Analyzing Academic Performance

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Every department with a graduate program annually faces the task of admitting or rejecting prospective graduate students and allocating the scarce funds available to support them. In the past, these decisions have been made in a simplistic and subjective manner. Information is regularly accumulated on each applicant, but most departments have no framework to incorporate all relevant information in their decisions. Consequently, information important to the decision-making process may be ignored or improperly used by weighting it too heavily or too lightly while making these decisions. The information on former graduate students has not been systematically analyzed as an aid to this decision-making process.

This paper describes an analytical and systematic approach to predict the potential academic performance of graduate students in a particular program. This information would assist a department in accepting or rejecting an individual student. It would also provide guidelines for ranking students for financial support from limited funds.

The Model

For many years admission to graduate programs was predicated primarily on undergraduate academic performance. This performance could be measured by undergraduate grade point average and letters of recommendation, while taking into consideration the universities attended. Special consideration was given to related work experience for those students who had not performed well in their undergraduate careers. In such cases it was felt that added maturity, as well as job-related experience, would improve their ability to perform in a graduate program.

A student's major as an undergraduate also influenced his acceptability into a program. Students entering a graduate program from a similar undergraduate program were expected to have an advantage over other majors since they had already studied most preparatory material. Coursework in some other majors was also acceptable. For example, an agricultural economics graduate program would consider an undergraduate degree in business administration appropriate for students who wanted to study agri-business. Also, agronomy or animal science would be appropriate for students who wanted a career in farm management.

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Within the last decade, student aptitude has played an important role in graduate admission. Many departments have now established minimum scores on the graduate record exam as requirements for admission. These requirements may be related to either minimum verbal, quantitative, or total scores.

The real difficulty in assessing a prospective student's credentials concerns the relationship among all these variables. What is the tradeoff between the undergraduate grade point average and the graduate record exam score? Consider these two students: student A has a 1050 GRE and a 2.5 GPA, while student B has a 900 GRE and a 3.2 GPA. Are both students admissable to the graduate program? Which student is likely to perform better in the graduate program? Furthermore, the student's undergraduate major, nationality, age, and work experience must be considered. All available information must be systematically analyzed before the department can make decisions on admission and financial support. Analytical techniques can be used to predict the academic performance of prospective graduate students and therefore determine their acceptance into the program.

Data and Methods

Information from the files on 1969-74 graduates of the master's program in the Department of Agricultural Economics at the University of Georgia was used to determine factors affecting graduate student performance. The study included the records of 53 graduate students. Factors considered to influence academic performance were restricted to information regularly collected for each applicant. Academic performance in the graduate program was assumed to be measured by the graduate grade point average.[1] Hopefully, the present analysis will provide background material for subsequent analyses to broaden this definition of academic performance.

Graduate students in the agricultural economics department were cross-classified by graduate grade point average and selected characteristics. Regression analysis was used to quantify the impact of undergraduate grade point average and GRE scores on graduate grade point average. The regression results give information on the trade-off between these two important explanatory variables.

A more in-depth analysis is used to predict how a particular student would perform in the graduate pro-

[1] Although the grade point average will depend on the courses taken, restricting the study to one discipline should help standardize this measure of academic performance.

Table 1. Selected Characteristics of Graduate Students Grouped by Graduate Grade Point Average.

	Units	Graduate Grade Point Average			
		Less than 3.30	3.30-3.60	Greater than 3.60	Overall Average
Students	Percent	22.6	30.2	47.2	-
Grade Point Average					
Graduate	Cumulative GPA	3.1	3.4	3.8	3.5
Undergraduate	Cumulative GPA	2.7	2.8	3.1	2.9
Graduate Record Exam					
Verbal	Test Score	334.2	363.1	381.2	365.1
Quantitative	Test Score	458.3	545.0	560.6	532.3
Total	Test Score	793.7	908.8	941.8	897.4
Percentage less than 260 Verbal	Percent	41.7	12.5	4.0	15.1
Percentage less than 900 Total	Percent	66.7	56.3	36.0	49.1
Related Work Experience	Years	3.0	2.0	0.6	1.6
Age	Years	29.0	27.6	24.4	26.4
Undergraduate Major					
Agricultural Economics	Percent	58.3	37.5	72.0	58.5
Business College	Percent	0.0	18.8	12.0	11.3
Agriculture College[a]	Percent	25.0	12.0	12.0	14.9

[a] Excludes agricultural economics majors.

gram. Discriminant analysis was used to differentiate between groups of students on the basis of several characteristics of those students.[2] Any single measurement might not classify the students correctly; however, a linear combination of various measurements whose distributions for the various groups would possess very little overlapping can be used to classify students. This linear combination would provide a type of index number which could be used to differentiate among groups with a high percentage of success. The procedure for discriminating among groups for an individual would consist of finding his index value for each of the groups and assigning him to the group for which he had the highest index value.

Analysis

Cross Sectional Analysis

The graduate students in this study appeared to cluster into three groups: the lower group had graduate grade point averages less than 3.30, the middle group had between 3.30 and 3.60, and the higher group had graduate grade point averages greater than 3.60[3] Note that subsequent analysis of these groups does not necessarily mean that the lower group reflects unacceptable academic performance. However, mean graduate GPAs for the three groups were statistically different. Mean scores for this variable and other selected characteristics for the three groups are shown in Table 1.

As expected, those students with higher graduate grade point averages had higher undergraduate grade point averages. The undergraduate grade point averages were 2.7 for the lower group, 2.8 for the middle group and 3.1 for the upper group. Thus, there was little difference between the lower two groups, but the upper group had a significantly higher grade point average.

In general, verbal, quantitative, and total graduate record exam scores showed a positive relationship to graduate grade point average. Those students having verbal scores below 260 were more likely to fall into the lower group than the middle or higher groups, as were those students with total graduate record exam scores below 900. More specifically, 41.7 percent of the lower group had verbal scores under 260 compared to only 4.0 percent for the higher group. Two-thirds of the lower group had total graduate record exam scores below 900 compared to only slightly over one-third for the higher group.

Related work experience and age had a negative relationship to graduate grade point average. In each group there were more undergraduate majors in agricultural economics than in other majors. However, students with undergraduate majors in agricultural economics comprised a greater percent of the higher graduate GPA group than of either the lower or middle groups.

A student with the combination of a higher undergraduate GPA, higher GRE scores, and an undergraduate major in agricultural economics is more likely to fall

[2] For a thorough discussion of the applications of discriminant analysis to guidance, see David V. Tiedeman, "The Utility of the Discriminant Function in Psychological and Guidance Investigations," Harvard Education Review, Volume 21, 1951, pp. 71-80.

[3] These groups were used in the discriminant analysis.

Table 2. Discriminant Functions Which Classify Graduate Students According to Graduate Grade Point Average.

Variable	Graduate Grade Point Average			F-Value
	Less than 3.3	3.3-3.6	Greater than 3.6	
Undergraduate Grade Point Average	10.628	10.489	12.204	2.512*
Graduate Record Exam Quantitative	0.142	0.167	0.159	6.009**
Students with less than 260 verbal score	-8.848	-12.763	-12.446	4.138**
Students with less than 900 total score	21.383	24.544	23.231	2.644*
Undergraduate Agricultural Economics Major	0.614	-0.960	0.966	3.137*
Age	1.395	1.432	1.284	1.919
Constant	-72.535	-85.774	-83.085	

* .10 level of significance
** .01 level of significance

into the higher graduate GPA group. However, further analysis is required to quantify the impact of these variables on academic performance.

Regression Analysis

Two of the most widely used admission criteria are undergraduate grade point average and graduate record exam scores. The graduate grade point averages of the students included in this study were regressed on these two factors to determine possible tradeoffs between them. Since this relationship was not expected to be linear, the following regression model was postulated:

$$(1)\ GPAg = b_0 GPAu^{b1}\ GRE^{b2}$$

where:

GPA is cumulative grade point average (g is graduate and u is undergraduate), GRE is total graduate record exam score, and b^1 is regression coefficient. This equation was estimated with linear regression by transforming the three variables through the natural logarithm function. The estimated equation, with Student-t coefficients (in parentheses) and R^2 are presented below.

$$(2)\ \ln GPAg = 0.131 + \underset{(2.68)}{0.154}\ \ln GPA_u + \underset{(2.81)}{0.142}\ \ln GRE$$

$$R^2 = 0.25$$

where: ln is natural log function.

These results can be interpreted as follows: each one percent increase in GRE score will raise graduate GPA 0.142 percent, and each one percent increase in undergraduate GPA will raise graduate GPA 0.154 percent.

These results can readily be applied through the use of Figure 1, which shows the expected graduate GPA for selected combinations of undergraduate GPA and GRE scores. For example, a student who had scored 800 on the GRE and had maintained a cumulative undergraduate GPA of 2.6 would be expected to achieve a 3.6 graduate GPA. A confidence interval could be developed for this estimate using the standard error from the regression equation. For an interval of one standard error, this student would be expected to achieve a graduate GPA of 3.6 within $\pm$ .2, i.e. his average would be expected to be between 3.4 and 3.8. If a department wanted to set a

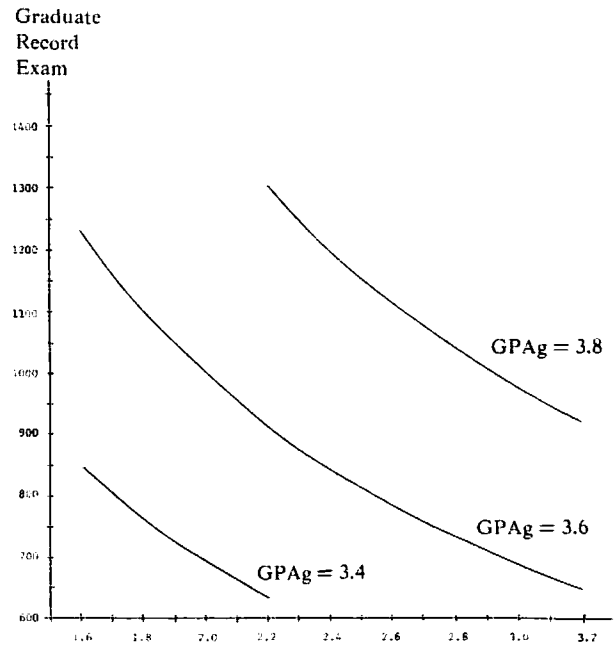

Figure 1.

minimum **expected** graduate GPA, such as 3.4 or 3.6, as an entrance requirement then the regression equation or Figure 1 would indicate what combinations of undergraduate GPA and GRE scores would be acceptable.

Discriminant Analysis

Discriminant analysis assigns the individual student to the group which he most resembles. The classification task is accomplished in a manner which makes the probability of correct classification as large as possible. The discriminant function combines the set of independent variables into a linear function or index. The discriminant analysis results - the coefficients or weights for each variable in each linear function and related F-statistics - are shown in Table 2. With the particular program used in this study[4], the individual is classified in the group for which his index is highest. Interpretation of the results for each individual variable is based on its statistical significance and the relative magnitudes of the coefficients. The largest coefficient for a variable indicates in which group a student would be classified if the value of the functions without the effect of the variable were equal.[5]

As expected, students with higher undergraduate grade point averages were more likely to be in the upper group with respect to graduate grade point average. However, the size of the undergraduate grade point average had little impact on distinguishing between the lower - and middle - groups in the graduate program.

Scores Significant

Scores from the graduate record exam were statistically significant in distinguishing among groups. It was found that the GRE component scores (verbal and quantitative) did a better job in explaining graduate student academic performance than the total GRE score. The coefficients for the quantitative GRE scores were higher for the middle - and upper - GPAg groups, indicating that students with higher quantitative GRE scores were more likely to be in these two groups. Students with less than 260 verbal GRE scores were more likely to be in the lower GPAg group. The middle - and upper - groups could be distinguished by low-GRE total scores: students with less than 900 total points were more likely to be in the middle group than the upper group.

After accounting for differences in undergraduate GPA and GRE scores, agricultural economics majors as undergraduates apparently had a real advantage to be in the upper group over the middle group. Older students were more likely to be in either the lower or middle groups.

Two factors which were expected to influence academic performance but were not found to be statistically significant were nationality and work experience. Domestic students did not have a clear advantage over foreign students after correcting for such factors as GRE scores and undergraduate GPA. Work experience and age were positively correlated, but age was a better indicator (although statistically insignificant) in classifying students according to academic performance.

Predicting Academic Performance

The discriminant analysis technique was used to predict graduate student academic performance. The sample of 53 students was divided into subsamples A and B. Subsample A contained 25 percent of students randomly selected from each of the three groups classified by graduate GPA. The academic performance of these students was predicted using discriminant functions estimated for the rest of the students, subsample B.

Based only on the student's credentials available at the time of admission and discriminant functions estimated for other graduate students, almost two-thirds of the students were correctly classified according to their eventual performance in graduate school. Even those students classified in the wrong group were always classified in the next nearest group, i.e. no students who achieved high academic performance were predicted to be in the lowest group. Thus, these results appeared to be quite satisfactory as an aid to departmental decision-making relating to the admission and funding of prospective graduate students.

Conclusions

This paper has described methodology to systematically analyze graduate student performance in a particular program. The results for this group of students were intended for illustrative purposes rather than generally applicable to other programs. These techniques can easily be applied to data available in almost every department with a graduate program and the results readily applied to periodic but nevertheless difficult and important decisions concerning the admission and financial support of prospective graduate students. Hopefully other departments will pursue a systematic approach to evaluating students.

We considered only one dimension of academic performance in this analysis. Further research may be required to incorporate other dimensions including length of time required to complete graduate programs and quality of graduate research.

[4] The multiple discriminant analysis computer program used in this study was BMDO7M which utilizes g discriminant functions to assign individuals to g groups. For discussion of the computational procedures used in BMDO7M, see W. J. Dixon (Ed.), BMD Biomedical Computer Programs, University of California Press, Berkeley, California, 1968, pp. 185-214.

[5] Interpretation of the discriminant function coefficient is presented in Dixon pp. 185-214.