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SELECTING CREATIVE Ph.D. CANDIDATES FOR ADMISSION

by

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and

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ABSTRACT

An equation useful for predicting the performance of Ph.D.'s during their careers in research is developed, using information available at the time applications are submitted. A quality adjusted index of research is used to measure performance. Undergraduate grades, age at time of application and previous graduate training appear to be important for the prediction. Scores on standardized tests do not discriminate within the range covered by the sample.
Each year graduate schools across the country select students for their doctoral programs. At most schools, the doctoral degree remains a professional degree with primary emphasis on professional development shown by research or scholarly attainment. As in other professional programs, the learning acquired during the training period is but a small part of the professional's education. The attainments of former students during their professional careers, their ability to continue their education and contribute to the development of their discipline through creative work, are used to judge the success of doctoral programs and the quality of the schools.¹

Very little is known about the selection process, and few if any attempts have been made to evaluate selection criteria or set down the particular criteria that are most useful for selecting the candidates most likely to be creative and productive. There are few usable measures of creativity and perhaps even less information about the value of the particular pieces of information collected on application forms. Nevertheless, at most schools, a substantial amount of faculty time is spent reading and assessing such information as part of the process of choosing candidates and awarding fellowships and assistantships to prospective doctoral students. A much larger cost is the investment of the school's resources, particularly faculty time, in the training and supervision of the doctoral students who enter and complete the program. A main purpose of our study is to
improve the selection process and thereby raise the average quality of students admitted.

This paper reports on a study of approximately fifty Ph.D.'s who completed all of the requirements for the doctoral degree in economics or industrial administration before June 1967. The study uses multiple regression to develop a relationship between items of information available at the time admissions decisions are made and a measure of professional accomplishment. Since the study is concerned with the characteristics of "successful" candidates, students who failed to complete the program or who are still in process were excluded from the sample.

Procedure

All Ph.D. alumni who had received the degree in industrial administration or economics prior to June 1967 were asked to submit bio-bibliographic information. The mailing was sent to the (entire) 56 alumni, and 47 returns were received. Casual examination suggests that the 9 non-respondents include some of the more productive alumni, so that non-response probably does not introduce substantial bias. An additional 50 students that entered the program were not included in the sample. Of these, 21 entered the program after 1963 and had completed all of the requirements except the dissertation while the remaining group included those who transferred out of the program, were asked to leave, or failed to complete the dissertation. None of the data included students currently enrolled.
The school attempts to train researchers and in judging its program gives pride of place to the amount and quality of the research done by its alumni. The school's catalogue makes this emphasis clear. In addition, students are reminded of the importance of high quality research in the school's program at time of enrollment and through a number of devices built into the program such as participation in research projects or encouragement to revise and publish term papers or the results of summer work. These devices and the frequently expressed attitudes of both faculty and administration leave little room for doubt about priorities.

To measure the quality of research output, we classified the journals in which alumni had published into four broad categories -- economics and finance, management and administration, computers and systems, and behavioral sciences -- representing the four areas of principal interest to the school and asked current faculty members to rate the average quality of the research published in each journal within his own area(s) of interest. Weights of 5, 2, 1 were chosen to rank articles according to whether the faculty judged the journal to be of high, average, or low quality. Scholarly books were considered to be equivalent to two high-quality journal articles, and books of readings were considered equal to one low-quality article. Conference proceedings, working papers, and chapters were treated as publications in low quality journals. Book reviews were not counted, and articles were not recognized unless they had been published or accepted for publication, not merely submitted. Theses were counted only if published. Using the weights, we constructed a quality-adjusted index of professional output.

The values of the index ranged from zero to ninety-six. The mean index, 26.5, shows that an average alumnus published the equivalent of
five articles in high quality journals. The mean number of years since completing the residency requirement is 5.6 for our sample so on the average a representative alumnus published the equivalent of one article per year in a high quality journal during the period. We suspect that the respondents have been substantially more productive than a representative sample of Ph.D.'s from research oriented Ph.D. programs, and this should be kept in mind when judging the results reported below. Table 1 shows the distribution and range of the index by years out of school.

Insert Table 1 here

The independent variables in the regression were taken from the information available at the time admission decisions were made. For most alumni, these included scores on either the Graduate Record Exam (GRE) or Aptitude Test for Graduate Study in Business (ATGSB), college transcripts, letters of recommendation and the information requested on most standard applications to graduate school.

Results and Discussion

We tested a number of different hypotheses. The results in Table 2 suggest that seven variables explain slightly more than fifty per cent of the variance in our measure of performance, the quality-adjusted publications index. In this section, we discuss the variables that were used and describe some of the alternatives that were tried and rejected.

Insert Table 2 here

Three variables measure previous academic aptitude and/or achievement--undergraduate grade average, prior graduate study, and type of undergraduate degree (science and technology or other). A qualitative or dummy (0,1) variable was used to measure the last two attributes. Students who enter with
higher grade averages and previous graduate training publish more after they receive their Ph.D. degree. Other things equal, students who enter with previous training in science and engineering publish less.

Grade averages are often regarded as ambiguous indicators of future performance that confound measurement of ability, motivation and past achievement. Our study suggests, however, that undergraduate grade average is one of the most useful variables for predicting future performance of the Ph.D. candidates in our sample. Our regression suggests that among students with equal ranks on measures other than grades available at the time admission decisions are made, C-average students publish fifty per cent less than the mean and A students publish fifty per cent more than the mean. One reasonable explanation for this difference in accomplishment is that, given test scores and the other measures of achievement and ability included in the regressions, undergraduate grade average becomes a useful measure of motivation.

The positive coefficient on previous graduate study may be a crude measure of intellectual maturity and motivation. The highly specialized nature of most doctoral programs is of greatest benefit to students with well defined goals. Since most students do not change schools or programs between the masters and doctors degree, those that do include able students with clearly defined goals who were not satisfied by their previous program. A qualified applicant who has narrowed his interests is probably more highly motivated, receives training more closely related to a career goal and as a result achieves more.

The negative effect on performance of undergraduate training in science and engineering is more difficult to explain and runs counter to strongly held beliefs about the higher levels of ability required for successful performance in these fields. One suggested explanation is that the students in our sample are drawn from a small, unrepresentative segment of the college population. From this group the achievement represented by successful completion
of a degree in science or engineering may be measured by other variables used to select students, such as scores on national aptitude tests or grade averages. However, this argument explains a lack of association, not a negative relation. An alternative explanation consistent with the finding is that engineering education stresses manipulation and techniques, rather than creativity, and is therefore less desirable as preparation for research in social and management sciences.

Two measures of aptitude or achievement that we expected to be important were scores on standard aptitude tests such as the GRE or ATGSB and the quality of the undergraduate college from which the student graduated. We found little support for using any of the several measures of quality or aptitude that we tried. Generally, the regression coefficient for the aptitude test score was negative and not significant at the 90% level. When quantitative and verbal scores were separated, both had negative coefficients, and neither appeared to be significant.

One reasonable explanation of the lack of significance is that the explanatory power of test scores is restricted by the small range from which students are drawn. Most students were in the 90th percentile or above. On this explanation, the aptitude tests may be more useful for screening students than for selecting students that pass the preliminary screening. A second proposed explanation is that within the restricted range we use, the highest test scores measure two related but different attributes. One is the creative problem-solving ability that is a requisite for a career in research. The other is an efficient, well-organized memory and an ability to perform well on standardized tests. Our attempts to separate these two effects if they are present, proved fruitless as did our attempt to find a non-linear relation between test score and our measure of performance.

Three different ratings were used to measure the quality of undergraduate schools. Two of the measures were published ratings of colleges and universities in the United States. [2], [3]. The third is the average score on the ATGSB exam received
by all students taking the test as the applicant's undergraduate college during
the years 1957-62. None of these measures added to the explanatory power of the
regression equation, so none are included in the final results.

A second group of three variables included in Table 2 measures attributes
of the applicant other than aptitude and the applicant's proposed field of
study. Younger students are significantly more productive than older students
and foreign students have been marginally more productive than U.S. or Canadian
citizens. The effect of foreign birth is of marginal significance; the variable
was originally included in an attempt to hold constant one of the factors that
might account for the insignificant effect of the ATGSB score. The significant
negative coefficient on the dummy variable measuring choice of field suggests
that students who majored in administration or organization theory published less
than students in economics or management science. Although this dummy variable
is significant by the usual statistical tests, \( T = 3.24, p<.005 \) the result
may indicate nothing more than the arbitrary method by which journals were ranked
by faculty members.

The final significant variable is the number of years since completing
residency in school, "years out." Given the scale of the productivity index, the
coefficient of "years out" suggests that, on the margin, each of our alumni
publishes annually either two articles in a journal of average quality or slightly
less than one article in a journal of highest quality. This is similar but
slightly smaller than the average productivity per year shown earlier.

A number of hypotheses about research productivity have been offered. One is
that productivity increases with time, at least for a few years, because doing
research and publishing papers involves learning about the research process as
well as about the subject matter. A related argument suggests that the researcher
learns about the standards of the profession and spends less time revising
papers for publication. With increasing recognition of published work and past
research, there are more opportunities to participate in conferences, present papers at meetings and publish papers that are not reviewed as carefully. All of these hypotheses, if true, suggest that our linear relation misstates the effect of "years out" on the productivity index.

Each of these arguments may be true for individuals but false for the group. Some of those who trained for a career in research drop out after a few trials. Others continue to publish but allocate an increased portion of their working time to other activities—consulting, administration, teaching—or having achieved some rank, devote less time to work.

To estimate the relative strength of these positive and negative effects, we divided the productivity index by "years out" for each of our alumni and reran the regression shown in Table 2. The coefficient of "years out" became negative (-.07) and was not significant even at the 70% level. In our sample, the two effects appear to be offsetting. Since the mean alumnus has held the Ph.D. for little more than five years, our results suggest that the type of creative activity measured by our index declines rapidly. This finding is of particular interest since the overwhelming majority of the group successfully completed and published at least one article.

Conclusion

Very little is known about the factors useful for predicting research productivity or other measures of creative scholarship. From among the many items of information available at the time of admission, our study identifies a few that can be used to predict future research productivity of the members of a group of relatively productive Ph.D.'s. Clearly, our list of variables is
incomplete. Motivation is measured mainly by undergraduate grade average. We neglected such standard items as personal interviews, or essays on career goals, considered useful by many and possibly most admissions officers or committees. Our attempts to scale letters of recommendation, another common source of information, proved unsuccessful.

Our findings suggest that some of the variables stressed by admissions committees are considerably less important than is commonly believed while other frequently neglected, variables are useful for explaining differences in performance. Scores on standard aptitude tests appear to provide little information within the range covered by our data. An undergraduate degree from the more prestigious and higher ranked schools does not appear to indicate research potential, although again the schools represented only a small portion of the range of schools in the U.S. On the other hand, the much maligned grading system appears to provide relatively useful information for predicting research outputs and our data suggest that older students are significantly poorer prospects than younger students.

Finally, our study suggests that two opposing forces affect the research productivity of the group. The effect of increasing individual productivity over time appears to be offset by the decline in the proportion of the group engaging in research. Since, on the average, the alumni in our sample had held the Ph.D. for five years, our data suggest that the "drop out" rate or rate of withdrawal from research is relatively rapid even among a group of Ph.D.'s that we suspect is more productive than the national average. Given the very high cost and increased demand for training, these findings suggest the importance of research designed to improve methods of recognizing research oriented invididuals.
Table 1
Distribution of Publication Index

<table>
<thead>
<tr>
<th>Years Out</th>
<th>Number</th>
<th>Range</th>
<th>Average Publication Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>0-12</td>
<td>4.25</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>0-8</td>
<td>5.25</td>
</tr>
<tr>
<td>3</td>
<td>8</td>
<td>0-40</td>
<td>23.4</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>2-24</td>
<td>15.0</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>6-71</td>
<td>37.5</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
<td>14-38</td>
<td>26.0</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>0-76</td>
<td>35.7</td>
</tr>
<tr>
<td>8</td>
<td>6</td>
<td>5-29</td>
<td>15.5</td>
</tr>
<tr>
<td>9</td>
<td>2</td>
<td>22-38</td>
<td>30.0</td>
</tr>
<tr>
<td>10</td>
<td>3</td>
<td>42-96</td>
<td>63.0</td>
</tr>
<tr>
<td>more than 10</td>
<td>3</td>
<td>39-60</td>
<td>46.3</td>
</tr>
</tbody>
</table>
Table 2
Relationship Between Publication Index
and Explanatory Variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Regression Coefficient</th>
<th>Std. Error of Coeff.</th>
<th>t-statistic</th>
<th>P</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Undergraduate grade-point average</td>
<td>14.22</td>
<td>5.98</td>
<td>2.38</td>
<td>&lt;.025</td>
<td>3.12</td>
</tr>
<tr>
<td>2. Previous graduate study</td>
<td>9.36</td>
<td>5.43</td>
<td>1.72</td>
<td>&lt;.05</td>
<td>.49</td>
</tr>
<tr>
<td>3. Undergraduate degree (scientific or technical=1; non-scientific=0)</td>
<td>-10.03</td>
<td>5.13</td>
<td>-1.96</td>
<td>&lt;.05</td>
<td>.49</td>
</tr>
<tr>
<td>4. Age at entrance</td>
<td>-1.50</td>
<td>.84</td>
<td>-1.78</td>
<td>&lt;.05</td>
<td>24.40</td>
</tr>
<tr>
<td>5. Citizenship (US or Canada=0; foreign=1)</td>
<td>8.92</td>
<td>8.94</td>
<td>1.00</td>
<td>&lt;.25</td>
<td>.09</td>
</tr>
<tr>
<td>6. Field of study (Organizational behavior=1; other=0)</td>
<td>-20.34</td>
<td>6.28</td>
<td>-3.24</td>
<td>&lt;.005</td>
<td>.21</td>
</tr>
<tr>
<td>7. Years out</td>
<td>4.02</td>
<td>.87</td>
<td>4.62</td>
<td>&lt;.001</td>
<td>5.62</td>
</tr>
<tr>
<td>8. Constant</td>
<td>- .03</td>
<td>30.73</td>
<td>- .00</td>
<td></td>
<td>1.0</td>
</tr>
</tbody>
</table>

Publication Index

R² adjusted = .51
R adjusted = .72
Degrees of freedom = 39
FOOTNOTES

1/ The recent Cartter [1] report on graduate education, for example, distinguished between the reality of the faculty and the quality of the program. The latter is more closely related to the achievement of former students.

2/ Science and technology include all engineering, mathematics, physical and biological science but not psychology, social sciences or humanities.
BIBLIOGRAPHY

