses on the ups and downs in the market for trained manpower, a process that he has labeled as the "cobweb" cycle. Especially in fields such as engineering, high demand in one year stimulates enrollments, causing over-supply several years hence, which then encourages low enrollments and under-supply at even later dates. Although he has done research on particular fields, Freeman too seems to make most of his contributions at the macro level, aggregating all doctorates into one pool.

The credentialist approach is more theoretical than the others. It holds that doctorate demand will increase as the supply of doctorates outside of colleges and universities increases. In other words, supply of educated personnel creates its own demand. Employers will simply require a higher educational level (credential) for positions than would otherwise have been the case. The social status associated with higher educational achievement, as well as the perceived differences among doctorates as to the "quality" of their degrees, are also part of the credentialist argument (Niland, 1972).

The demographic, market, and credentialist approaches can be thought of as focusing on individual student decisions as to whether or not to pursue a doctorate, although they do treat such decisions in aggregate terms.

These three approaches view the individual student as acting in light of perceived supply, demand, and social realities. The training opportunities approach, on the other hand, takes the viewpoint of the educational unit (i.e., department) training the future doctorates. Rather than being passive recipients of individual students, departments and universities are seen as being active agents in their training. The training opportunities approach emphasizes sources and amounts of support for graduate training as being a primary force in the production of doctorates, and in particular the training of students in one field rather than in another.

Freeman (1971:107) found evidence to support this approach in that graduate enrollments have been maintained by the use of student financial support even when the fields of sutdy have had poor market prospects. Cartter (1976:137-38), while still contending that total graduate enrollments are fixed by demographics, also found evidence of a high level of substitutability among fields. This suggests that decreased graduate support in one field will not decrease total graduate enrollment, but that it may shift graduate students from one discipline to another.

A potentially fruitful hypothesis that emerges from studying the four approaches summarized by Moffat is that the training opportunities model incorporates the demographic, market, and credentialist approaches, in a sense. Demographics reflect a potential pool of students for scientific graduate study (supply of people); enrollees and potential enrollees have a need for financial support (demand for funds). The training opportunities approach describes the level of response made by departments and universities to these forces. Likewise the marketplace requires skilled manpower (demand for people) and often encourages enrollments in specific fields (supply of funds). Again the training opportunities approach incorporates these forces by pointing out the changes among disciplines over time. Finally, the funds and students tend to flow disproportionately to the most prestigious institutions, confirming a major argument of the credentialist approach. The differences in training opportunities among universities serve as a barometer of these trends.

Thus training opportunities are interrelated with the other three variables; in a sense training opportunities reflect and confirm trends among the other three. The resulting hypothesis incorporated here is that by studying training opportunities alone, one ought to be able to predict doctoral production in various scientific disciplines. Graduate assistant and faculty levels are utilized as variables which measure level of training opportunities.

Methodology

In order to do a preliminary test of the hypothesis that the training opportunities approach incorporates the other three, a study was developed at the University of Illinois at Urbana-Champaign (UIUC). The basic assumption was that the availability of financial aid to students in scientific fields as well as the faculty staffing levels in those same fields, ought to serve as a useful predictor of enrollments and degrees produced.

The University of Illinois at Urbana-Champaign is a very representative institution for testing this hypothesis in that it produces large numbers of graduate degrees in the sciences each year. In engineering, for example, UIUC alone enrolled 1.67% of all undergraduates and 2.40% of all graduate students in the United States during the fall of 1976 (Engineering Manpower Commission, 1976).

For purposes of the study, both enrollments and degrees initially were predicted using the following variables for each Fall Semester of the five years prior to the year in which enrollments or number of graduates were being predicted:

1. Number of graduate assistantships funded from non-state sources;
2. Number of graduate assistantships funded from state sources;
3. Number of academic employees funded from non-state sources;
4. Number of academic employees funded from state sources.

Later another predictor, prior year's enrollment, was added. The initial result was twenty variables (four in each year times five years) being used to predict graduate enrollments and degrees. The addition of prior year's enrollment increased the number of predictors to twenty-one. Stepwise multiple regression was the statistical technique used to build the preduction equations employing these predictors.

The departments from which data were gathered for this study were those which are surveyed by the National Science Foundation's own Survey of Scientific and Engineering Personnel Employed at Universities and Colleges. At UIUC these departments were as follows:

Agricultural Engineering
Aeronautical Engineering
Chemical Engineering
Civil Engineering
Electrical Engineering
Mechanical Engineering
Ceramic Engineering
Metallurgy and Mining
Nuclear Engineering
Theoretical & Applied Mechanics

Agronomy
Animal Science
Dairy Science
Food Science
Horticulture
Plant Pathology

Botany
Biochemistry*
Entomology
Biology
Microbiology
Physiology and Biophysics
Zoology**

Economics
Agricultural Economics
Sociology
Political Science
Anthropology
Geography
Linguistics

Chemistry*
Physics
Astronomy

Psychology

Mathematics
Computer Science

*Until Fall, 1970, the Chemistry Department included what is now the Biochemistry, Chemistry, and Chemical Engineering Departments.

**Zoology split into two departments as of Fall Semester, 1976: Ecology, Ethology, and Evolution and Genetics and Development.

Results

There were several types of prediction equations generated using the data from these departments. In predicting degrees, equations were computed which estimated the number of master's and doctoral degrees granted in the years 1972 through 1976 utilizing the twenty predictors mentioned earlier for each graduating year. One way to do this is to treat all the departments as a single group and compute the best prediction equation for that group. This yielded a correlation (R) of .90 for master's degrees and .95 for doctorate's with a population of 179. The population figure is based on each department contributing five separate sets of predictions, one for each year. The odd number (179) is caused by the splitting of departments involved. Of the twenty predictors, eight were found to be significant in predicting master's degrees and five in predicting doctorates. It should be noted, however, that data for a single department were highly correlated from year to year. It should also be noted that these high correlations were obtained despite the absence of any enrollment data for the departments and despite the wide variation in disciplines.

Other summaries of the data were also tested in trying to build equations that predicted well. The Engineering, Physical Science, and Mathematics departments were lumped together, with a resulting R = .98 and N = 72 for master's degrees and R = .99 and N = 72 for doctorates. The Agricultural and Biological Sciences yielded R = .67 and R = .79 for master's and doctoral degrees respectively, each with N = 67. Psychology and the Social Sciences had values of R = .93 and R = .96 for master's degrees and doctorates, each with N = 40.

An alternate means of grouping the data was tried as well. Prediction equations were developed which predicted number of graduate degrees across all the disciplines mentioned, but only for a single year. The results are given below:

UIUC Graduate Degree
Correlations 1972-76

Year	Master's R	Master's N	Doctorate R	Doctorate N
1972	.94	35	.98	35
1973	.94	35	.99	35
1974	.96	35	.98	35
1975	.94	37	.97	37
1976	.92	37	.96	37

As with degrees earned, it was possible to develop prediction equations for enrollments. For purposes of this study the data available for predicting enrollments were more current than those used in predicting degrees, principally because the number of degrees used was a three-year average in an attempt to smooth out short-term ups and downs in degrees granted. Consequently the enrollments predicted were for the Fall Semesters, 1974 through 1978, and previous year's enrollments were added as predictors.

Again grouping the Engineering, Physical Science, and Mathematics departments together achieved relatively high correlations, R = .98 and R = .99 for master's and doctoral enrollments respectively with N = 74 for each. The Agricultural and Biological Sciences results were R = .94 and R = .96 with N = 69, while Psychology and the Social Sciences yielded R = .93 and R = .98 where N = 40. For all departments included over the five-year period, master's degree enrollments showed a correlation of R = .97 and doctoral enrollments were R = .99 and N = 183 each. The year-by-year results were as follows:

UIUC Graduate Enrollment
Correlations 1972-76

Year	Master's R	Master's N	Doctorate R	Doctorate N
1974	.98	35	.99	35
1975	.99	37	.99	37
1976	.99	37	.99	37
1977	.98	37	.99	37
1978	.99	37	.99	37

Discussion and Conclusions

The results of this study were of course encouraging. They also revealed at least two facts that were somewhat unexpected. First, they showed that degrees (and enrollments) can be predicted with surprising accuracy without the use of prior enrollment figures. Secondly, they demonstrated that levels of faculty and staff are important predictors of numbers of graduate students. In other words, simply increasing numbers of assistantships will not in and of itself produce higher enrollments in the absence of sufficient numbers of scientific mentors for the potential graduate students.

The type of investigation described here is probably most useful to a person involved in manpower planning at the national or regional level. When many departments and universities are used in building equations to predict graduate enrollments and degrees conferred, institutional iodiosyncracies are less likely to throw the predictions off target; unusual local circumstances tend to "wash out." The kind of approach described here would be particularly useful in planning programs to increase manpower in specific areas such as energy-related fields. If one could determine the average assistantship level in a discipline, for instance, he then ought to be able to estimate how much financial aid would be necessary to produce a certain number of graduates in that particular field.

While acknowledging the limits of this type of study at a single university, it might still be useful to explore the possibilities opened up by such an approach. It would be possible, for instance, to simulate the possible effects on enrollments within a university of increasing or decreasing graduate student financial aid by using prediction equations based upon multiple regressions of historical data. Developing equations for different years can also show the changing influence of certain variables over time. For example, an institution might find that more assistantships were necessary to produce graduate students in 1976 than in 1968, since poorer job prospects in 1976 made paying one's own way less attractive financially.

From a theoretical perspective the study tends to support the seemingly simplistic notion that the training opportunities approach can be used as a proxy for the demographic, market, and credentialist approaches in analyzing scientific manpower supply and demand.

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