A CLASSIFICATION MODEL FOR PREDICTING ACADEMIC PERFORMANCE FOR MASTER OF BUSINESS ADMINISTRATION STUDENTS AT MICHIGAN STATE UNIVERSITY

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This is to certify that the

thesis entitled

A CLASSIFICATION MODEL
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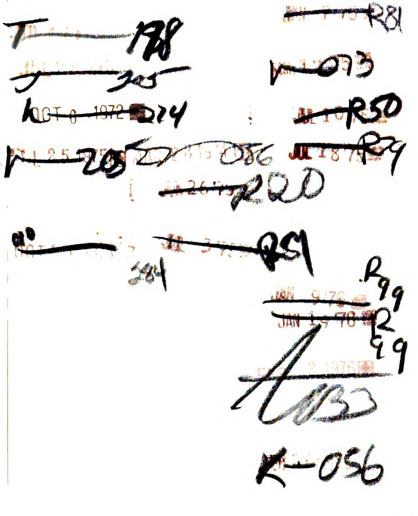

ABSTRACT

A CLASSIFICATION MODEL FOR PREDICTING ACADEMIC PERFORMANCE FOR MASTER OF BUSINESS ADMINISTRATION STUDENTS AT MICHIGAN STATE UNIVERSITY

by Robert George Harris

The purpose of this study was to develop a classification, or probability, model for predicting academic performance in the Master of Business Administration program at Michigan State University. This model was designed to assist the admissions officer in answering two questions:

(1) What is the likelihood that this applicant could successfully complete the MBA program and graduate?

(2) What would be the extent of this applicant's academic success in the MBA program?

The sample of students used in constructing the model was selected from the population of all students admitted and enrolling for the first time in the MBA program at Michigan State University from Fall term, 1962, to Summer term, 1966, inclusive. The "check" sample, used to validate the model's ability to correctly classify individuals, was selected from students entering MSU, under the same conditions in Fall term, 1966.

Application of selective criteria (essentially excluding foreign students, students with incomplete records, and females), reduced the number of students eligible for selection to 514 graduates and 72 academic withdrawals.

From those eligible, three extreme groups were selected for analysis. These groups were : (1) Upper level graduates; (2) lower level graduates, and (3) lower level withdrawals. Each of the graduate groups contained 138 students, or 27%, of all graduates. Because of the small number of academic withdrawals, 38 students, about 50%, were included in the third group.

Two multivariate statistical procedures, both programmed for machine computation, were used in the analysis. Multiple-discriminant analysis was used to investigate the significance of group differences and to determine the location of group centroids in discriminant space. Maximum likelihood classification methods were used to develop a classification model on the basis of the measurements of predictor variables for each individual in the sample. With such a model, then, unclassified individuals were assigned to a group characterized by academic performance in which the individual had the greatest likelihood--the greatest probability--of membership. By assigning members of a "check" sample--individuals not involved in the formulation of the model--in this manner, the model was evaluated for its accuracy in predicting the academic performance of an "unclassified" individual, such as an applicant for the MBA program.

The 12 predictor variables used were those elements of information generally available for all applicants for admission from either the standard MSU application for graduate study or university record files for each individual, with the exception of a new variable which was formed in an attempt to "adjust" or "weight" the applicant's undergraduate GPA in respect to the "quality" of his undergraduate institution. The measure of "quality" used was the mean ATGSB Total score for the undergraduate college, as reported by ETS.

In general, there is a monotone descending relationship between the mean values of the 12 predictor variables and the level of academic performance. As the mean value of the predictor variable decreases, the level of academic performance decreases.

From the data, one observes that the more academically successful student has most of the following characteristics. He:

(1) Attained a higher undergraduate GPA (both "raw" and "adjusted");
(2) scored higher on all three ATGSB tests;
(3) attended an undergraduate college other than MSU that was relatively large (over 10,000) but not as large as that attended by the less successful MBA student;
(4) was older, married, and delayed longer before beginning the MBA program;
(5) maintained legal residence outside of Michigan, and
(6) had completed a non-business undergraduate major course of study.

The classification model was constructed from the set of values for the predictor variables for each individual in the "main" sample. This data permitted computation of the coefficients and constant terms for a set of classification functions--one classification function for each of the three classification groups. Evaluation of these classification functions yielded a set of three scores for each individual. The model compared the computed classification scores for each unclassified individual and assigned him to the group for which he had the highest score.

In this manner, the 109 unclassified individuals in the "check" sample were also assigned to the three academic performance categories. The academic performance of 53.2% of the "check" sample was accurately predicted and were termed HITS, 21.1% were MISSES, while 24.7% were labeled NEAR HITS, since they were predicted as graduates but the level of performance was inversely predicted. If HITS were to be defined simply as predicted graduation or predicted withdrawal, the model produced 78.9% HITS and 21.1% MISSES.

From the analysis of the results it was found that:

(1) the three classification groups could be distinguished from each other on the basis of the 12 predictor variables used in the study,

(2) the group centroids were colinear (points on the same straight line) and ordered in the same manner as the three levels of academic performance,

(3) the upper level graduate group was well separated from both the lower level groups, but that the lower level graduates and the academic withdrawals were relatively close together,

(4) the likelihood of individual membership in one or another such group can be predicted on the basis of the elements of information known about the individual at the time of the admissions decision,

(5) the model offers the admissions officer an objective, systematic method to assist in the selection of students for the MBA program. It establishes an order of priority in the selection of students, provides a basis for admission to either regular or provisional status, identifies "borderline" applicants, and suggests when additional information should be considered in arriving at the admissions decision.

Therefore, from these findings it was concluded that:

(1) The three groups--upper level graduates, lower level graduates, and academic withdrawals--are distinct separate groups that can be distinguished from each other on the basis of measurements on the 12 predictor variables used in this study,

(2) the major problem in classification of individuals results from the difficulty in discriminating between the lower level graduates and the academic withdrawals,

(3) the classification, or probability, model, constructed on the basis of the measurements of the 12 predictor variables for each individual in the "main" sample is a valid model for the prediction of academic performance for MBA students at MSU,

(4) the model does no worse than the less objective methods used in the admissions decision-making process during the time period encompassed in the study.

Admission to graduate school is a major and most serious decision. While the state of the art is not sufficiently advanced to entrust admissions decision-making to a computerized model, the assistance that such a model can provide should not be overlooked. By increasing the objectivity of the selection process, the exercise of subjective judgment, which in the final analysis is still the major element in the admissions decision, can be sharpened.

A CLASSIFICATION MODEL FOR PREDICTING ACADEMIC PERFORMANCE FOR MASTER OF BUSINESS ADMINISTRATION STUDENTS AT MICHIGAN STATE UNIVERSITY

By

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CHAPTER I

INTRODUCTION

Need

Problems associated with the admissions decision-making process exist in varying degrees at all educational institutions. These problems have, generally, become more acute in recent years because growing interest in education, and particularly higher education, has measurably increased the number of applicants for admission to the nation's colleges and universities. A partial solution to these admissions problems has often been found by increasing student enrollment. However, increased enrollments are subject to the limitations imposed by maintenance of respectable academic standards and such factors as the availability--or better, the non-availability--of adequate facilities, competent staff, and sufficient financial support. Generally, these limitations preclude unlimited or greatly increased enrollment and dictate the use of selective admissions criteria.

In recent years, the Graduate School of Business Administration at Michigan State University, like many others, has been the recipient of an increasing number of applications for admission. At the same time, there has

been a general improvement in the qualifications of the students seeking advanced study. This has been particularly true in the Master of Business Administration (MBA) program at Michigan State University. In response to the increased demand, there have been larger student enrollments in the MBA program each year for the past several years. Because of an abundance of qualified applicants, however, and the limited (although increased) resources allocated to the program, the admissions decision-making process has become more difficult.

Faced with this situation, it is suggested that selective admissions criteria objectively answer two major questions about each applicant, based on the kind of information about the individual now available. First, it should be asked, "What is the likelihood that this applicant could successfully complete the MBA program and graduate?" Next, providing the first answer is in the affirmative, one should inquire, "What would be the extent of his academic success in the program?"

If the answer to the first question is "no likelihood at all," then of course, the second question is superfluous and the admissions decision has been made. If, however, the answer is something other than that, it is important to weigh the degree of academic success that the applicant is likely to achieve. Given the answers to these two questions, it would seem reasonable to select

those applicants who were most likely to attain the highest academic performance, and to reserve a decision on admission of those individuals who might be expected to meet minimum graduation standards but generally perform just above the academic "borderline."

"Selective admissions," as an institutional policy, is based on merit and is limited to those applicants considered to be best qualified to benefit from the educational opportunity provided by the college. Information such as the applicant's past academic achievement, recommendations, reports on character, personal qualities, entrance examinations, test scores and personal interviews are often included in the selective admissions procedure. Many of the elements of information obtained about the applicant are qualitative in nature. A substantial portion of the information, however, is quantitative or is represented in a quantitative form.

Regardless of its form, both subjective and objective evaluation and judgments are made about the applicant, based on the available information. These elements of information are evaluated and a judgment is made about the likelihood of the applicant's academic success if selected

for admission. Both Snook[1] and Stuart[2] maintain that selection of students must rely to a large extent upon the subjective judgment of the admissions officer. Nevertheless, it would seem advantageous to maximize the objective evaluation of all available information, both qualitative and quantitative, in the selection process. Hopefully, a more objective method would permit selection of those applicants for admission who can reasonably be expected to satisfactorily complete a particular course of study; conversely, such a method would tend to "select out" those candidates with little likelihood of academic success.

Purpose

The purpose of this study is to develop a probability model to predict the academic performance of applicants for admission to the MBA program at Michigan State University. This probability model will incorporate the recorded experience of former MBA students at the University; and, prediction of academic performance of new prospective students will be predicated on elements of information known about them at the time of the admissions decision.

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[1]John L. Snook, Qualitative Admissions Factors--Proof, Practice, and Prejudice, a paper presented to the 1966 Symposium of schools using the Admission Test for Graduate Study in Business, Princeton, N.J., May 5, 1966.

[2]Douglas Stuart, A Study of the Relationships of Admissions Data to Student Performance in the Graduate School of Business during the Period, 1958-1961, East Lansing, Michigan State University, Office of Institutional Research, June, 1962, p. 13.

The study will use multivariate procedures to construct a probability model that would determine the maximum likelihood of an applicant being a member of one of three groups: top level graduates; lower level graduates, or academic withdrawals. This model will be designed to assist the admissions officer in answering the two questions previously posited:

1. What is the likelihood that this applicant could successfully complete the MBA program and graduate?
2. What would be the extent of this applicant's academic success in the MBA program?

Research Problems

Two research problems are to be investigated in this study. They are as follows:

1. Can groups of MBA students, who have either graduated or withdrawn from the program, when grouped by the overall graduate grade-point average, be distinguished from each other on the basis of the elements of information known about the students at the time of the admission decision?
2. Can the likelihood of individual membership in each of these groups be predicted on the basis of the elements of information known about the individual at the time of the admissions decision?

The elements of information known about the students at the time of the admissions decision are, for the most part limited, directly or indirectly, to the information available on the completed "Application for admission to Graduate Study" required of all persons seeking admission for advanced study at Michigan State University.

Rationale

Customarily, researchers concerned with predicting academic performance have used a statistical procedure known as multiple-regression analysis. This procedure requires the identification of a set of factors (independent variables), that are considered to be predictive of academic performance. The criterion for academic performance (the dependent variable), most frequently selected is the grade-point average.

The rationale of the present investigation is that students grouped according to academic performance can be distinguished from each other on the basis of the measurements of a set of independent variables; further, that the probability of membership in each group can be determined for an unclassified individual and the most likely group membership (and therefore the associated academic performance) can be predicted for each individual.

The technique of classifying individuals in this manner was developed for biometric research by Rao[3] and extended by researchers such as Anderson[4] and others.

In recent years, there has been increased interest in this approach in the field of educational and vocational guidance and counseling.

Overview

In Chapter II, the review of literature is of two kinds. A review of the literature in the general area of prediction of academic success is presented, as well as a general discussion of selected research techniques applicable to the problem of predicting academic performance.

In Chapter III, the methodology and procedures used to conduct the study, as well as the statistical models used in the study are presented.

The results of the study are analyzed in Chapter IV. The final chapter, Chapter V, presents an overall summary, the conclusions, and a discussion of the findings and their implications for future research.

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[3] C. Radhakrishna Rao, Advanced Statistical Methods in Biometric Research (New York: John Wiley and Sons, 1952).

[4] T. W. Anderson, An Introduction to Multivariate Statistical Analysis (New York: John Wiley and Sons, 1958), pp. 147-152.

CHAPTER II

REVIEW OF THE LITERATURE

Introduction

The design of this study, detailed in a later section, while not a replication of any previous research reviewed in the literature, has nevertheless evolved from experiences of earlier researchers concerned with prediction of academic performance and/or success.

The literature was first reviewed to determine what research had been conducted in the general area of prediction of academic success of students, and more specifically, of graduate students in business administration, were examined.

A second aspect of the review of literature involved focusing on statistical procedures used in the aforementioned studies and possible applications of other techniques as yet untried, or relatively unused, in the prediction of academic performance.

Review of Studies of Predictions of Academic Performance

The literature contains studies of performance at all educational levels, and that pertaining to undergraduates is particularly voluminous. Most studies use high school

grades, standard intelligence test scores or tests specifically designed for the purpose, such as the scholastic Aptitide Test (SAT), as predictors of future school performance. In an earlier review, Cronbach reported that college level ability tests correlated about .50 to .55 with college grade-point averages.[5] More recent studies have not substantially altered this finding.

Typical of the many predictive studies reported in the literature is one by Glover at the University of Massachusetts.[6] Glover used multiple-regression techniques to develop prediction equations for three groups of students: men (excluding engineers); women, and engineers. The data was collected for students admitted over a three year period. The prediction equations were cross-validated using new data collected from the most recent year group. The predictor variables used were SAT Verbal and Mathematics scores and class rank as reported by the student's secondary school. The multiple correlation ranged from .430 for the men to .537 for the women. Attempts to improve upon the predictive efficiency of this basic variable combination by "adjusting" class rank according to the "quality" of the secondary school produced negative results.

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[5]Lee J. Cronbach, Essentials of Psychological Testing (New York: Harper and Brothers, 1949).

[6]Robert H. Glover, Preselection in College Admissions at the University of Massachusetts, Office of Institutional Studies Information Series No. 9, University of Massachusetts (Amherst: University of Massachusetts, 1963).

Linn reviews the results of several empirical studies that have used "adjusted grades" to predict academic achievement.[7] His paper considers some of the possible techniques which could be used to make grade adjustments for interschool differences; it is observed, however, that most researchers have found that the improvement in predictive validity due to the use of adjusted grades, as compared to unadjusted grades, has been "discouragingly small."[8]

Studies indicate that predictability of graduate school performance is generally lower than for undergraduate performance. This is probably because graduate students are a more highly selected group than undergraduates. They are of higher quality with less variation in ability--consequently, the correlations are lower. Moreover, some of the tests used as predictors of academic success at the graduate level are often used, also, as admissions screening devices at the same level.

A study conducted at Stanford University Graduate School of Business in 1957-58 provided an opportunity to observe the effect of the Admission Test for Graduate Study in Business (ATGSB) when test scores are used as a

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[7] R. L. Linn, "Grade Adjustments for Prediction of Academic Performance: A Review," Journal of Educational Measurement, 3 (Winter, 1966), 313-329.

[8] Ibid., p. 326.

basis for admission.[9] Although Stanford was not using the ATGSB in admitting students in 1957, the School administered the test to those same MBA students in the summer of 1958 in connection with another study. By 1962, Stanford was using the ATGSB in its selection procedures. A comparison of the correlation of ATGSB scores for 1957 first year students and first year students in 1962, reflects the effect on use of the test as a predictor of first-year-average grades. The ATGSB Total score correlation for 1957 first year students was .64, as compared to .56 for the similar group in 1962.

The Admission Test for Graduate Study in Business (ATGSB) focuses on the measurement of general abilities associated with academic success rather than on specific preparation. The test provides in two broad areas of academic skill--verbal ability and quantitative ability. Scores on the ATGSB are reported on a standard normative scale. A Total score, two part-scores--a Verbal score, and a Quantitative score are obtained.

The research design of many studies concerned with prediction of academic performance in graduate programs is not unlike that of the studies previously described.

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[9]Educational Testing Service, The Admission Test for Graduate Study in Business: A Handbook for Deans and Admissions Officers, A report prepared by the Educational Testing Service (Princeton, N.J.: Educational Testing Service, 1966), pp. 54-56.

For example, in a study investigating the feasibility of predicting grade-point averages for students in a graduate education course, Herbert found that the following factors were useful as predictors: undergraduate grade-point average in education courses; overall undergraduate grade-point average; type of undergraduate curriculum; grade in student teaching, and scores from the National Teacher's Examination.[10] The best single predictors were undergraduate grades in education courses and overall undergraduate grade-point average.

In another study of the prediction of academic success in a master's program in education, Owens and Roaden compared the grade-point averages and advisor's ratings of graduating students with their undergraduate grade-point averages, test scores, area of graduate study specialization and the enrollments of their undergraduate colleges.[11] Again, it was found that undergraduate grade-point average was the best single predictor; that test scores added only slightly to predictive efficiency. Other factors were found to be of little value in predicting academic performance.

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[10]David J. Herbert, "A Predictive Study of Quality Point Averages in Graduate Education Courses," Journal of Educational Research, 60 (January, 1967), 218-220.

[11]Thomas R. Owens and Arlies L. Roaden, "Predicting Academic Success in Masters Degree Programs in Education," Journal of Educational Research, 60 (November, 1966), 124-126.

DeGrandis evaluated the effectiveness of undergraduate grades as predictors of future academic success in the graduate study of business at the University of Southern California.[12] Her finding was that undergraduate grades can be useful predictors, particularly if the student pursues graduate study at the same institution at which he was an undergraduate. It was also found that higher graduate grades were earned by full-time students than by part-time students, and by students who had had a significant time lapse between undergraduate study and commencement of graduate study.

A number of studies have been conducted which in one way or another evaluate the effectiveness of the Admissions Test for Graduate Study in Business (ATGSB), either alone or in conjucntion with other measures of ability, to predict academic performance in graduate study in business.

In a study during 1958-1959, Pitcher showed that ATGSB Total scores are useful alone or in combination with undergraduate records in predicting first-year grade averages of graduate business school students.[13] Her study confirmed the findings of an earlier study conducted by

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[12]Norma L. DeGrandis, "The Prediction of Scholastic Success in a Graduate School of Business Administration" (unpublished Master's thesis, University of Southern California, 1962).

[13]Barbara Pitcher, The Admissions Test for Graduate Study in Business as A Predictor of First-Year Grades in Business School, 1958-1959, SR-60-34 (Princeton, N. J.: Educational Testing Service, 1960).

the Educational Testing Service (ETS), designers of the ATGSB, during the period 1954-1955. The multiple correlation coefficient of the ATGSB and undergraduate record with first-year grade averages was .50 for 1954-55, and .49 for 1958-59. The total ATGSB score alone had a correlation of .43 in both studies, while the undergraduate record alone was .35 in the earlier study and .28 in the 1958-59 study. It was also found that Verbal and Quantitative scores, which were not included in the 1954-55 study, predicted first-year grade averages less effectively than Total ATGSB scores. Finally, it was found that students who had undergraduate major fields of study other than business and economics did better on the ATGSB (all three scores) than did those who majored in business and economics.

In 1965, Pitcher and Winterbottom confirmed the findings of previous ETS studies that the combination of ATGSB scores and undergraduate grade record was a useful predictor of graduate school performance.[14] Analyses were made of several subgroups of students defined according to undergraduate major, of time delay between college graduation and entrance to business school, of survival (drop-out vs. non-drop-out) and of national origin (foreign vs. non-foreign). The findings, while not

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[14]Barbara Pitcher and John A. Winterbottom, The Admissions Test for Graduate Study in Business as a Predictor of First-Year Grades in Business School, 1962-1963, SR-65-21 (Princeton, N. J.: Educational Testing Service, 1965).

conclusive, provided sufficient evidence that these factors should be considered in the prediction of academic performance. The authors explained that the observed validity of both predictors had declined due to the more extensive use to which they had been put in selecting entering students. This statement further substantiated the Stanford study, which had found that use of the ATGSB for selection of students reduces the correlation of the ATGSB with criteria of success.

In a recent handbook, ETS has reviewed the most significant studies pertaining to ATGSB.[15]

A University of Pennsylvania study took up the relative effectiveness of various combinations of predictors with first-year grades in graduate business school.[16] The three ATGSB scores and undergraduate record were validated singly and in combination against first-year grade averages. The resulting correlations were characteristic of studies of this kind. The undergraduate record, with a correlation coefficient of .39, was the best single predictor. The combination of all three scores and the undergraduate record, with multiple correlation coefficient of .52, was slightly higher than all other combinations. This suggests that it may be more practical to use a combination of the undergraduate record and only one score as a valid predictor,

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[15] Educational Testing Service, op. cit., pp. 41-80.

[16] Ibid., pp. 56-58.

rather than going to the additional effort of including all three scores in the combination.

A Harvard study also used the three ATGSB scores and the undergraduate record as predictors of the first-year grade averages at the Harvard Business School.[17] In addition, however, the study predicted separate course grades. The correlation of the combined predictors was found to be remarkably consistent for three different year groups of students: .49, .48 and .49. There were, however, considerable variations among the correlation coefficients found for the various courses. It appeared that the correlations with the more structured courses were higher. This suggests that personality factors, which the tests do not directly measure, affect performance to a considerable degree.

A study of predicting average grades at the end of an MBA program was conducted at Emory University using the three ATGSB scores, overall undergraduate grade averages, and the grade average for the junior and senior years of college.[18] The best single predictors were the ATGSB Quantitative and Total scores, with correlation coefficients of .46 and .45, respectively. For a part of the same sample, the grade averages for the first-year of business school was also available. The correlations of

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[17] Ibid., pp. 58-59.

[18] Ibid., pp. 59-61.

these first-year grade averages with final MBA grade averages was .64. It was concluded that relative to other predictors, the first-year grade average was extremely high in terms of predictive accuracy and could almost be used alone. This study shows that previous academic performance within the business school itself is an accurate predictor of final success in that school. It also suggests that a pervasive educational philosophy within a given university may lend the undergraduate grade average in itself a degree of reliability in predicting graduate academic performance at the same institution.

Stuart conducted a study of the relationships of admissions data to student performance in the Graduate School of Business at Michigan State University for the period, 1958-1961.[19] The study weighed the worth of using the Miller Analogies and ATGSB tests for all students entering the school. It concluded that while both tests showed positive but low coefficients of correlation with academic performance in the graduate school, there was sufficient evidence to support use of the ATGSB in screening candidates for admission to the MBA program.

Review of Statistical Methods

With one exception, the statistical procedures used in all of the above studies were restricted to calculations

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[19]Douglas Stuart, op. cit.

of simple or multiple correlations. (The exception was a non-parametric statistical approach employed by DeGrandis.) Consequently, before the methodology for development of the statistical model used in this study could be formulated, an extensive review of applicable statistical procedures was conducted.

This study is concerned with two general problems. The first is that of discrimination, where the emphasis is on the problem of differentiating between groups of students on the basis of various elements of information about them, at the time of the admissions decision. The second is one of classification. This involves "assignment" of an individual student to one of several groups, on the basis of the same elements of information, and it also involves comparing the characteristics of an individual with that of a group. Various methods for differentiating between groups and assessing similarity are used to solve problems of discrimination and classification. Two methods available are multiple-discriminant analysis and maximum likelihood classification. These methods, however, have been put to relatively little use in the general area of prediction of academic performance, and only slightly more use in guidance and counseling.

A popular and useful approach used in studies of predicting academic performance is known as multiple-regression analysis or multiple correlation. Multiple regression

analysis provides information concerning the probable degree of success or performance of an individual in each of several groups, given data on the characteristics or past performance of that individual.

Multiple discriminant analysis and maximum likelihood classification methods use the same data on the individuals in each of several groups and are designed to answer the questions, "Can one distinguish one group from another?" and "What group is the unclassified individual most like?"

Multiple-regression analysis, on the other hand, is concerned with the question, "In what group would the individual perform best?" By way of clarification, it should be pointed out that the problems of "discrimination" and "classification" as defined above share a common theoretical base and historical development. They often, in fact, are viewed as simply two different aspects of discriminant analysis.

Tatsuoka presents an excellent review of the development of objective methods based on the idea of profile similarity.[20] He reports that a differential prediction method was first introduced in 1928, and later developed by many researchers, including R. L. Thorndike. Other approaches maximizing the overall efficiency of the method

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[20]Maurice M. Tatsuoka, Joint-Probability of Membership and Success in Group: An Index which Combines the Information from Discriminant and Regression Analyses as Applied to the Guidance Problem, Harvard Studies in Career Development No. 6, Office of Naval Research, Contract Nonr-1866 (31) (Cambridge, Mass.: 1957), pp. 1-5.

were later introduced by other investigators. It is observed that all of the early methods suffered from the major defect of forcing a multi-dimensional situation into a uni-dimensional problem. Development of a method of analysis that involved multi-dimensional space was accomplished in recent years by researchers in both the natural and behavioral sciences.

A more comprehensive review of the literature and research of discriminant analysis is presented by Tatsuoka and Tiedeman in an earlier publication.[21] In one of his many significant contributions, Rao addresses the problems related to the utilization of multiple measurements in the field of biological classification.[22] This is a situation where the researcher is confronted with the problem of assigning an individual to one of several groups to which he might belong. Rao presents an objective method, based on the modern theories of statistical inference, which minimizes errors of classification.

Anderson studied the multivariate methods based on normal distribution and developed a method for classification of an individual into one of several multivariate normal distributions.[23] This method is a particular

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[21]Maurice M. Tatsuoka and David V. Tiedeman, "Discriminant Analysis," Review of Educational Research, XXIV (December, 1954), pp. 402-420.

[22]Rao, op. cit., pp. 273-378.

[23]Anderson, op. cit., pp. 147-152.

interest in the present study since, under the proper assumptions, it provides a methodology for use in the problem at hand.

In recent years, there has been increased interest in discrimination and classification methods in the field of educational and vocational guidance. A study by Cutting is typical of this new research.[24] Cutting differentiated between groups of students on the basis of fifteen variables of self-concept of ability and occupational interest, using multiple discriminant analysis. The purpose of the study was to identify, through predictive variables of certain elements of the self-concept, the academic field of concentration that the college student would select.

Summary

Thus, the foregoing review of literature indicates that there has been extensive effort in the area of predicting academic performance and success. The literature concerned with predicting success in college for graduating high school students is particularly voluminous. Generally, the predictor variables and the criterion for successful performance are the same in all studies. The record of past academic performance, course grades, (or,

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[24]Donald J. Cutting, "Predicting the Selection of a Field of Concentration at MSU from the Personal Preference Inventory" (unpublished Ph.D. dissertation, Michigan State University, 1966).

more likely, overall grade averages), along with standard test scores are usually the predictors. Similarly, the college grade average, or on occasion an individual course grade, is the favorite criterion of success. A few of the studies consider other factors, such as residence, age, sex, high school or college attended, or major course of study, as contributers to academic performance.

Along with the computation of simple correlations, an often used statistical technique in the studies is multiple-regression analysis. The results of this latter analysis, in most of the studies, indicate that the past academic performance record is the best single predictor of future academic performance. The past record in combination with the scores on special predictive tests (such as SAT or ATGSB) improves this prediction. Generally, the coefficient of multiple correlation between the predictors and the criterion for academic success is between .20 and .50. There have been several attempts to improve this correlation by "adjusting" the past academic performance record, in accordance with the estimated "quality" of the former school. Past efforts have been generally disappointing.

While the multiple regression method will continue to be a very valuable tool, it does not appear to offer any marked improvement over past studies in prediction. On the other hand, multiple-discriminant analysis, a relatively new method in educational research, offers some

evidence of producing useful results in future investigations. Several recent studies have taken this approach in studying problems in guidance and counseling. Essentially, multiple-discriminant analysis uses the same predictor variables as are used in studies where multiple regression methods have been employed. Multiple discriminant analysis, however, addresses the twin problems of discrimination between criterion groups and classification of an individual on the basis of these predictor variables.

CHAPTER III

DESIGN AND METHODOLOGY OF THE STUDY

Sample

The sample of students for this study was selected from a population composed of all full-time students admitted and enrolling for the first time in the Master of Business Administration program at Michigan State University during the period beginning with Fall term, 1962, and ending with Summer term, 1966. Criteria for selection of the sample were established after consideration of several problems.

For example, selection of foreign students for the MBA program is quite unlike that of students from undergraduate institutions in the United States. For the most part, the records and test scores of foreign students are not available to the admissions officer. In most instances the foreign student has not taken the ATGSB, a stated requirement for all applicants. If his undergraduate record is available, it is most likely subject to considerable individual interpretation and subjective evaluation. Of a total of 1,304 students entering the MBA program during the four year period under study, 167 were foreign students. It was felt that inclusion of this group of atypical students

in the sample would unquestionably introduce bias, and so they were excluded.

For various reasons, too, there are students for which the information on file is incomplete. But the statistical design of the study did not allow for inclusion of individuals with missing data, and therefore, these students could not be included in the sample.

Fifteen of the total number of students were females. In view of the small number, but also to avoid the possible introduction of a bias due to sex difference, these students were excluded from the sample.

Finally, some students admitted during the period under study had not yet "completed" their programs--either through graduation or by withdrawal--and for this reason were ineligible for inclusion in the sample.

Of the students who had withdrawn from the program, it was known that many had done so for other than academic reasons. But since in most cases student record files did not include explicit reasons for withdrawal, it was assumed that those students--and only those students--with an overall grade-point average (GPA) below that required for graduation had withdrawn for academic reasons. It is this group that is defined herein as "academic withdrawals."

A GPA of 3.00, where A=4, B=3, C=2, D=1, and F=0 is required for graduation. (All other students who withdrew were considered to have done so for other than academic reasons, but were also excluded.)

Consequently, the sample was selected in accordance with the following criteria:

1. Student had received a baccalaureate degree from an undergraduate institution in the United States;
2. A report of student's ATGSB test scores was on file with the University;
3. A report of student's undergraduate grade-point average was on file with the University;
4. Student had either completed his MBA program and received the degree, or had withdrawn from the program for academic reasons by the time data collection began;
5. Student who had withdrawn from the MBA program had done so with an overall graduate GPA of less than 3.00; and,
6. Student was a male.

The sample was divided into three groups: (1) the upper level of degree recipients; (2) the lower level of degree recipients; and (3) the lower level academic withdrawals. After ordering the degree recipients (hereafter called the "graduates,") according to their GPAs at graduation, an upper group, consisting of approximately 27 per cent of the graduates who had accumulated the highest GPAs and a lower group consisting of an equal number of graduates who had accumulated the lowest GPAs, were selected.

The academic withdrawals, i.e., those with cumulative GPAs below 3.00, were ordered in the same way. Arbitrarily, the lower 50 per cent of this withdrawal group, rather than 27 per cent, was selected because of the relatively small number of students in this category. In this manner, a total sample consisting of 313 MBA students was selected, composed of 138 upper level graduates, 138 lower level graduates, and 37 lower level academic withdrawals. Setting of sub-sample size at 138 individuals or 27 per cent of each of the graduating groups, was determined both by certain constraints in computer programming and in light of the arguments developed by Kelley for selection of criterion groups.[25] Use of a sub-sample size of 138 for both the upper and lower level graduates provided the best compromise between two desirable but inconsistent aims: to make the extreme groups as large as possible, and to make the extreme groups as different as possible.

A "check" sample of students satisfying the same criteria as the "main" sample was selected from all MBA students admitted and enrolled for the first time in the Fall term, 1966. The purpose of the "check" sample was to test the validity of the model which was developed from the data obtained from the "main" or larger sample previously described.

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[25]Truman L. Kelley, "The Selection of Upper and Lower Groups for the Validation of Test Items," Journal of Educational Psychology, XXX (1939), pp. 17-24.

The "check" sample, composed of all eligible students registered Fall term, 1966, consisted of 109 students--95 graduates and 14 academic withdrawals. It was also divided into three groups. The division was made according to median GPAs of the two groups of successful graduates in the "main" sample. As a result, 57 were tagged "top level" graduates and the remaining 38 labelled "lower level." The third group included all of the 14 academic withdrawals.

Variables

The variables in the study were limited by the available sources of data. The independent variables included all of the elements of information available to the admissions officer at the time of the admissions decision. They were, for the most part, the information available on Michigan State University's "Application for Admission to Graduate Study," a copy of which is included as Appendix A. The remainder are available in other University records held by the Registrar and/or the College of Business. In sum, the 12 independent variables, or "predictors," considered in this study are:

1. Marital Status
2. Legal residence
3. Age at time of Admission
4. Undergraduate major curriculum
5. Undergraduate institution attended
6. Undergraduate grade-point average

7. Delay in beginning MBA program since last formal school attendance
8. Size of enrollment at the undergraduate institution
9. Total ATGSB score
10. Verbal ATGSB score
11. Quantitative ATGSB score
12. Product of the student's undergraduate grade-point average and the mean ATGSB score for his undergraduate institution.

Data about the first eight variables were obtained either directly or indirectly from the "Application for Admission to Graduate Study" previously cited. An interpretation (if required) and the coding used in the study for each of these variables follows:

1. Marital Status: Single = 1; Married = 2.
2. Legal residence: Michigan = 1; Out-of-state = 2.
3. Age at time of admission: Number of years (rounded to nearest whole year).
4. Undergraduate major curriculum: Business = 1; Non-business = 2.
5. Undergraduate institution: MSU = 1; other than MSU = 2.
6. Undergraduate grade-point average: GPA for last two undergraduate years reported to two decimal points on basis of A = 4.00 . . . , F = 0.

7. Delay in beginning MBA program since last formal school attendance: Number of years (rounded to nearest whole year).
8. Size of enrollment at undergraduate institution: enrollment size to nearest 100 students for year of graduation.[26]

ETS reports to the graduate school of ATGSB scores for each individual provide the information required by variables 9 through 11.

The product of the student's undergraduate GPA and the mean ATGSB score for his undergraduate institution, variable 12, is an effort to "adjust" or "weight" the individual's undergraduate GPA by a measure of the "quality" of his undergraduate college. ETS compiles a confidential publication for the use of deans and admissions officers of the graduate schools of business.[27] In it, the mean ATGSB total score and the number of persons writing the test are presented in year groupings for most of the undergraduate institutions in the United States. The possibility of misinterpreting or misusing these mean scores are acknowledged by the publisher. Nevertheless, in the spirit of experimentation and in the

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[26]Garlan G. Parker, "Statistics of Attendance in American Universities and Colleges," Annual Reports School and Society, 83-94 (January, 1955-1967).

[27]Educational Testing Service, Admission Test for Graduate Study in Business, 1957-65, Statistical Summary by Undergraduate Colleges attended (Princeton, N. J.: Educational Testing Service, 1965).

absence of any better estimation of the "quality" of the students from a given institution seeking admission to graduate study in business, the product was used as a predictor variable. To repeat, the product was formed by multiplication of each individual student's undergraduate GPA (computed to two decimal places) and the mean ATGSB Total score for his undergraduate institution. The resulting figure was rounded to five digits for use in the computer program.

Research Problems

The two research problems investigated in this study can now be more specifically restated as follows:

1. Can the three extreme groups in the sample of MBA students, upper level graduates, lower level graduates and lower level academic withdrawals, be distinguished from one another on the basis of the measurements made on the set of predictor variables described in the preceding section?
2. Can an unclassified individual be accurately classified as a probable upper or lower level graduate or as an academic withdrawal on the basis of individual measurements made on this same set of predictor variables?

Analysis

Two statistical methods were used in the investigation of the research problems. Both methods, multiple-discriminant analysis and maximum likelihood classification, are techniques for analyzing data that consist of several measures on each individual in each of several groups.

Multiple-discriminant analysis requires the determination of linear combinations of variates, called discriminant functions, such that, with respect to the discriminant functions, the ratio of the between-groups to within-groups dispersion is a maximum. In general, there is more than one discriminant function. The maximum number of discriminant functions is the lesser of (1) the number of predictor variables, or (2) the number of groups, minus one. The significance of each discriminant function can be examined by means of Chi-square approximation[28] or by the per cent of trace attributable to the function. The per cent of trace indicates the portion of the discriminating power contained in a particular discriminant function.

The location of group centroids in discriminant space is also obtainable with discriminant analysis. The determination of inter-centroid distances is valuable in the examination of group separation.

Tatsuoka and Tiedeman conclude that multiple discriminant analysis

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[28]Rao, op. cit., pp. 372-373.

> can be used as a unified approach in solving a research problem involving multivariate comparison of several groups, which is likely to have as its three phases, (a) the establishment of significant group differences, (b) the study and "explanation" of these differences, and (c) the utilization of multivariate information from the samples studied in classifying a future individual known to belong to one of the groups represented.[29]

Phases (a) and (b), which pertain to the first of the research problems, were investigated using multiple-discriminant analysis. However, in approaching phase (c), pertaining to the problem of classification, a method based on the principle of maximum likelihood was used.

Maximum likelihood classification requires the computation of a set of linear equations for the purpose of classifying an individual into one of several groups. One linear function is formed for each classification group. Each of these classification functions contains a constant term and a number of terms equal to the number of predictor variables. Evaluation of the classification function, given a set of values for the predictor variables and the constant term for an individual, yields a classification score. Classification scores are monotone functions in relation to the probability of group membership of the individual. An individual is classified with the group for which he has the largest classification score--greatest probability of group membership.

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[29]Tatsuoka and Tiedeman, op. cit., p. 414.

The value for each of the coefficients and the constant term for each classification function were derived from the values for the set of predictor variables of each individual in the "main" sample.

Using the values of the coefficients and constant terms derived from the measurements of the "main" sample, the classification score for each group was computed for each individual in the "check" sample. Each individual in the "check" sample was assigned to the group for which he had the greatest score. Since the actual classification of each individual in the "check" sample was already known, comparison of the "actual" classification with the "predicted" classification indicated the validity of the model for prediction of academic success.

The analysis, using both methods described above, was programmed for the Control Data Corporation "3600" Computer--CDC 3600. The programs used are: (1) Program DISCRIM--Multiple Discriminant Analysis, and (2) Program BMD05M--Maximum Likelihood Classification.[30]

Summary

The sample of students for the study was selected from the population of all students admitted and enrolling for the first time in the MBA program at Michigan State University from Fall term, 1962, to Summer term, 1966,

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[30]Computer Institute for Social Science Research, Index for Technical Reports/Program Abstracts (East Lansing: Michigan State University, 1967), p. 8.

inclusive. The "check" sample, used to validate the model's ability to correctly classify individuals, was selected from students entering MSU, under the same conditions, in Fall term, 1966.

Application of selective criteria (essentially excluding foreign students, students with incomplete records, and females) reduced the number of students eligible for selection to 514 graduates and 72 academic withdrawals.

From those eligible, three extreme groups were selected for analysis. These groups were: (1) upper level graduates, (2) lower level graduates, and (3) lower level withdrawals. Each of the graduate groups contained 138 students, or 27% of all graduates. This group size provided the best compromise between two desirable but inconsistent aims--to make the extreme groups as large as possible, and to make the extreme groups as different as possible. Because of the small number of academic withdrawals, 38 students, about 50%, were included in the third group.

The 12 predictor variables are those elements of information generally available for all applicants for admission, either the standard MSU application for graduate study or in the college of university record files for each individual, with one major exception. A new variable was formed in an attempt to "adjust" or "weight" the applicant's undergraduate GPA in respect to the "quality"

of his undergraduate institution. The measure of "quality" used was the mean ATGSB Total score for the undergraduate college, as reported by ETS.

The analysis is directed to the two questions posited as the research problems of this study: (1) can the three extreme groups be distinguished from one another on the basis of the set of predictor variables? (2) Can an unclassified individual be accurately classified as an upper or lower level graduate or an academic withdrawal on the basis of this same set of predictor variables?

Two statistical approaches, both programmed for machine computation, were used in the analysis. Multiple-discriminant analysis was used to investigate the significance of group differences and to determine the location of group centroids in discriminant space. Maximum likelihood classification methods were used to develop a classification model on the basis of the measurements of the predictor variables for each individual in each of the extreme groups. With this model, unclassified individuals are assigned to a group characterized by academic performance in which the individual has the greatest likelihood, the greatest probability of membership.

By assigning members of the "check" sample in this manner, the model can be tested for its validity in predicting the academic performance classification of an "unclassified" individual.

CHAPTER IV

ANALYSIS OF RESULTS

This chapter is presented in three parts. The first is a description of the data of the "main," or larger, sample. It is followed by a multiple-discriminant analysis of this data for the purpose of answering the first of the research problems posited in this study. The third part of the chapter is concerned with the classification problem, second of the research problems. Each of the parts includes both a presentation and discussion of the data and a relevant analysis. The chapter concludes with a summary discussion of the three sections.

Description of the Sample

Because of the nature of the predictor variables, the description of the data is presented in two forms. Four of the variables are not continuous, but binary, and therefore their values provide an either-or type of knowledge. The mean values of these variables are presented separately in Table 4.1 as percentages of the group sample.

About twice as many of the upper level graduates (Group I) are married compared to either the lower level graduates (Group II) or the lower level academic withdrawals (Group III).

TABLE 4.1.--Characteristics of MBA students by percentage of each group.

	I Upper Level Graduate	II Lower Level Graduate	III Lower Level Academic Withdrawal
Married	71.1%	36.2%	29.7%
Out-of state Resident	69.6	47.1	37.8
Non-Business Undergraduate Major	31.2	24.6	21.6
Undergraduate College Other Than MSU	78.3	54.4	51.4

This ratio also exists in the comparison of Groups I and III in regard to out-of-state residency. However, there are only about one-half as many upper level graduates from out-of-state as there are lower level graduates.

The number of students in Group I who had a non-business undergraduate major field of study was also about one and one-half times greater than either of the other two groups.

A similar ratio, about 3 to 2, is also found for Group I compared to either Group II or III, for students admitted from undergraduate colleges other than MSU.

From Table 4.1 it appears as if the more academically successful students are married, from out-of-state, had a

non-business undergraduate major and were admitted from an undergraduate institution other than MSU.

The remaining eight predictor variables used in the study are continuous. Computed means for each of these variables are presented in Table 4.2.

TABLE 4.2.--Group means for predictor variables.

	I Upper Level Graduates N=138	II Lower Level Graduates N=138	III Lower Level Academic Withdrawal N=37
Age at Admission (years)	27.0	24.8	24.6
Delay in Entering MBA Program (yrs)	3.9	2.5	1.3
Undergraduate GPA	3.11	2.75	2.65
Product (GPA x Mean ATGSB Total Score)	15,278	13,110	12,302
Verbal ATGSB Score	31.4	28.0	28.5
Quantitative ATGSB Score	30.8	29.0	29.1
Total ATGSB Score	524.8	487.2	493.9
Enrollment at Undergraduate Institution	13,560	17,317	17,843

The two items obviously associated with maturity of the student are age at time of admission to the MBA program

and the number of year's delay since last formal school attendance. The data in Table 4.2 generally indicate that the older students, and/or the students who have the greatest time lapse between last school attendance and the beginning of graduate study, achieve greater academic success. The average age of the lower level graduate and the academic withdrawal is about the same. The number of years of delay, however, are in the approximate ratio of 3:2:1, with the top level graduates delaying almost 4 years between completion of their undergraduate programs and the beginning of graduate education.

As one might expect, both undergraduate GPA and the "product" (individual's undergraduate GPA multiplied by the mean ATGSB Total score of the individual's undergraduate institution) are directly related to the level of academic performance. Top level graduates have attained the highest undergraduate GPAs and both the lower level graduates and lower level academic withdrawals averaged below the stated admissions requirement of a 3.00 during the last two years of undergraduate work.

There is a high correlation between the undergraduate GPA and the "product" for all groups. Consequently, a similar pattern is exhibited by the product values for the three groups. A more expository presentation of the "product" relationship to undergraduate GPA and the variation of the "product" between groups can be acquired by computing an "adjusted" undergraduate GPA. The national

mean ATGSB Total score for the time period 1957-1965 is 486.[31] Therefore, if each of the "product" values is divided by 486, the quotients can be viewed as an "adjusted" undergraduate GPA. Table 4.3 provides a comparison of the "raw" and "adjusted" mean GPAs of students in each of the three groups.

TABLE 4.3.--Comparison of "raw" and "adjusted" undergraduate GPA.

	I Upper Level Graduates	II Lower Level Graduates	III Lower Level Academic Withdrawals
"Raw" UG GPA	3.11	2.75	2.65
"Adjusted" UG GPA	3.14	2.70	2.53

The remaining variables from Table 4.2 are the three ATGSB scores: Verbal, Quantitative and Total. The scores of upper level graduates were the highest in all three areas. However, all three scores were slightly higher for lower level academic withdrawals than for lower level graduates.

As measure of the student's undergraduate environment, perhaps contributing to academic success at MSU, the

[31]Educational Testing Service, Admission Test for Graduate Study in Business: 1957-1965, p. iii.

enrollment at the individual's undergraduate institution was included. From Table 4.2, it is seen that the average enrollment at the undergraduate colleges of the upper level graduates is 13,560 and the enrollment of the undergraduate college for the other, less successful groups, is greater and about equal at 17,317 and 17,843, respectively.

Discriminant Analysis

The discriminant analysis of the data is addressed to the first research problem. Can the three extreme groups be distinguished from one another on the basis of the set of predictor variables?

It is recalled that the discriminant functions, which in this study are linear combinations of the twelve predictor variables, are determined such that the ratio of the between-groups dispersion to the within-groups dispersion is a maximum. This ensures the optimum separation between groups in discriminant space. The dimensions of discriminant space are essentially determined by the number of significant discriminant functions. If there are three significant discriminant functions, then there is a corresponding three-dimensional space. The maximum number of discriminant functions is the lesser of the number of predictor variables or the number of groups minus one. Therefore, in this study the maximum number of discriminant functions is two--one less than the number of

groups. It follows, also, that in this study, discriminant space cannot exceed two dimensions.

The computer program for discriminant analysis computed values of the two discriminant functions:

$\phi_1 = 0.68702$ with 13 degrees of freedom

$\phi_2 = 0.01867$ with 11 degrees of freedom

Rao's Chi-square approximations for the two discriminant functions were computed as:[32]

$\chi^2_{\phi_1} = 160.29$ with 13 degrees of freedom

$\chi^2_{\phi_2} = 5.67$ with 11 degrees of freedom

At the .005 level of significance with the appropriate degrees of freedom the values from the χ^2 table are respectively,

$\chi^2_{1,15} = 29.82$

$\chi^2_{2,11} = 26.76$

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[32]Rao, op. cit., pp. 372-373.

Therefore, since in testing for significant differences,

$$\chi^2_{\phi_1} > \chi^2_{1,13}$$

and,

$$\chi^2_{\phi_2} < \chi^2_{2,11}$$

it can be concluded that the first discriminant function, ϕ_1, is significant, and that the second function, ϕ_2, is not significant.

A similar conclusion can be reached by examination of the "per cent of trace" attributed to each of the two discriminant functions. It is recalled that the "per cent of trace" indicates the portion of the discriminating power contained in a particular discriminant function.

The first discriminant function accounts for 97.4% of trace, while the second discriminant function (which has been shown above to be not significant) accounts for only 2.65% of the discriminating power.

With only one significant discriminant function the discriminant space becomes uni-dimensional. This means, therefore, that projections of the group centroids (the "centers" of the multivariate distributions), are located on one line--that they are colinear.

The projection of the group centroids on a line that best separates the groups are computed and translated as follows in Table 4.4.

TABLE 4.4.--Projection of group centroids.

I Upper Level Graduates	II Lower Level Graduates	III Lower Level Academic Withdrawals
0.3838	1.3342	1.5761

Further, it can be seen that not only are the group centroids colinear, but that they are also located along the line in the same order as the groups vary in level of academic performance. That is, the lower level graduates, Group II, are located between Groups I and Group III.

It can also be noted that the distance between Group I and either Group II or Group III is much greater than the distance between Group II and Group III. This indicates that the separation between upper level graduates and either of the two other groups is better defined and more easily distinguishable.

Classification: The "Main" Sample

The second research problem considered in this study asks, "Can an unclassified individual be accurately

classified as an upper or lower level graduate or an academic withdrawal on the basis of the set of predictor variables?" Analysis of the results of using the method of maximum likelihood classification is presented in this section.

It is recalled that the method of maximum likelihood requires computation of a set of linear equations for the purpose of classifying an individual in one of several groups. One linear classification fucntion is formed for each group. Each of these classification functions contains a constant term and a number of terms equal to the number of predictor variables. Each of the terms in the function is a product of a coefficient and a variable. The evaluation of this linear classification function yields a classification score. The general form of the classification function is,

$$a_i \, x_{1j} + \ldots + l_i \, x_{12j} + K_i = P_{ij}$$

where,

$a_i, \ldots l_i$ = coefficients for i^{th} classification group

$x_{1j}, \ldots x_{12j}$ = set of twelve variables for j^{th} individual

K_i = constant term for i^{th} classification group

P_{ij} = classification score for the i^{th} group of the j^{th} individual.

Therefore, for each individual to be classified, three classification functions are computed. Since classification scores are monotone functions in relation to the probability of group membership, the individual is assigned to (or classified with) one of the three groups for which he has the largest score.

The computer program for the maximum likelihood classification method computes the values for each of the coefficients and the constant term associated with each classification group. Values computed for this study were derived from the values for the set of predictor values of each individual in the "main" sample. Table 4.5 is a table of these computed values.

The reader is cautioned that the magnitude of the coefficients cannot be meaningfully interpreted individually or in comparison with the other coefficients within the same classification group. Perhaps the only valuable insight to be gained through Table 4.5 is a comparative evaluation of the coefficients for the same variable between classification groups. Two observations are in order regarding the magnitude of the incremental change and the direction of this change (increasing or decreasing) from one classification group to another. Consider, for example, variable (1), the marital status of the student.

TABLE 4.5.--Value of coefficients and constant terms for linear classification functions.

	Variables	I Upper Level Graduates	II Lower Level Graduates	III Lower Level Academic Withdrawals
1.	Marital Status	7.78187	6.12314	5.75389
2.	Legal Residence	2.93991	2.61883	2.41928
3.	Age at Admission	1.31338	1.27915	1.32128
4.	UG Major	0.54688	9.12629	9.04922
5.	UG Institution	35.50497	33.55483	33.30129
6.	UG GPA	24.98496	24.71419	25.31582
7.	Delay Before MBA	-0.45653	-0.46518	-0.52949
8.	Enrollment of UG College	0.13541	0.13104	0.13003
9.	Total ATGSB Score	0.52645	0.51947	0.53350
10.	Verbal ATGSB Score	-3.36051	-3.36592	-3.44850
11.	Quantitative ATGSB Score	-2.41230	-2.40459	-2.48370
12.	Product (UG GPA x Mean ATGSB Score for UG Institution)	-0.00088	-0.00135	-0.00166
	CONSTANT TERM	-153.39880	-134.03993	-133.43082

The value of the coefficient for variable (1) decreases as the level of academic performances decreases. The incremental change between Group I and Group II is about four times greater than that between Groups II and III. The term in the classification function corresponding to this variable will, because of the values of its coefficients, contribute to the ordering and separation of the married students into the groups with higher levels of academic performance. The ordering and separation of married students in this manner is the result of the experience gained from analysis of the data from the "main" sample. This experience is "quantified" in the valuation of the coefficient for each of the classification groups.

The majority of the coefficients are monotone decreasing in relation to decreasing academic performance. However, the coefficients for variables (3), (9), (10) and (11) are convex in nature. For each of these variables, except (11), the value of the coefficient decreases from Group I to Group II, but the values for Group III exceed those of Group II. For variable (11), the value increases from Group I to Group II, but decreases to less than Group I for Group III.

Computation of the classification score for each of the 313 individuals in the "main" sample was accomplished and the classification matrix presented in Table 4.6 resulted. It is recalled that the actual level of academic

TABLE 4.6.--Classification matrix of main sample.

Actual Group Membership		Predicted Group Membership I Upper Level Graduates	II Lower Level Graduates	III Lower Level Academic Withdrawals
I	Upper Level Graduate	105	24	9
II	Lower Level Graduate	31	56	51
III	Lower Level Academic Withdrawal	5	15	17

performance achieved by each individual was known before the classification method (or model which was constructed with the experience of "main" sample), was used to predict the academic performance of each individual in the sample.

In analyzing Table 4.6, three terms, or definitions, are introduced: Hits--when predicted group membership coincides exactly with actual group membership; Near Hits--when predicted membership in either upper or lower level graduate groups actually occurs, but inversed, and Misses--when a predicted graduate was actually a withdrawal or when the predicted withdrawal was actually a graduate.

Using the terms as defined above, the data of Table 4.6 can be interpreted as follows:

$$(105 + 56 + 17) = 178 \text{ Hits}$$

$$(24 + 31) = 55 \text{ Near Hits}$$

$$(9 + 51) + (5 + 15) = 80 \text{ Misses}$$

or in percentages:

56.8% Hits

17.6% Near Hits

25.6% Misses

It is recognized that there are really two types of Misses: (1) rejecting student for admission who is in fact a "graduate," and (2) accepting student for admission who in fact is an "academic withdrawal." Borrowing from the terminology of the more familiar "Types of Error" used in testing hypotheses, let us define these types of Misses as Type I and Type II, respectively.

Now it is seen that there were:

$(9 + 51) = 60$ or 19.2% Type I Misses,

and $(5 + 15) = 20$ or 6.4% Type II Misses.

If one were to state that one type of Miss was less desirable or more serious than the other, Type I Misses would be so designated. A philosophy of education which would envision educational opportunity for all persons would very likely consider rejection of a student who, in fact, was capable of succeeding in an academic program to be less desireable than accepting a student who, in fact, was not capable of succeeding.

Classification: The "Check" Sample

Using the values of the coefficients and constant terms derived from the measurements of the "main" sample, a classification score for each classification group was computed for each individual in the "check" sample. The score for each of the 109 individuals in the "check" sample was made by dividing the graduates into upper level and lower level on the basis of the median GPA of all eligible graduates in the population from which the main sample was selected. The median GPA so determined was 3.25. The third and remaining category was comprised of all academic withdrawals in the "check" sample.

The classification matrix for the "check" sample is presented in Table 4.7.

TABLE 4.7.--Classification matrix for the "check" sample.

	Predicted Group Membership		
Actual Group Membership	I Upper Level Graduates	II Lower Level Graduates	III Academic Withdrawals
I Upper Level Graduates	37	18	2
II Lower Level Graduates	10	16	12
III Academic Withdrawals	2	7	5

Analyzing Table 4.7 in the manner previously used for the "main" sample classification matrix yields the following:

(37 + 16 + 5) = 58 Hits

(10 + 18) = 28 Near Hits

(2 + 12) + (2 + 7) = 23 Misses

or expressed in percentages,

53.2% = Hits

24.7% = Near Hits

21.1% = Misses

Considering the simplified prediction problem of separating graduates from academic withdrawals, a modified classification matrix would yield:

78.9% Hits (where a Hit is predicted graduation or withdrawal, regardless of the level of performance)

21.1% Misses

Of the "check" sample, 12.8% are Type I Misses, (rejection of a student who should be accepted), and 8.3% are Type II Misses (accepting a student who should be rejected).

Classification: Test of Significance

A test of the significance of the classification model developed in this study involves the question of whether or not the distribution of the "check" sample in the classification matrix of Table 4.7 is different from that which could be reasonably expected by chance. In

other words, did the classification model do any better job of accurately classifying individuals than could have been done by chance?

The χ^2 test was used to test the null hypothesis that the distribution presented in Table 4.7 was no different than a distribution that is the result of chance.

The test statistic can be expressed in words,

$$\chi^2 = \sum \frac{(\text{number observed} - \text{number expected})^2}{(\text{number expected})}$$

The evaluation of the χ^2 statistic was accomplished using the data of the "check" sample from Table 4.7 with the result

$$\chi^2 = 25.615$$

The χ^2 table value for the .005 level of significance and the four degrees of freedom of this problem is

$$\chi^2_{.005,4} = 14.86$$

Therefore, χ^2 is greater than $\chi^2_{.005,4}$ since,

$$\chi^2 = 25.615 > \chi^2_{.005,4} = 14.86$$

The null hypothesis is rejected at the .005 level of significance. This means that there are about five chances in 1,000 that the classification matrix in Table 4.7 could have been the result of chance.

Comparative Analysis

Analysis of the results of this study must include a comparison of the classification model and the actual selection of MBA students at MSU during the time period covered in the study.

Unfortunately, the analysis cannot be complete because there is no way of determining what "might have been"; it is impossible to determine what would have been the academic performance of those applicants who were refused admission. A certain percentage of this group of rejected applicants would probably have been successful if given the opportunity, but the number is undeterminable. Nevertheless, a comparison of such data as are available is presented in Table 4.8.

In the comparative analysis, consider the classification matrices for the "main" and "check" samples presented as Tables 4.6 and 4.7, respectively. The definitions of Hits and Misses provides a basis for introducing the additional terminology now used in Table 4.8:

Hits: Two types--

(1) "Accepted / should have been accepted" (A/A)

(2) "Rejected / should have been rejected" (R/R)

Misses: Two types--

(1) Type I: "Rejected / should have been accepted" (R/A)

(2) Type II: "Accepted / should have been rejected" (A/R)

Ideally, the analysis would compare the percentage of error attributable to each of the methods of selection--the model and the actual system of selection used during the time period.

The errors in selections occur as Misses--Type I, "Rejection / should have been accepted" (R/A), and Type II, "Accepted / should have been Rejected" (A/R). Unfortunately, the number of Type I Misses, (R/A), is undeterminable from actual experience, and thus a meaningful comparison cannot be made. However, in regard to Type II Misses, a comparison of the model and actual experience was made and the results listed in the last column of Table 4.8.

In Table 4.8, the Type II Miss is expressed as a percentage of the total number of students. This percentage, for the model, is less than that which actually occurred in

TABLE 4.8.--Comparison of model and actual experience with "check" and "main" sample MBA students

		Number of MBA Students				
		Hits		Misses		Ratio
		A/A	R/R	R/A	A/R	A/R:Total
Model:	"Main" Sample	216	17	60	20	9.3%
* Actual:	"Main" Sample	276	?	?	37	11.8%
Model:	"Check" Sample	81	5	14	9	10.0%
* Actual:	"Check" Sample	95	?	?	14	12.8%

*170 applicants refused admission during Fall term, 1966. The comparable number for the "main" sample is unknown.

both "main" and "check" sample periods; in this respect, the model is superior to the actual selection process.

Summary

In general, there is a monotone descending relationship between the mean values of the twelve predictor variables used in the study and the level of academic performance. That is to say, for example, that the younger the student, the lower the level of his academic performance. Only the three ATGSB scores and the size of enrollment at the student's undergraduate institution vary from this pattern. Both values decrease from upper level to lower level graduate, but increase slightly above the lower level graduate values for academic withdrawals.

In the data, one observes that the upper level graduate and therefore the more academically successful student has most of the following characteristics. He:

1. Attained a higher undergraduate GPA (both "raw" and "adjusted");
2. Scored higher on all three ATGSB tests;
3. Attended an undergraduate college other than MSU that was relatively larger (over 10,000) but not as large as that attended by the less successful MBA student;
4. Was older, married, and delayed longer before beginning the MBA program;

5. Maintained legal residence outside of Michigan, and;
6. Had completed a non-business undergraduate major course of study.

Discriminant analysis indicated that the three classification groups can be distinguished from one another as separate groups on the basis of the twelve predictor variables used in the study.

Only one discriminant function was determined to be significant. This function, however, accounted for 97.4% of the discriminating power of the analysis. With one significant discriminant function, the location of the group centroids can be projected on to one line. The projections of the group centroids were both colinear and ordered in the same manner as the classification groups. The intercentroid distances revealed that the upper level graduate group is well separated from both of the lower level groups, but that the lower level graduates and the academic withdrawals are relatively close together. This indicates that the major difficulty in classification may occur in the assignment of individuals to one of these two groups.

The classification model was constructed from the set of values for the predictor variables for each individual in the "main" sample. This data permitted computation of the coefficients and constant terms for a set of

classification functions--one classification function for each of the three classification groups. Evaluation of these classification functions yielded a set of three scores for each individual. The model compares the computed classification scores for each unclassified individual and assigns him to the group for which he has the highest score.

In this manner, each of the 109 unclassified individuals in the "check" sample was also assigned to one of the three academic performance categories. The academic performance of 53.2% of the "check" sample was accurately predicted and were termed Hits, 21.1% were Misses, while 24.7% were labeled Near Hits since they were predicted as graduates, but the level of performance was inversely predicted. If Hits were simply defined as predicted graduation or predicted withdrawal, the model produced 78.9% Hits and 21.1% Misses.

Not all Misses are the same. A Type I Miss is the rejection of a student who should be accepted, whereas a Type II Miss is the acceptance of a student who should be rejected. In this respect, the classification model produced 12.8% Type I Misses and 8.3% Type II Misses.

A χ^2 test of significance rejected the hypothesis that the classification distribution resulting from the model was no different than that which could reasonably be expected to occur by chance.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

In recent years, the Graduate School of Business Administration at Michigan State University, like many others, has been faced with the problem of selecting a limited number of students for the Master of Business Administration program from a field of applicants increasingly bigger and better in terms of both quantity and quality. The purpose of this study was to develop a probability model predicting the academic success of these applicants, something that could assist the admissions decision-maker in answering two questions:

(1) What is the likelihood that this particular applicant could successfully complete the MBA program and graduate?

(2) What would be the extent of this applicant's academic success in the MBA program?

A review of the literature revealed considerable research in the area of prediction of academic performance and/or success at both undergraduate and graduate levels. It was relatively extensive and particularly voluminous as it related to the undergraduate level, and somewhat repetitious of method throughout.

Most of the research used simple correlations or multiple-regression analysis as the statistical techniques for predicting academic performance (generally a grade-point average) from a set of predictor variables. The research showed conclusively that the best single predictor of future academic performance was the high school or undergraduate grade record, as the case may be. Improvement in prediction was achieved by using a battery of predictor variables, usually the high school or undergraduate GPA in combination with scores on tests specifically designed, generally, for screening applicants for admission. Addition of other intellective factors as predictors generally resulted in insignificant increases in the multiple correlation coefficient of the predictors with the criterion of success (usually the GPA). Here, a correlation coefficient of .50--or as high as .70 (extremely rare in this type of research)--would mean that the predictor variables used would at best account for less than 50% of the variations in academic performance.

Clearly, use of the tried and tired method of multiple-regression analysis held little promise for improving the accuracy of predicting academic success for applicants to the MBA program. Further research of the literature, however, revealed two multivariate statistical procedures--multiple discriminant analysis and maximum likelihood classification--that offered a different approach to the prediction problem.

In recent years, these methods have been used with considerable success in the area of guidance and counseling, in which group membership was predicted on the basis of the measurements on a series of predictor variables (test scores, interest inventories, ratings, etc.).

Two research problems were formulated to provide answers to the crucial questions of the admissions decision-maker:

(1) Can groups of MBA students who have either graduated or withdrawn from the program, when grouped by the overall graduate grade-point average, be distinguished from each other on the basis of the elements of information known about them at the time of the admissions decision?

(2) Can the likelihood of individual membership in one or another such group be predicted on the basis of the elements of information known about the individual at the time of the admissions decision?

The two multivariate statistical procedures, both programmed for machine computation, were used in the analysis. The first research problem was approached through multiple-discriminant analysis to investigate the significance of group differences and to determine the location of group centroids in discriminant space. Maximum likelihood classification methods were used to develop a classification model for the second research problem on the basis of the measurements of the predictor variables for each individual in the sample. With such a model, then, unclassified individuals were assigned to a group characterized by academic performance

in which the individual had the greatest likelihood--the greatest probability--of membership. By assigning members of a "check" sample--individuals not involved in the formulation of the model--in this manner, the model was evaluated for its accuracy in predicting the academic performance of an "unclassified" individual, such as an applicant for the MBA program.

The sample of students used in constructing the model was selected from the population of all students admitted and enrolling for the first time in the MBA program at Michigan State University from Fall term, 1962, to Summer term, 1966, inclusive. The "check" sample, used to validate the model's ability to correctly classify individuals, was selected from students entering MSU, under the same conditions in Fall term, 1966.

Application of selective criteria (essentially excluding foreign students, students with incomplete records, and females) reduced the number of students eligible for selection to 514 graduates and 72 academic withdrawals.

From those eligible, three extreme groups were selected for analysis. These groups were: (1) Upper level graduates; (2) lower level graduates, and (3) lower level withdrawals. Each of the graduate groups contained 138 students, or 27%, of all graduates. Because of the small number of academic withdrawals, 38 students, about 50%, were included in the third group.

The 12 predictor variables used were those elements of information generally available for all applicants for admission from either the standard MSU application for graduate study or university record files for each individual, with the exception of a new variable which was formed in an attempt to "adjust" or "weight" the applicant's undergraduate GPA in respect to the "quality" of his undergraduate institution. The measure of "quality" used was the mean ATGSB Total score for the undergraduate college, as reported by ETS.

In general, there is a monotone descending relationship between the mean values of the 12 predictor variables and the level of academic performance. As the mean value of the predictor variables decreases, the level of academic performance decreases.

From the data, one observes that the more academically successful student has most of the following characteristics. He:

(1) Attained a higher undergraduate GPA (both "raw" and "adjusted");
(2) scored higher on all three ATGSB tests;
(3) attended an undergraduate college other than MSU that was relatively large (over 10,000) but not as large as that attended by the less successful MBA student;
(4) was older, married, and delayed longer before beginning the MBA program;
(5) maintained legal residence outside of Michigan, and
(6) had completed a non-business undergraduate major course of study.

The results of the analysis of the data showed that the three classification groups could be distinguished from each other on the basis of the twelve predictor variables used in this study.

Only one discriminant function was determined to be significant, but this lone function accounted for 97.4% of the discriminating power of the analysis. With one significant discriminant function, projections of the group centroids were both colinear and ordered in the same manner as the classification groups. The intercentroid distances revealed that the upper level graduate group was well separated from both the lower level groups, but that the lower level graduates and the academic withdrawals were relatively close together. This indicated that a major difficulty in classification would be in distinguishing between the two lower groups.

The classification model was constructed from the set of values for the predictor variables for each individual in the "main" sample. These data permitted computation of the coefficients and constant terms for a set of classification groups. Evaluation of these classification functions yielded a set of three scores for each individual. The model compared the computed classification scores for each unclassified individual and assigned him to the group for which he had the highest score.

In this manner, the 109 unclassified individuals in the "check" sample were also assigned to the three academic performance categories. The academic performance of 53.2% of the "check" sample was accurately predicted and were termed Hits, 21.1% were Misses, while 24.7% were labeled Near Hits, since they were predicted as graduates but the level of performance was inversely predicted. If Hits were to be defined simply as predicted graduation or predicted withdrawal, the model produced 78.9% Hits and 21.1% Misses.

Not all Misses are the same. A Type I Miss is the rejection of a student who should be accepted and a Type II Miss is the acceptance of a student who should be rejected. In this respect the classification model produced 12.8% Type I Misses and 8.3% Type II Misses.

A chi-square (χ^2) test of significance rejected the hypothesis that the classification distribution resulting from the model was no different than that which could reasonably be expected to occur by chance.

Conclusions

For the sake of clarity and ease of understanding, the conclusions derived from an analysis of the results of this study are presented in four sections: General, Discrimination, Classification and Comparative Analysis.

General

Analysis of the results provided the answers to the two research problems considered in this study. It is concluded that:

(1) Groups of MBA students who have either graduated or withdrawn from the program, when grouped by the overall graduate grade-point average, can be distinguished from each other on the basis of the elements of information known about them at the time of the admissions decision.

(2) The likelihood of individual membership in one or another such group can be predicted on the basis of the elements of information known about the individual at the time of the admissions decision.

Discrimination

It was concluded that the three extreme groups--upper level graduates, lower level graduates, and academic withdrawals--are distinct separate groups that can be distinguished from each other on the basis of measurements on the twelve predictor variables used in this study. This determination was based on the investigation of the location of the centroids of the multivariate distributions of each of the three groups. The group centroids were found to be colinear (points on the same straight line) and ordered in the same manner as the three levels of academic performance.

From the intercentroid distances, it was determined that the separation between the upper level graduates and the two lower level groups was relatively large and that the

distance between these lower level groups was very small. From this observation, it was concluded that the major problem in classification of individuals would result from the difficulty in discriminating between the lower level graduates and the academic withdrawals.

Classification

It was concluded that the classification, or probability model, constructed on the basis of the measurements of twelve predictor variables for each individual in the "main" sample was a valid model for the prediction of academic performance for MBA students at MSU. In the test of significance, it was found that there were only about five chances in 1,000 that the prediction matrix of the model was the result of chance. The prediction of the individuals in the "check" sample was improved in comparison with the predictions made on the "main" sample.

Comparative Analysis

One of the most interesting and significant questions relating to the effectiveness of the model developed in this study cannot, unfortunately, be answered conclusively as a result of the analysis presented in this study. Comparison of the model with the actual experience of selecting MBA students was necessarily undeterminable and, therefore, incomplete. However, it can be negatively concluded that

the model does no worse than the less objective methods used in the admissions decision-making process during the time period encompassed in the study.

Discussion

The purpose of this study was to develop a probability, or classification, model to predict the academic performance of applicants to the MBA program at MSU. Hopefully, this classification model would assist the admissions officer in the admissions decision-making process. Development of this model was intended to improve the objectivity of the selection process and to optimize use of the elements of information known about the applicant at the time of the admissions decision. Efforts to improve objectivity are evidenced by the quantification of certain predictor variables and construction of a new variable which incorporated the concept of "adjusting" the applicant's undergraduate GPA according to the "quality" of the undergraduate institution.

It was concluded that the model so constructed did no worse, if not a little better, than the actual system of selection used in the Graduate School of Business during the 1962-1966 period. In addition to the advantages of a more objective, systematic method of processing applicants, the model offers several other opportunities.

Since the applicants would be classified as members of one of the three performance groups, the model would provide a system of priorities in selection of students to fill available class space. Not only would the model indicate those who should be accepted, but it would also indicate which of these applicants should be accepted on a regular or provisional basis.

The model would also identify the "borderline" applicants. If the individual classification scores for the two lower groups were about the same, this would indicate that additional information about the applicant should be considered before the admissions decision is made. Additional information from personal interviews or references are possible sources that are not included in the model.

In summary, the model offers the admissions officer an objective, systematic method to assist in the selection of students for the MBA program. It establishes an order of priority in the selection of students that would provide a basis for admission to either regular or provisional student status. The model would identify "borderline" applicants, and suggest when additional information should be considered in arriving at the admissions decision.

Implications for Future Research

The methodology used in construction of the classification model appears to be sound. The twelve predictor variables used in the study represent elements of information commonly most readily available for the majority of applicants to the MBA program. Limited subsequent investigation holds little promise for improving the model by inclusion of additional variables of similar nature.

The model could possibly be improved by including certain non-intellective factors as predictor variables. Below are seven such factors that should be considered in future research on the development of an improved classification model. The first six factors were presented by Rowe in a conference on research related to college admissions.[33]

(1) Social and economic status of the student's family,
(2) Educational and/or cultural level of this student's home,
(3) The educational aspirations and expectations of the student's peers,
(4) The student's own educational and vocational aspirations,
(5) The student's attitudes toward the environment of the educational institution,
(6) The student's own personal and social needs,
(7) The self concept of the individual student.

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[33]Frederick B. Rowe, "Non-Intellective Factors Affecting Student Performance," Research Related to College Admissions, ed. Kenneth M. Wilson (Atlanta: Southern Regional Education Board, 1963), p. 135.

The most difficult problem in classification of an individual in the model arises because of the minimum separation between the lower level graduates and the academic withdrawals. Therefore, it is recommended that future research investigate ways of improving the discrimination between these two groups.

In any event, the present approach to the problem of predicting academic success through use of a maximum likelihood classification model appears to invite future research into the measurement and inclusion of additional elements of information, to improve discrimination, and thereby to improve the power of the classification method used in the model.

Admissions officers, deans and teachers must, to varying degrees, either make decisions or help others make decisions that have significant affect on the student and the course of his life. Admission to graduate study is a major and most serious decision. While the state of the art is not sufficiently advanced to entrust admissions decision-making to a computerized model, the assistance that such a model can provide should not be overlooked. By increasing the objectivity of the selection process, the exercise of subjective judgment, which in the final analysis is still the major element in the admissions decision, can be sharpened.

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BIBLIOGRAPHY

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APPENDICES

APPENDIX A

APPLICATION FOR ADMISSION
TO GRADUATE STUDY
MICHIGAN STATE UNIVERSITY

FOR OFFICE USE ONLY

Quarter.....Year.....	Application fee paid
College.....	.....
Student Number.....	Checked by
Accept.....	.....

G-002

MICHIGAN STATE UNIVERSITY

EAST LANSING, MICHIGAN 48823

APPLICATION FOR ADMISSION TO GRADUATE STUDY

AND/OR

GRADUATE ASSISTANTSHIP, FELLOWSHIP
OR TUITION SCHOLARSHIP

Return to Office of Admissions and Scholarships

MSU Student Number | Degrees Held | Middle Name | First Name | Last Name

Complete with typewriter or print in black ink, according to *instructions* (see yellow sheet).

This is an application for: ☐ **Admission to Graduate Study,** ☐ **Fellowship,** ☐ **Tuition Scholarship,**
(Check appropriate boxes See no. III of instructions.) ☐ **Assistantship in the Department of**.....

Date .....

1. Full Name: Mr. ☐ Mrs. ☐ Miss ☐ ..... | | | |
Last (Family) Name — First Name — Middle (or Maiden) Name — Social Security Number

This is an application for Fall ☐ Winter ☐ 19.....; Summer ☐ Spring ☐ 19..... Male ☐; Female ☐: Single ☐; Married ☐.

If married: a) Name, address and occupation of spouse .....
b) Is spouse: Now an MSU student ☐; now an MSU staff member ☐; former MSU student ☐; former MSU staff member ☐; also applying for MSU admission ☐?

Have you served in the armed forces of the United States? YES ☐; No ☐. If yes, enclose copy of your separation papers, form DD214.

2. Home Address ..... Telephone .....
Number — Street — City — State — Zip Code

Present Address ....
Number — Street — City — State — Zip Code — Telephone — (Last date you will be at this address)

Your legal residence? ..... How long have you lived there? ..... years ..... months
City — County — State

3. a. Date of Birth ..... 19 . Place of Birth ..... Country of present citizenship .....
Month — Day — State or Country

b. If a citizen of another country, currently living in the United States, what type of visa do you have? .....

4. List in chronological order ALL colleges attended including evening and extension work. Transcripts of ALL academic work must be submitted.

NAME OF INSTITUTION	CITY	STATE	ATTENDANCE DATES (Month and Year)	GRADUATION		
				Date	Degree	Major
			from to			
			from to			
			from to			
			from to			
			from to			

5. In what field are you planning to major? — (See Yellow Sheet): Field ..... Specific Area .....

6. Toward which degree are you planning to study at Michigan State University? Master's ☐ Doctoral ☐ Non-degree ☐ Educational Specialist (6 years) ☐ Diploma Program for Advanced Graduate Studies (6 years) ☐.

7. Do you plan to take courses in East Lansing? ..... If not, where? .....

8. a. Have you previously applied for admission to graduate study at MSU? When .....
b. Have you previously attended MSU or taken off-campus work through MSU? Yes ☐ No ☐
c. Date of last attendance: Term ..... Year ..... Student Number .....
d. Are you currently enrolled as a graduate student in any MSU course at East Lansing? ..... If not East Lansing, where? .....
e. Indicate grade point average as determined at bottom of pages 3 and 4 →

CPA	Page 3	
	Page 4	

9. The enclosed $10 application fee paid by ☐ check, ☐ money order.

Do not write below this line

First time at this level ..... Transfer at this level ..... Undergrad. G.P.A. ..... Credits ..... ; Grad. G.P.A. ..... Credits .....

Program .....
Adm. Status — Level — College — Major

Adviser ..... Checked by ..... Date .....

LVL.	CURR.	CL.	SEX.	RES.	DATE OF BIRTH			UNDERGRAD.		GRADUATE		ADM.	LAST SCHOOL			ACAD. ADV.	CLSF.	MAJ.	CODED BY	K.P. BY
					YR.	MO.	DAY	G.P.A.	CREDIT	G.P.A.	CREDIT		STATE	CITY	SCH.					

5-67—100M

10. **State in chronological order periods of employment including military service since earning a bachelor's degree.**

DATES	EMPLOYER	CITY	STATE	NATURE OF POSITION

11. (a) **Are you presently employed by Michigan State University? Yes** ☐; **No.** ☐. **If yes, where** .....
(b) Do you have an agreement for employment at Michigan State University? Yes ☐; No ☐. If yes, where .....

12. Academic honors, distinctions, scholarships, etc., which you have earned or graduate assistantships held .....
.....

13. Professional organizations in which you hold a membership .....
.....

14. Describe the degree of your proficiency (reading and speaking) in French .....
German ....., other foreign languages .....

15. Titles or names of any of your publications, research, or inventions .....
.....

16. Insert one separate page (8½ x 11) stating your plans for graduate study and a professional career. Be as specific and detailed as you can at this time.

17. College of Business applicants, only: Have you taken the Admissions Test for Graduate Study in Business? ..... (yes) or ..... (no). If yes, when? ..... (date) ..... If no, when will you take it? ..... (date)

18. Some departments require the Graduate Record Examination (See Yellow Sheet). Have you taken this test? ..... (yes) or ..... (no). If yes, give scores:

Scores:

Verbal	Quantitative	Advance	Code

19. Do you have a teaching certificate? ..... If yes, specify type .....

20. List names, titles and addresses of three individuals submitting letters of recommendation **to the chairman of your graduate study department** at M.S.U. (There is no special form provided for these letters.)

NAME	TITLE	ADDRESS
1		
2		
3		

I certify that all the answers I have given in this application are complete and accurate to the best of my knowledge, and if admitted, I agree to observe all the rules and regulations of Michigan State University.

Date ..... Signed .....

MICHIGAN STATE UNIVERSITY
Office of Admissions and Scholarships

COURSES TAKEN IN THE SECOND HALF OF FOUR-YEAR UNDERGRADUATE PROGRAM

Report grades as requested in No. II of Instructions.

EDUCATIONAL INSTITUTION	YEAR TAKEN	COURSE TITLE AND NUMBER	GRADES AND CREDITS									
			SEMESTER CREDITS					QUARTER CREDITS				
			A	B	C	D	F	A	B	C	D	F
		(COURSES IN MAJOR FIELD)										
		(COURSES IN MINOR FIELD)										
		(OTHER COURSES)										
	Credits for each grade. *(Add each column to determine the number of credits for each grade.)*											
	Grade points for each grade. *(Multiply the total credits for each grade by the number directly below it, for example multiply A credits by 4, B credits by 3 etc.)*		x4	x3	x2	x1	x0	x4	x3	x2	x1	x0

Total Credits

Total Grade Points

Undergraduate grade point average: *Divide total grade points by total credits* = Total G.P. / Total Cr.

Grade Point Average

Date

Last Name

First Name

Middle Name

Degrees Held

MSU Student Number

(Please PRINT information in above space.)

MICHIGAN STATE UNIVERSITY
Office of Admissions and Scholarships
COURSES TAKEN AS A GRADUATE STUDENT

Report grades as requested in No. II of Instructions.

EDUCATIONAL INSTITUTION	YEAR TAKEN	COURSE TITLE AND NUMBER	GRADES AND CREDITS: SEMESTER CREDITS					QUARTER CREDITS					
			A	B	C	D	F	A	B	C	D	F	
	Credits for each grade. *(Add each column to determine the number of credits for each grade.)*												Total Credits
	Grade points for each grade. *(Multiply the total credits for each grade by the number directly below it, for example multiply A credits by 4, B credits by 3 etc.)*		x4	x3	x2	x1	x0	x4	x3	x2	x1	x0	Total Grade Points

Graduate grade point average: *Divide total grade points by total credits:* = $\frac{\text{Total G.P.}}{\text{Total Cr.}}$ Grade Point Average

Date | Last Name | First Name | Middle Name | Degrees Held | MSU Student Number

(Please PRINT information in above spaces.)

APPENDIX B

CLASSIFICATION SCORES FOR EACH INDIVIDUAL IN "CHECK" SAMPLE AND ASSIGNMENT TO ACADEMIC PERFORMANCE GROUP

Note: Group 1--Upper level graduates
Group 2--Lower level graduates
Group 3--Academic withdrawals

RESPONDENT	SOURCE GROUP	SCORE 1	SCORE 2	SCORE 3	ASSIGNED GROUP
1	3	143.93262	145.34955	145.30683	2
2	3	127.84316	127.96845	126.95052	2
3	3	146.68421	146.82757	146.32806	2
4	3	113.09012	115.59969	115.91611	3
5	3	137.44151	139.39274	139.69154	3
6	3	117.54332	119.45902	119.33055	2
7	3	135.27339	135.67158	135.16728	2
8	3	146.85971	147.95595	147.92515	2
9	3	127.65725	127.91813	127.54707	2
10	3	120.10479	122.35892	122.93013	3
11	3	155.41686	154.73685	154.65210	1
12	3	156.08317	154.67637	153.97065	1
13	3	120.74103	122.42469	122.59121	3
14	3	152.31206	153.54273	154.48247	3
15	1	138.23094	136.86475	135.75200	1
16	1	151.74418	149.62141	148.85643	1
17	1	142.67503	142.51224	141.60802	1
18	1	156.21290	156.26543	155.61748	1
19	1	167.40991	163.74402	162.19256	1
20	2	136.71261	136.72468	138.98038	3
21	2	140.44219	141.14445	141.88486	3
22	2	114.00692	115.56147	115.05065	2
23	2	151.81359	151.44253	150.74407	1
24	2	134.07913	135.78587	135.13918	3
25	2	124.91201	126.47515	126.53508	3
26	2	129.52289	131.69411	131.69890	3
27	2	145.21608	147.14745	147.33137	3
28	2	153.57454	154.10354	154.93762	3
29	2	127.75766	128.92756	127.59648	2
30	2	127.17965	129.42594	129.14253	2
31	2	151.61281	152.14548	152.41712	3
32	2	136.74233	145.28594	144.01208	1
33	2	155.15577	154.67489	154.34747	1
34	2	131.54257	131.46927	131.11176	2
35	2	156.69377	152.16509	151.48222	1
36	2	147.08675	148.81974	148.69858	3
37	2	147.41406	166.55457	165.75627	1
38	2	116.74440	119.42421	119.49210	3
39	2	135.95797	134.40729	136.02150	2
40	2	139.74056	140.92273	141.44642	3
41	2	154.47550	154.45467	154.81094	2
42	2	116.05609	119.72461	119.34923	2
43	2	153.22898	153.91144	153.69808	2
44	2	149.53507	148.86503	147.85405	1
45	2	131.51529	132.34486	132.14360	2
46	2	154.93840	153.47754	152.84205	1
47	2	122.99304	124.76708	124.06670	2
48	2	126.55660	129.41114	128.78508	2
49	2	134.14268	135.50284	135.35513	2
50	2	141.27205	140.21681	139.57918	1
51	2	163.65923	161.55454	160.50025	1
52	2	134.14575	144.90282	144.83551	2
53	2	126.85761	129.49164	129.47965	3
54	2	136.12999	136.30764	136.07909	2
55	2	125.51212	126.46448	126.17514	2
56	2	129.92259	130.75554	130.37110	2
57	2	163.05044	162.46564	161.77066	1
58	1	146.05807	145.67929	145.34936	1
59	1	138.74441	138.47041	138.42849	1
60	1	133.24811	134.86154	134.40042	2

61	1	150.92997	151.18331	150.70933	2
62	1	133.30304	134.64915	134.55975	2
63	1	139.81004	139.33969	138.79603	1
64	1	150.28059	151.52136	151.55492	3
65	1	145.02586	145.54023	145.45625	2
66	1	113.15737	114.82347	114.14485	2
67	1	173.47554	171.37374	170.33299	1
68	1	159.05091	159.09883	159.04102	2
69	1	161.03676	159.86197	158.91543	1
70	1	149.28303	149.91123	149.61252	2
71	1	117.17042	118.66771	118.39730	2
72	1	159.29394	159.80907	159.44521	2
73	1	159.99484	159.44369	158.94252	1
74	1	169.73977	169.00503	168.41723	1
75	1	142.66948	142.01597	141.34796	1
76	1	153.61149	153.79507	153.44770	2
77	1	160.56131	158.96459	158.58456	1
78	1	135.10352	135.54463	135.51217	2
79	1	141.31563	140.91368	140.54019	1
80	1	132.01330	131.27644	130.23917	1
81	1	145.64667	145.50901	144.95124	1
82	1	161.28058	159.33267	158.58730	1
83	1	160.12413	159.17343	158.54671	1
84	1	168.76394	166.91881	165.61697	1
85	1	162.59262	160.32821	159.67609	1
86	1	139.29307	139.90309	139.65432	2
87	1	156.16003	154.35947	154.32238	1
88	1	125.41086	126.50982	126.05779	2
89	1	117.64508	114.48627	113.77720	1
90	1	132.96072	134.13904	133.61012	2
91	1	127.68867	128.10799	128.07615	2
92	1	148.66237	147.62861	147.47121	1
93	1	171.43045	159.96124	159.77091	1
94	1	139.55408	138.95161	138.55894	1
95	1	163.42751	161.46769	160.22770	1
96	1	150.34444	149.93489	149.61908	1
97	1	155.41088	153.59370	152.93377	1
98	1	141.81721	141.69986	141.58997	1
99	1	125.44242	128.11206	127.55965	2
100	1	130.96026	128.17204	127.78631	2
101	1	151.65399	149.23793	148.34964	1
102	1	158.26267	157.41036	156.96207	1
103	1	139.01970	137.91373	137.07322	1
104	1	134.97455	133.54381	132.41143	1
105	1	147.98101	148.20516	147.51622	2
106	1	140.96638	141.73293	141.63092	3
107	1	133.47113	133.39163	132.61461	1
108	1	162.54760	159.56314	157.97401	1
109	1	166.57652	166.24161	166.57064	1