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ELHASSY, JUMA'A KHALIFA

SCHEMATIC FACES AND FINANCIAL PREDICTIONS: SENSITIVITY TO SELECTED CONSTRUCTION ASSUMPTIONS

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SCHEMATIC FACES AND FINANCIAL PREDICTIONS:

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APPROVED BY

DISSERTATION COMMITTEE

To The Memory of My Father Khalifa Yousif ElHassy

And My Mother Menajee

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CHAPTER I

PURPOSE AND OVERVIEW

Accounting is concerned with the quantitative expression of economic phenomena. It is the process of recording, classifying, summarizing, interpreting, and communicating economic data. A necessary aspect of the accounting function is the development of the communication process so that information can be transmitted in a comprehensible manner to potential users. There is a large amount of highly interdependent information contained in financial statements. To ease the burden of comprehending this large and complex set of information, a number of means of financial statement analysis have been developed to help people understand the information contained in accounting statements.[1]

Users of financial statements employ a variety of tools to reduce reliance on pure hunches, guesses, and intuition and to narrow the inevitable areas of uncertainty which attend all decision making processes.[2] Among the tools available to users are: comparative

financial statements (year to year changes), index number trend series, common size financial statements, cash forecasts, analysis of changes in financial position and ratio analysis. Among these, ratio analysis is most widely known and used in financial analysis. It facilitates the interpretation of financial statement information by reducing the amount of information to a relatively small number of ratios. Ratio analysis has been widely used to measure a firm's profitability, short and long-term solvency, efficiency (turnover ratios), and credit worthiness.

In addition to the use of ratios and other quantitative techniques, graphs have also been used as an interpretive aid. Graphs especially help those who are not prepared to deal with the quantitative aspects of financial statement analysis. Also in graphs, trends and patterns are easily depicted and become obvious to users. Examples of widely used graphs are bar charts, pie charts, and curves.

The annual reports of most large firms include several of the common ratios. In addition, they frequently include a variety of graphs for sales, earning per share and charges in financial position. To determine whether firms should incur the cost to prepare and report these items, the information should be evaluated in terms of its usefulness.[3] Usefulness, in turn, is measured in terms of the ability of information to facilitate decision making.[4] One way of doing that is to examine the predictive ability of information. "A prediction can be

made without making a decision, but a decision cannot be made without, at least implicitly, making a prediction."[5] In order to evaluate the predictive ability of a model, it should be tested in a real situation where the actual outcome is known. Such a situation exists with bankruptcy prediction, and bankruptcy prediction has become a popular criterion for accounting studies.

A number of statistical models (such as cluster analysis, discriminant analysis, regression analysis and bayesian theory) have been used to investigate the ability of accounting information to predict subsequent business bankruptcy. These statistical models have proven to be useful predictors. While graphs have been thought to be useful for depicting trends and patterns, they have been limited to the description of the relationship between just a few variables, and their predictive ability has not been systematically examined. Recently, however, Moriarity[6] has described multi-dimensional graphs for representing a large number of variables. His initial results suggest that a multi-dimensional graphic representation of ratios can be an efficient vehicle for predicting business bankruptcy. This study extends Moriarity's study and elaborates on some of the questions he raised.

Statement of the Problem

This study will examine the effect on the predictive ability of multi-dimensional graphics from

changing the manner in which they are drawn. The context will be the prediction of bankruptcy, in part, because bankruptcy represents one of the most serious events a firm may face. It is of great interest to users because failure is an event which produces substantial losses to stockholders and creditors. A model which predicts potential business failure as early as possible will serve to help reduce such possible losses by providing ample warning to interested parties so that corrective action can be taken.

The graphic technique presented by Moriarity represents a way of communicating the accounting information to users. The technique transforms ratios into a form which may allow people to predict business bankruptcy. Moriarity concluded his study by stating that "while the potential of schematic faces for representing financial information seems great, a number of areas requiring further investigations are required."[7]

The Purpose of the Study

Better communication can be fostered by searching for better means of transmitting accounting information. Moriarity's study represents an example of a possible useful communication channel. The objective of this study is to improve the communication model developed by Moriarity.

Research Methodology

To achieve the objective of this study, an experiment was conducted in the spring semester, 1980, at the University of Oklahoma. The experiment used 504 students enrolled in the first introductory accounting courses. The details of the research methodology are given in chapter three.

This study was conducted through an experiment. This approach is taken for several reasons. First of all, if accouting is a science, then it must be rooted in observation, not arm-chair speculation.[8] Second, for the purpose of this study, there is no theory which provides a base for arguments. For instance, the question of which aspects of the graphs are most salient is not the type of question that can be answered theoretically. Also, empirical studies could shed light on new developments. As Chambers said:

> Compared with the volume of mere opinions and dogma which fill the so-called theoretical literature of the past fifty years, the amount of actual evidence, the empirical evidence, is pitifully small.[9]

A science needs empirical work to develop theory. Science has, as its purpose, the explanation of the real world facts, and without going into the epistemological question involved, the body of the real world facts is gathered only by empirical work.[10]

If there are several different theories that lead to different conclusions, or if there is no theory at all on a subject matter, the best manner of resolving the issue is to test, empirically, the significance of the results or its soundness. In accounting this would mean that it would be desirable to test, empirically, which of various alternatives is the best to use. For these reasons, then, an empirical investigation was used to examine the model.

Significance of the Study

The results of this study should aid in indicating the areas which need more research and the way to approach them. The study also indicates to what extent the graphic technique is a useful means of communication. The identification of shortcomings of the model and the way to overcome them will also help in improving the model further.

Organization of the Study

Chapter two discusses, in brief, the related literature. The chapter starts with a discussion of the various statistical models developed to predict business failure. A review of the use of the graphic technique in accounting is also discussed in chapter two. Chapter

three includes a discussion of the experiment and the detailed steps and procedures followed in the design of the different treatments. Chapter four presents the results, and their analysis and interpretation. The last chapter, five, includes the summary and conclusions of the study.

FOOTNOTES TO CHAPTER I

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2. Bernstein, Leopold, Financial Statement Analysis: Theory Application and Interpretation, (Homewood, IL, Richard Irwin, 1974), p. 35.

3. Beaver, W., Kennelly, J.W., and Voss, W.M., "Predictive Ability as a Criterion for the Evaluation of Accounting Data," The Accounting Review, October 1968, p. 678.

4. Ibid., p. 678.

5. Ibid., p. 680.

6. Moriarity, Shane, "Communicating Financial Information Through Multi-Dimensional Graphics," Journal of Accounting Research, Spring 1979, p. 205-224.

7. Ibid

8. Ketz, John, "A Comparison of the Predictablity of Business Failure by the Financial Ratios of General Price Level Statements with Those of Historical Cost Statements," Unpublished Doctoral Dissertations, Virginia Polytechnic Institute, August 1977, p. 17.

9. Chambers, R.J., "Prospective Adventures in Accounting Ideas," The Accounting Review (42), April 1967, p. 251.

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CHAPTER II

REVIEW OF THE RELATED LITERATURE

Business Failure

A business firm might be classified as failing, insolvent, or bankrupt when it faces a variety of financial distresses. There is no single accepted definition of failure in the literature. To some, failure is defined as economic failure, where a firm is still in operation, but its rate of return on invested capital is significantly and continually lower than prevailing rates on similar investments.[1] In this form, the "failing" firm has a positive equity position and may not even have liquidity problems. At another level, Walter used the term technical insolvency to describe the situation where a given business enterprise is unable to meet its currently maturing obligations.[2] Others restrict the term failure to so-called real insolvency where the firm finds itself in a position where its total liabilities exceeds a fair valuation of its total assets. In this last case, real net worth is negative.[3] Obviously, insolvency may be a temporary condition for a firm. It may be insolvent yet keep operating for a while and even recover.[4] But if the firm is

in such a bad situation that it cannot pay its debt, when it can voluntarily or involuntarily enter into bankruptcy in the legal sense.

Causes of Business Failure

Even though there is considerable information available on the causes of failure, there is no single theory which can be used to identify and generalize the major reasons for failure. Lev attributed the lack of a unified theory to the complexity and diversity of business operations, the lack of a well-defined economic theory of the firm under uncertainty, and a surprising reluctance by many researchers to incorporate the failure phenomenon in their models.[5]

Several attempts have been made to catalogue the causes of business failure. Dewing listed four fundamental economic causes of failure:

1. Excessive competition
2. Unprofitable expansion
3. Change in public demand for the commodity, and
4. Excess payment of capital charges.[6]

In a continuing survey, Dun and Bradstreet attempts to determine the causes of failure. Based on the opinion of informed creditors and the Dun and Bradstreet information, the major causes appear to be management incompetence and lack of experience.[7] In his book, Corporation Collapse: The Cause and Symptoms, Argenti gives a detailed list of causes of corporate failure. Some of these are:[8]

1. Poor management:
   - one-person rule
   - non-participating board of directors
   - unbalanced top team
   - lack of management depth.
2. Inadequate accounting information
   - lack of budgetary control
   - lack of cash flow forecasts or failure to keep them up to date
   - lack of an adequate costing system for each product, department and subsidiary
   - incorrect valuation of assets.
3. Overtrading:
   - attempting to expand revenues at the expense of profit margins, i.e., when revenues increase faster than profit
4. Inadequate response to changes:
   - not knowing how to compete with, for example, new foreign low cost producers, or with increased competition created by a merger of other competitors.
   - being slow to respond to political change in national and/or international quotas, duties, taxes, or levies, or in political attitude towards business in general or certain industries in particular.

- Failure to keep up with changes in technology.

5. Mishandling the big project:
   - tackling more than the company can handle
   - not knowing precisely what to do and making a significant miscalculation as a result.

No matter how the causes of failure are classified, they have all precipitated failure in the past and may be symptoms of failure in what is apparently a healthy business.[9] Unfortunately, what might be a principal cause of failure in one case might not be the cause for another. This latter attribute substantially complicates the search for symptoms of impending failure. Nevertheless, substantial progress has been made in predicting failure through the use of ratio analysis.

Uses of Financial Ratios to Predict Failure

Financial ratios have long been regarded as barometers of corporate health. They have been used for reporting such things as liquidity, leverage, activity, and profitability. It has been argued that from ratios an investor may be reasonably expected to appraise the performance of a firm and to determine its prospects for success. The following two sections summarize the existing literature as it relates to ratios in statistical and graphic forms.

Statistical Techniques

In an early study, Fitzpatrick[10] compared the financial ratios of 19 successful firms with nonsuccessful ones for the period 1920 to 1929. Fitzpatrick's objectives were to see if the ratios of successful firms were satisfactory while the ratios for failed firms were not so, and whether the majority of the ratios of successful companies were favorable or unfavorable, and to what extent. The technique used was to compare the ratios of matched pairs of firms to a set of minimum standards and to examine these ratios for trends.[11] The results of the study showed that failed firms tended to be below the minimum values for several ratios. In contrast, the surviving firms surpassed the minimum value in most, if not all, cases. As far as the trend is concerned, the ratios for failed firms deteriorated as the year of the failure approached. Net worth/debt and net profit/net worth were the most revealing indicators of failure among the ratios used. Fitzpatrick concluded

> . . . The ratios are important tools in ascertaining significant relationships of business facts. These relationships are worthwhile indicators. . . not . . . absolute indicators of impending financial difficulties.[12]

In another study, Winakor and Smith[13] examined the financial ratios of 183 failed firms during the period 1923 to 1931. The mean ratios of the middle half of all the firms was used to compare individual changes for the whole group. . . these mean ratios were compared with the accepted minimum

levels and were examined for any trends or tendencies. . . .[14]

The results of the study showed that for the 183 companies studied, the ratio of working capital/total assets was the most accurate and steady indicator of failure. Actually, their data indicates that the long-term solvency ratios were equally good indicators.

Tamari built a very simple index of risk. Six ratios

> generally accepted as indicators of financial soundness are chosen, and each is given a weight according to its importance in the eyes of financial analysts, economists, and credit men. . . .[15]

The ratios included in the index were: (1) equity capital + reserves/total liabilities, (2) profit trend, (3) current ratio, (4) value of production/inventory, (5) sales/receivables (including notes), and (6) value of production/working capital. The first and second ratios were given 25 points each, the third ratio was given 20 points and the remaining three ratios were given 10 points each. The weights total 100, and each firm is then given a certain number of points for each item as explained in Table 2-1. The index was tested to see if it was really lower for bankrupt companies[16] in the year prior to bankruptcy than for all industrial companies for the period 1956-1960. Tamari found that 75 percent of the bankrupt firms had less than 35 points and 50 percent had less than 25 points. The non-failing firms had more than 46 points 75 percent of the time and 50 percent had 63 or more points. The index of risk reveals that firms with lower ratios (or lower indices)

TABLE 2-1

KEY FOR CALCULATING INDEX OF RISK

	Points
1. Equity capital + reserves	
Over 50 per cent of total liabilities	25
41 - 50 per cent	18
31 - 40 per cent	15
21 - 30 per cent	10
10 - 20 per cent	5
Under 10 per cent	0
2. Profit trend	
Profits every year and rising net profit/ turnover ratio	25
Profits every year but no uniform trend	20
Profits every year but declining trend or loss during first year followed by profits	15
Loss in a year other than the first year	10
Loss in first two years	5
Loss in more than three years or in last two years	0
3. Current ratio	
Firms with a ratio of over 2	20
1.5 - 2	15
1.1 - 1.5	10
0.9 - 1.1	5
Under 0.9	0
4. Value of production by inventory	
Firms with a ratio equal to or greater than the upper quartile of branch and size group	10
Between median and upper quartile	6
Between lower quartile and median	3
Below lower quartile	0
5. Sales by receivables	
Firms with a ratio equal to or greater than the upper quartile of branch and size group	10
Between median and upper quartile	6
Between lower quartile and median	3
Below lower quartile	0

Table 2-1, Continued

	Points
6. Value of production by working capital	
Firms with a ratio equal to or greater than the upper quartile of branch and size group	10
Between lower and upper quartile	
Below lower quartile	

Source: Tamari, M. "Financial Ratios as a Measure of Forecasting Bankruptcy," Management International Review, Volume 4, 1966, p. 21.

are more susceptible to bankruptcy than those with higher ratios. But lower ratios do not prove that companies with weak ratios necessarily go bankrupt. For this reason, Tamari studied the profitability of firms with a low risk index and concluded that firms with less than 30 points are more likely to go bankrupt than those with over 60 points. Similarly, he found that there is little likelihood that firms with a high index will drop to a low category.[17]

More recently, Beaver[18] concluded the most complete study to date of the relationship between ratios and business failure. The sample included firms defaulting on interest payment on debt, overdrawing their bank account, or declaring bankruptcy. Data for 79 firms which failed during the period 1954-1964 were collected and matched by industry and asset size to similar data for 79 firms which had not failed. Beaver

computed 30 financial ratios for each year (five years were used in the study) and conducted a "profile analysis", where he stated several propositions as to the probability of failure when certain relationships existed between certain characteristics of a cash flow model and the ratio. The study showed that the ratio of cash flow/total debt misclassified only 13 percent of the sample firms one year before failure and 22 percent of the sample firms five years before failure. Net income to total assets predicted the second best.

In a later reference to this study, Beaver said:

> This evidence. . . suggests that financial ratios can be useful in the prediction of failure for at least five years prior to the event;. . . the user cannot choose among ratios indiscriminately. Persistent differences in predictive ability were found, many of which were not correctly anticipated by the a priori arguments in the literature.[19]

The second type of analysis that Beaver used was a dichotomous test. In this test, the decision maker would base his decision on whether the firm will fail or not solely on his knowledge of financial ratios. To make predictions

> . . . the firms are randomly divided into two subsamples. For a given ratio, the data of the first subsample are arrayed in ascending order. The array is inspected to find an optimal cutoff ratio--a cutoff point that minimizes the percentage of incorrect predictions. If a firm's ratio is below the cutoff ratio, the firm is classified as failed. If the firm's ratio is above the cutoff point, the firm is classified as nonfailed . . . to make the test conform more closely to the decision-making situation, the optimal cutoff point for the first subsample was used to predict the failure status of firms in the second subsample. Similarly, an optimal cutoff point was derived for the second subsample and was used to predict the failure status of the firms in the first subsample.[20]

The method was thus tested on firms other than those on which it was developed and the tests allowed a determination of type I and type II prediction errors. The predictive ability of each ratio was assessed based on the percentage of errors. The lower the percentage of errors, the greater the predictive power of the ratio. The ratios consistently showed better predictive ability than that which could be achieved by random prediction. The most striking feature of the data is the consistently superior performance of the non-liquid asset ratios.

In another study, Beaver observed that changes in market prices of stock were also good indicators of potential financial distress. ". . . The finding of the cross-section and time-series analysis" showed

> The price changes of the common stocks acts as if investors rely upon ratios as a basis for their assessments, and impound the ratio information into the market prices.[21]

Lev, using Beaver's sample, tested the predictive power of financial ratios using a decomposition measure. The study was based on the assumption that ". . . failing firms, which usually experience substantial changes in assets and liabilities, will have on average larger measures than solvent ones."[22] The results of the study did confirm this assumption.

Edward Altman also examined the ability of financial ratios to predict bankruptcy. Using multiple discriminant analysis, Altman compared 33 manufacturing firms declaring bankruptcy during the period 1946-1965 with a stratified sample of 33 nonfailing manufacturing firms.

> Multiple discriminant analysis is a statistical technique used to classify an observation into one of several a priori groupings dependent upon the observation's individual characteristics. It is used primarily to classify and/or make predictions in problems where the dependent variable appears in qualitative form, e.g. male or female, bankrupt or nonbankrupt ...After the groups are established, data are collected for the objects in the groups; MDA then attempts to derive a linear combination of these characteristics which best discriminates between the groups.[23]

From an initial list of 22 variables, Altman selected the following five ratios to be included in the discriminant function: working capital/total assets, retained earnings/ total assets, earnings before interest and tax/total assets, market value of equity/book value of total debt, and sales/ total assets. The ratios which were included and the weights that were given were determined by the significance of the contribution they made to the predictive ability of the model. The predictive success of the Altman model is notable during the first two years prior to bankruptcy (95% accuracy for the first year and 72% for the second year), but declines substantially for longer lead times.

Edward Deakin searched for the linear combination of the 14 ratios used by Beaver which best predicts potential failure in each of five years prior to failure. In his study, he used the 14 ratios to build a discriminant function. Even though it is often possible to decrease the number of variables included in a discriminant function without reducing its power, it was not true in this study. The number of classification errors increased substantially when the variables contributing

very little were dropped. This would tend to support the use of many variables considered important in the literature.[24] He concluded that MDA can be used to predict business failure as far as three years in advance with high accuracy. But this should be considered only as further evidence of probable failure rather than as conclusive proof in itself.

Using accounting and financial market data, Blum used discriminant analysis to test the hypothesis that the "failing company model" can distinguish between failing and nonfailing firms. Failure was defined as "events signifying an inability to pay debts as they come due, entrance into a bankruptcy proceedings, or an explicit agreement with creditors to reduce debt.[25] Describing the business firm as a reservoir of financial resources and describing its probability of failure in terms of expected flows of these resources, the probability of failure is more likely: "The smaller the reservoir, the smaller the inflow, the larger the claim on resources, the greater the outflow. . . ."[26] The model was constructed with three common denominators underlying the cash-flow framework: liquidity, profitability, and variability. The model predicted companies to fail or not to fail with an accuracy of approximately 93 to 95 percent for the first year before failure. Predictive accuracy was approximately 80 percent for the second year before failure and 70 percent for the third, fourth, and fifth year before failure. One of the findings of this study was the inability of the stock market to anticipate the timing of failure.

Kennedy and Libby each studied financial ratios and their uses in prediction as they are perceived by individuals. Concentrating on the behavioral aspects of the problem, Libby designed a field study to jointly evaluate the predictive power of ratio information and the ability of loan officers to evaluate that information in a business failure prediction context. Since individual differences in cognitive judgments have long been recognized in psychology, "substantial disagreement among users' interpretation of accounting data would present a paradoxical situation for accountants."[27] That is, accounting information which is optimal for one decision maker might be nonoptimal for another. The study measured the level of agreement between loan officers' predictions based upon the 14 financial ratios used by Beaver and Deakin. Using principal components analysis, Libby reduced the number of ratios to 5 ratios representing five sources of variation: profitability, activity, liquidity, asset balance, and cash position. The ratios selected were net income/total assets, current assets/sales, current assets/current liability, current assets/total assets, and cash/total assets. Measuring prediction accuracy or achievement on the basis of the number of correct predictions, the success rate was 74%. A test-retest reliability was measured as the number of agreements of each subject between his earlier and later prediction of the repeat firm. The study showed that, "On the average, subject predictions were highly reliable over both an immediate and one

year period. This result implied that interpretations of accounting data do not vary greatly across time."[28]

Kennedy used Bayes' Theory as a model of human information processing to predict bankruptcy using financial ratios. Bankers were given six items of information--industry class, asset size, the tangible equity to debt ratio, the current ratio, the inventory turnover ratio, and the quick ratio. The sample consisted of 6 bankrupt and 6 non-bankrupt firms which were selected from Beaver's sample of 79 pairs of failed and nonfailed firms. The likelihood ratio was used to measure the relative impact of the four financial ratios and to measure the accuracy of the direction of the impact of financial ratios. The findings of the study were

> . . . the impact of both the equity to debt ratio and the total assets variable was greater than the impact of the current, quick and turnover ratios for all six pairs. Although the current, quick and inventory turnover ratios had the least impact, they did have an impact.[29]

Generally, the equity to debt ratio had greater accuracy for bankrupt firms in both electronic components and motor vehicles. The current ratio was less accurate for bankrupt firms in both household appliance and electronic components. The quick ratio was also less accurate for bankrupt firms in the household appliance industry. Kennedy concluded his study with this qualified statement:

> Bankruptcy is only one form of business failure. For less definitive forms of failure, such as bond default, or the non-payment of preferred dividends, the four financial ratios may be less useful.[30]

Graphic Technique

While analytical approaches to ratio evaluation have been shown to be useful in predicting failure, there has also been some recent study on subjective evaluation of ratios. This work has relied on multi-dimensional graphics to aid people in interpreting ratio data. The work uses a graphic technique developed by Chernoff in 1971[31]. The technique uses cartoon faces to represent multi-dimensional data. That is, each feature of the face can be used to depict a separate variable. As an example, a face may represent a group of financial ratios of a firm or industry in a specific period of time. The current ratio may be represented by the mouth, the debt/equity ratio may be represented by the eye size and another ratio by the nose length, and so forth.

Moriarity and Roach[32] were the first to use Chernoff's graphic technique in an accounting context. They used the 13 financial ratios reported in Dun and Bradstreet's Key Financial Ratios to draw faces for two firms. They drew faces representing financial information for ten years for each firm. In addition to presenting the mechanics for drawing the faces, their paper also suggested that the faces might be useful in an audit during analytic review.

Moriarity later tested the possibility of using the technique as a means to predict bankruptcy. The result of the study showed that student participants "were better able to discriminate bankrupt and non-bankrupt firms with schematic faces, as opposed to financial balances or ratios"[33]. Also,

the subjects using the faces were able to outperform Altman's multiple discriminant analysis model. In addition, Moriarity reported that a group of practicing accountants were also able to make better predictions with the faces than with ratios. These participants also outperformed the students.

For his study Moriarity assumed that financial ratios are normally distributed. This assumption was used to draw the deviations from the neutral face. In 1976 Deakin[34] studied the distribution of financial ratios for a number of manufacturing firms. The study concluded that many ratios are not normally distributed. This empirical result suggests the possibility that Moriarity's results might be improved if faces were redrawn on the basis of the actual distribution of ratios. Another question which arises from Moriarity's study concerns the matching of facial features with financial ratios. Chernoff and Rezvi[35] have shown that the particular matching of variables and features has an effect on the way people classify faces. Thus, a better matching of ratios and features may be even more effective than that used by Moriarity. Finally, Moriarity selected 13 financial ratios reported by Dun and Bradstreet. It is possible that another group of ratios, such as those which have been widely used in prediction of business failure, would improve the model accuracy. These questions form the motivation for the current study. From the previous discussion of the related literature, a summary table is prepared in order to help choose the most widely used ratios in different studies. Table 2-2 represents those ratios widely used in the prediction of business failure.

The ratios used in the study are among those mentioned in the table.

The methodology followed in conducting the study is discussed in the next chapter.

TABLE 2-2

SUMMARY OF THE RATIOS USED IN PREVIOUS RESEARCH

RATIOS	AUTHOR							
	Altman 1968	Beaver 1968	Deakin 1972	Edmister 1977	Kennedy 1975	Libby 1975	Lev 1974	Moriarity 1979
1. Cash Flow to Total Debt		X	X					
2. Net Income to Total Assets		X	X			X		
3. Total Debt to Total Assets		X	X					
4. Sales to Total Assets	X			X			X	
5. Retained Earnings to Total Assets	X							
6. Market Value of Equity to Book Value of Debt	X							
7. Current Ratio		X	X	X		X	X	X
8. Cash to Total Assets		X	X			X		
9. Net Income to Net Worth								X
10. Net Income to Working Capital				X				X
11. Current Liability to Inventory								X
12. Current Liability to Equity				X				
13. Current Asset to Total Asset		X	X			X		
14. Net Working Capital to Total Assets	X	X	X	X				

TABLE 2-2, Continued

	Altman 1968	Beaver 1968	Deakin 1972	Edmister 1972	Kennedy 1975	Libby 1975	Lev 1974	Moriarity 1979
15. Net Operating Income to Total Debts							X	
16. Sales to Inventory				X*			X	X
17. Acid Test Ratio		X	X	X			X	X
18. Sales to Net Worth								X
19. Long-Term Debt to Net Worth								X
20. Current Assets to Sales		X	X					
21. Cash to Sales		X	X					
22. Earnings before Interest and Taxes to Total Assets	X							
23. Fixed Assets to Net Worth				X				X
24. Quick Assets to Sales		X	X					
25. Net Working Capital to Sales		X	X	X				X
26. Equity plus Long-Term Debt to Fixed Assets				X				
27. Fixed Assets to Sales				X				
28. Inventory to Working Capital								X
29. Current Liability to Net Worth								X

TABLE 2-2, Continued

	Altman 1968	Beaver 1968	Deakin 1972	Edmister 1972	Kennedy 1975	Libby 1975	Lev 1974	Moriarity 1979
30. Cash to Current Liability		X	X					
31. Earnings before Tax to Equity				X				
32. Net Income to Sales								X
33. Quick Assets to Total Assets		X	X					
34. Cash Flow to Current Liability				X				
35. Total Debt to Net Worth				X			X	X

*Edmister uses the ratio of inventory to sales.

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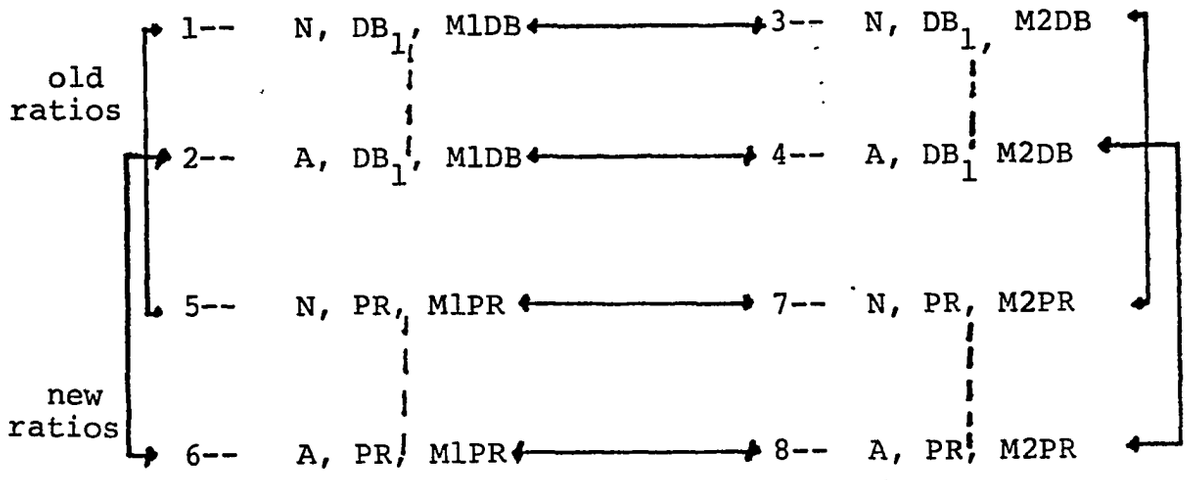
CHAPTER III

RESEARCH METHODOLOGY

The purpose of this chapter is to describe the study's experimental design. It is the purpose of the study to test alternative formulations of schematic faces to make better predictions of business failure. The experiment tested the effect of ratios, matching ratios with facial features and distributions. One group of ratios reported by Dun & Bradstreet was used in Moriarity's study. Another group of ratios widely recommended in the literature was introduced in this study to search for better results. An alternative mapping was also introduced in the study to trace the direction of a mapping (matching) effect. Finally, the experiment tested the effectiveness of the graphic technique under the assumption that ratios are normally distributed. Then, the actual (empirical) distribution was also used. Figure 3-1 summarizes the methodology followed in preparing for the treatments used in the study. The discussion of the experiment follows.



9-- N, PR, M2PR

vs

N, R_F, M2PR

N = Normal Distribution
A = Actual Distribution
DB = Dun & Bradstreet Ratios
PR = Previous Research Ratios
M1DB = Mapping one when DB is used
M2DB = Mapping two when DB is used
M1PR = Mapping one when PR is used
M2PR = Mapping two when PR is used

R_F = Fewer Ratios
⟷ = Mapping Effect
⋮ = Ratio effect
⌋ = Distribution Effect

FIGURE 3-1 SUMMARY OF THE TREATMENTS

Variables Used In The Study

Selected ratios

The variables used in this study were selected after a search was made for ratios that have been advocated by theorists or have been found in previous studies to be significant predictors of business failure. Beavor[1] chose 14 ratios, to be included in his study of prediction of failure, out of a total of 30 ratios collected. Horrigan[2] showed some evidence from the studies he analyzed that net working capital to total assets, net worth to total debt, and net income to net worth were among the ratios proven to be good indicators of business failure. Libby, Kennedy, Deakin and Edmister[3] used different combinations of Beaver's 14 ratios. O'Connor[4] calculated 33 ratios to study their usefulness to common stock investors, and, then, he reduced them to 10 ratios based on their correlation. Moriarity[5] used 13 ratios found in Dun and Bradstreet Key Business Ratios.

This study used a combination of the ratios most widely found to be useful predictors of failure in previous studies. In brief, the ratios used in the different treatments of the study are summarized in Table 3-1. The new group of ratios used to test the effect of using different ratios (from the ones used in Moriarity's study) are: current assets to current liabilities, net worth to total debt, sales to working capital,

TABLE 3-1

THE RATIOS USED IN THE STUDY

Dun and Bradstreet Ratios (Group One)	Previous Research Ratios (Group Two)
1. Sales to Inventory	Not Used
2. Fixed Assets to Net Worth	Fixed Assets to Net Worth
3. Sales to Net Worth	Not Used
4. Sales to Working Capital	Sales to Working Capital
5. Current Assets to Current Liabilities	Current Assets to Current Liabilities
6. Inventory to Working Capital	Not Used
7. Net Income to Working Capital	Net Income to Working Capital
8. Net Income to Sales	Not Used
9. Net Income to Net Worth	Not Used
10. Current Liabilities to Net Worth	Not Used
11. Total Debt to Net Worth	Total Debt to Net Worth
12. Long Term Debt to Working Capital	Not Used
13. Current Liabilities to Inventory	Not Used
14.	Working Capital to Total Assets
15.	Net Income to Total Assets
16.	Current Assets to Total Assets
17.	Quick Assets to Current Liabilities
18.	Sales to Total Assets
19.	Current Assets to Sales

sales to total assets, current assets to sales, net income to total assets, fixed assets to net worth, current assets to total assets, net income to working capital, and the acid test ratio.

Mapping

Part of this study tests the effect of, and searches for, other mappings. In this regard, Chernoff and Rizvi[6] designed an experiment to evaluate the effect of using a different correspondence between ratios and features. Their conclusion was that different mappings tend to affect the error rate in a classification task.

The mapping used in Moriarity's study was mainly based on his judgment. In this study, the author also used personal judgment to develop an alternative mapping. It would have been preferable to attempt a match of important ratios to salient features but the author was unable to discover a solid basis, in the literature, on which to order the saliency of facial features. Even though there is evidence of differences in the saliency of features, there is no specific research which indicates the priorities or the order of the importance for these features.[8]

Distribution of Ratios

This study used two types of distributions. First, it was assumed that ratios are normally distributed. Second, the actual distribution of the ratios for firms in the retail department store industry was estimated.

1. The Normal Distribution. Ratios were calculated for each of the 42 subject firms for each year. The necessary information for the computations was obtained from the financial information in Moody's Industrial Manual. The statements used were the ones published in the year of issue, hence if there is any adjustment thereafter, the original date would not be restated. In addition, the ratios for 102^{8} firms (including the 42 subject firms) were calculated. An average for each ratio over a 5-year period (1969-1973) was determined to avoid any unusual circumstances affecting the industry in any specific year. The mean and the standard deviation for each ratio was then determined.

Under the assumption that each of the financial ratios are normally distributed, the standard deviation was used to normalize the actual financial ratios for the subject firms on a scale from zero to one, with the mean equal to one-half. This is slightly different from Moriarity's study in that Moriarity used the first and third quartile of ratios for department stores as reported by Dun and Bradstreet to deduce the implied standard deviation for the industry. He then used the Dun and Bradstreet reported mean and the deduced standard deviation to standarize the ratios.

2. The Actual (Empirical) Distribution. Deakin studied the distribution of financial ratios and concluded that mose of them are not normally distributed. For this reason, the author chose to also test the effect of using the actual distribution of each ratio. After the ratios for the set of 102 firms were calculated from the published financial statements, they were averaged over a 5-year period. These averages were then arranged in descending order and the fractiles were computed given the lowest observed value one-tenth fractile (.1) and given one (1.0) to the highest observed value. The .5 fractile is the median of the distribution. The following table shows hypothetical values and their fractiles for a ratio.[9] Thus, if the value of a subject firm's ratio was 1.068, this would be mapped onto the 0-1 interval as .7.

Deciles	.9	.8	.7	.6	.5	.4	.3	.2	.1
Ratios	1.610	1.151	1.068	.938	.874	.730	.623	.490	.333

Source: George Foster, Financial Statement Analysis, 1978, p. 175.

These fractiles were used to scale the ratios onto the zero-one interval required by the drawing routine.

The Treatments

The study used nine treatments to search for improved predictions of failure. Four treatments were concerned with the mapping effect of ratios to facial features, another four treatments were used to test for the distribution effect. The last treatment searched for the effect of using fewer ratios. The discussion of the treatment follows.

Treatment One

This treatment is a replication of Moriarity's study. The ratios used were the ones published in Dun and Bradstreet Key Business Ratios. Also, it was assumed that ratios comply with the normalcy assumption. Table 3-2 shows the ratios used under this treatment, the features they represent, and the range of variables.

The mapping technique in this trial was not stated specifically in Moriarity's study but can be inferred from reading Moriarity's and Roach's study[10] where they illustrate how the faces can be interpreted. The mapping was based on the following relationships:

TABLE 3-2

RATIOS USED IN TREATMENT ONE AND TWO

Variable	Facial Feature	Range	Financial Ratio
X1	Face width	0-1	Sales/inventory
X2	Ear level	0-1	Fixed assets/net worth
X3	Face height	0-1	Sales/net worth
X4	Shape, top of head	0-1	Sales/working capital
X5	Shape, bottom of head	0-1	Current assets/ current liabilities
X6	Nose length	0-1	Inventory/working capital
X7	Mouth level	0-1	Net income/working capital
X8	Mouth length	-1 to 1	Net income/sales
X9	Mouth curvature	-1 to 1	Net income/net worth
X10	Pupil position	0-1	Current liabilities/ net worth
X11	Eye size	0-1	Total debt/net worth
X12	Ear diameter	0-1	Long term debt/working capital
X13	Nose width	0-1	Current liabilities/ inventory

Source: Moriarity, Shane. "Communicating Financial Information Through Multi-Dimensional Graphics." Journal of Accounting Research, Spring, 1979.

Feature	Variable Used
Head	Sales
Nose	Inventory and Short-Term Liquidity
Mouth	Profitability
Eyes	Debt: Long and Short-Term
Ears	Fixed Assets & Solvency

This grouping was confirmed through communications with Moriarity.

Treatment Two

The ratios used in this treatment are the same ones used in Treatment One. Also, the mapping of ratios and features were not different. The only difference in this treatment is the use of the actual distribution instead of the normal distribution.

Treatment Three

The purpose of this treatment is to test for significant change that can be attributed to a different mapping. The distribution used was the normal distribution. Again, the author made only one change so the differences can be easily traced and interpreted. The ratios used here were the same as those used in Treatment One. The correspondence between the ratios and the features was not the same as those used in Treatment One.

There are 13 factorial (over six and one quarter billion) combinations possible of mappings. Only four treatments were

concerned with mapping in the study. The purpose was to test the effect that can be attributed to different mappings under each group of ratios. Since there are two groups of ratios in the study, the least number of trials that can be used is four. When mapping was introduced, the idea was to see if different schemes would result in a different error rate. While the mapping selected for use is arbitrary, it was based on a rationale. The system followed here was to emphasize the mouth feature (among others) as one of the important ones. Moriarity had used the mouth feature to represent net income. The author chose, arbitrarily, to assign another ratio to the mouth feature as a way of detecting any differences that could be related to the saliency of this feature. One of the ratios assigned to the mouth feature in this treatment is the debt ratio. This change resulted in changing the matching of features and ratios from that used in Moriarity's study. Some of the other features arbitrarily used were: ears represented sales, face represented inventory problems, and eyes represented the net income. Table 3-3 shows the mapping followed in this treatment.

TABLE 3-3

RATIOS AND THE FEATURES THEY REPRESENT

FOR TREATMENT THREE AND FOUR

Variable	Feature	Range	Financial Ratio
X1	Face width	0-1	Inventory/working capital
X2	Ear level	0-1	Sales/Inventory
X3	Face height	0-1	Current liability/ inventory
X4	Shape, top of head	0-1	Fixed assets/net worth
X5	Shape, bottom of head	0-1	Net income/net worth
X6	Nose length	0-1	Sales/working capital
X7	Mouth level	0-1	Long-term debt/working capital
X8	Mouth length	-1 to 1	Total debt/net worth
X9	Mouth curvature	-1 to 1	Current liabilities/ net worth
X10	Pupil position	0-1	Net income/sales
X11	Eye size	0-1	Net income/working capital
X12	Ear diameter	0-1	Sales/net worth
X13	Nose width	0-1	Current assets/current liabilities

Treatment Four

In this case, the second and the third treatments were combined. That is, the actual distribution (Treatment Three) and the new mapping (Treatment Two) are used together so as to test for the combined effect that might result from the interaction.

Treatment Five

This treatment focuses on the assumption that a new group of ratios might introduce some improvements to the accuracy of the model. The ratios used here are selected from those widely used in different, previous research. The ones chosen are the ratios that seemed to be important in the previously mentioned studies. The question of mapping was discussed in the previous section and need not be repeated here. However, the schema followed in this treatment can be briefly outlined: The ratios that were used in Moriarity's study and selected among the combination of the new group of ratios were given the same features they represented under the first treatment. The other ratios (the ones introduced in this study) were assigned with what seemed to be reasonable matching. The schema developed because of these assignments is as follows: nose represented current assets, mouth represented net income, and eyes represented debt ratios. The distribution used here was the normal distribution. Table (3-4) shows the ratios used and the features they represent.

TABLE 3-4

RATIOS AND THEIR MATCHED FEATURES

FOR TREATMENT FIVE AND SIX

Variable	Feature	Range	Financial Ratio
X1	Ear level	0-1	Fixed assets/net worth
X2	Shape, top of head	0-1	Sales/working capital
X3	Shape, bottom of head	0-1	Current assets/current liabilities
X4	Nose length	0-1	Current assets/total assets
X5	Mouth level	0-1	Net income/working capital
X6	Mouth length	-1 to 1	Net income/total assets
X7	Mouth curvature	-1 to 1	Sales/total assets
X8	Pupil position	0-1	Quick assets/current liabilities
X9	Eye size	0-1	Total debt/net worth
X10	Ear diameter	0-1	Working capital/total assets
X11	Nose width	0-1	Current assets/sales

Treatment Six

The purpose of this treatment is to look for the distribution effect when new ratios are introduced. Because the treatment does not differ from Treatment Five in mapping, nor in ratios, the effect of different distribution can be checked if the results of these two treatments are compared with each other.

Treatment Seven

The purpose of this treatment is to test for the effect of a different mapping using the new group of ratios. So, the same ratios used in Treatment Five are used here. The only difference is the use of another schema for mapping. The changes are to use the mouth features to represent the debt, the ears to represent current assets, and the eyes to represent net income. The distribution is normal, i.e., the same as in Treatment Five, so the change could be easily traced. Table 3-5 shows the mapping of ratios and facial features.

Treatment Eight

This treatment tests the combined effect of both the mapping effect and the distribution effect. The mapping and ratios used in this treatment are the same ones used in Treatment Seven. The distribution used is the actual distribution.

TABLE 3-5

CORRESPONDENCE BETWEEN RATIOS AND FEATURES

FOR TREATMENT SEVEN AND EIGHT

Variable	Feature	Range	Financial Ratio
X1	Ear Level	0-1	Current assets/total assets
X2	Shape, top of head	0-1	Fixed assets/net worth
X3	Shape, bottom of head	0-1	Sales/total assets
X4	Nose length	0-1	Sales/working capital
X5	Mouth level	0-1	Working capital/total assets
X6	Mouth length	-1 to 1	Total debt/net worth
X7	Mouth curvature	-1 to 1	Quick assets/current liabilities
X8	Pupil position	0-1	Net income/total assets
X9	Eye size	0-1	Net income/working capital
X10	Ear diameter	0-1	Current assets/sales
X11	Nose width	0-1	Current assets/current liabilities

Treatment Nine

This treatment tests the ability of a few ratios to predict business failure. The ratios used were a subset of the new group of ratios (i.e., were chosen among those ratios used in Treatment 5). The treatment used the normal distribution assumption and mapping two of ratios group two (Table 3-6). The ratios used here were the ones which were reported to be very significant. The current assets/total assets, net income/total assets, current assets/current liabilities and current assets/sales were among five ratios reported by Libby[11] to be nearly as useful in predicting bankruptcy as the fourteen ratios used in Beaver's ratios. The ratio of working capital/total assets was also indicated to be of good value in predicting business failure by Altman, Blum, Horrigan, and Winakor and Smith.[12] The total debt to net worth was chosen because it was found to be the most useful ratio used by Kennedy.[13] Also, this ratio was appealing to loan officers used as subjects in Libby's study and it was recommended in Patrick and Horrigan's[14] studies. Table 3-6 shows the ratios and the mappings used in the treatment.

TABLE 3-6

RATIOS AND ASSOCIATED FEATURES

FOR TREATMENT NINE

Variable	Feature	Financial Ratio
X1	Ear level	Current assets/total assets
X2	Mouth level	Working capital/total assets
X3	Mouth length	Total debt/net worth
X4	Pupil position	Net income/total assets
X5	Ear diameter	Current assets/sales
X6	Nose width	Current assets/current liabilities

The Experiment

The Experimental Task

In the experiment, the subjects were presented financial information for six years. The information was presented in the form of schematic faces with an explanation of what the features represent. The participants were then asked to look at the faces and, based on the information they could gather from the faces, separate those firms which they thought went bankrupt from those they thought did not.

Firms

The primary source for locating bankrupt firms was The Wall Street Journal Index. A search was made for firms mentioned under the subject heading "Bankruptcy" and a list of 19 firms going bankrupt during the years 1974-1976 was prepared. The major line of business of each firm was then identified by reference to Moody's Industrial Index. The retail industry was chosen for the study because most of the bankrupt firms were in this industry during the 1974-1976 period. A six-year period was used by Moriarity in his study. For consistency, the same time horizon was chosen for this study. Due to this restriction, the number of bankrupt firms decreased from nineteen to fourteen firms. The non-bankrupt firms were randomly selected by reference to Moody's and included firms classified under the first two subclassifications of retail, and for which data were available for six consecutive years. Twenty-eight non-bankrupt firms were chosen. This number is twice the number of bankrupt firms. The reason for choosing this number was to minimize the chance of biasing the results in favor of the bankrupt firms. Table 3-7 lists the firms used in the study.

For the purpose of this study, firms were considered to be bankrupt if they (1) filed for reorganization under Chapter X or XI of the Federal Bankruptcy Act, (2) their stockholders voted to file under Chapter X or XI, or (3) they reached an agreement with its creditors to reduce the firm's liability at a loss to its creditors.

TABLE 3-7

LIST OF FIRMS INCLUDED IN THE STUDY

Name of the Firm	B = Bankrupt N = Non-Bankrupt
Aaronson Bros. Stores Corp.	B
Alexander's Inc.	N
Ames Department Stores	N
Bazar Inc.	N
Bohack Corp.	B
Caldor Inc.	N
City Stores Co.	N
Crowley, Milner & Co.	N
Daylin, Inc.	B
Dillard Department Stores Inc.	N
Eagle Clothes, Inc.	B
Eckerd Drug, Inc.	N
Evans, Inc.	N
Fisher Goods Inc.	N
Gimble Brothers, Inc.	N
Grant (W.T.) Co.	B
Gray Drug Stores, Inc.	N
Hartfield-Zodys Inc.	B
Harvey's Stores Inc.	N
Interco Inc.	N

TABLE 3-7, Continued

Jewel Companies, Inc.	N
Kenton Corp.	B
Kings Department Stores Inc.	N
Cone Bryant, Inc.	N
Lucky Stores, Inc.	N
Mammoth Mart, Inc.	B
Mangel Stores Corp.	B
Manhattan Industries, Inc.	N
Mays (J.W.) Inc.	N
National Bellas Hess, Inc.	B
Neisner Bros., Inc.	B
New Process Co.	N
Penn Fruit Co.	B
Penn Traffic Co.	N
Rich's Inc.	N
Steinberg's Ltd	N
Unishops, Inc.	B
United States Shoe Corp.	N
Volume Merchandise Inc.	B
Weisfields, Inc.	N
Woodward Stores LTD	N
Zale Corp.	N

Subjects

The subjects participating in the experiment were students enrolled in Introductory Accounting One classes at the University of Oklahoma in the Spring of 1980. Fifteen sections were chosen for the experiment. Each of the experimental trials were run during the first twenty minutes of class time. The students were not required to participate in the experiment.

Experimental Procedure

1. The financial information for each firm was presented on a single sheet of paper. Figure 3-2 gives an examples The information sheets were placed in a 9 x 12 envelope with a cover sheet attached. The coversheets were identical for all treatments except that the number of ratios used and their correspondence to the facial features were replaced by the appropriate phrases needed. Figure 3-3 represents an example of a cover-sheet.
2. The experiment used nine different treatments. Eight of these treatments tested the effect of different mappings, different ratios, and different distributions. The last treatment tested the effect of fewer ratios than were used under the other eight treatments. The first eight treatments were tested in the first trial. The last treatment was delayed so that the results of the first trial could be analyzed, checked, and incorporated into

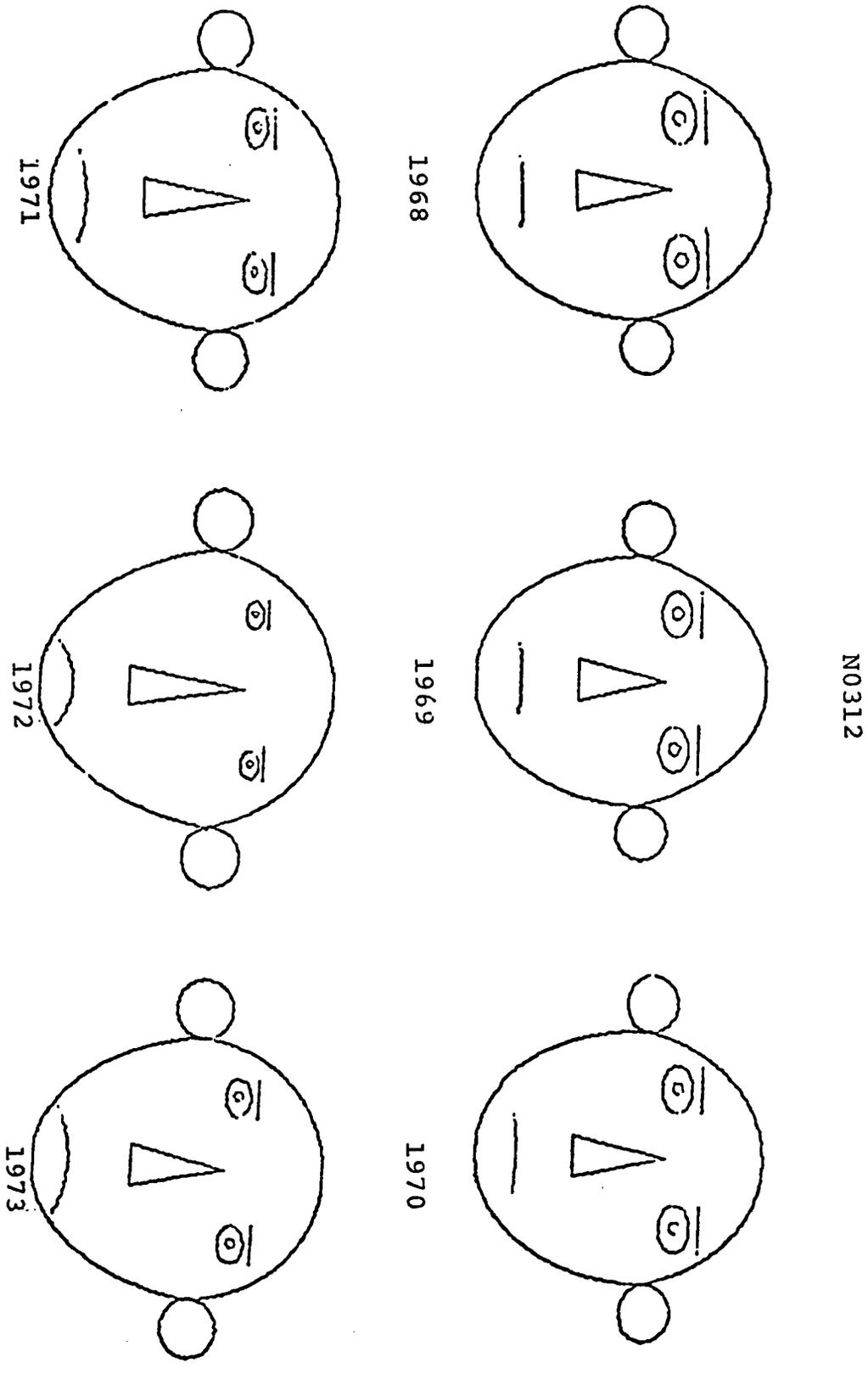


FIGURE 3-2. AN EXAMPLE OF THE STIMULUS.

the second trial in an attempt to come up with better results.

3. As a way of encouraging students to participate, the author gave $5 to the one student in each class who did the best job on the experiment, with "best" defined as the percent of correct classifications. See Figure 3-3.

The analysis and interpretation of the data are discussed in the next chapter.

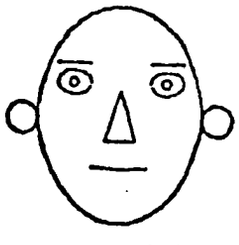
Name of School:_____ Section #:_____

Name:_____ Instructor:_____

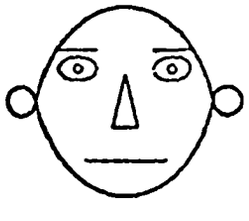
PLEASE DO NOT WRITE ON THE ENCLOSED MATERIALS

Inside are schematic faces which represent key financial information for forty-two (42) retail stores. Each sheet of paper represents six years of information for a single firm. During 1973-1977 there were a number of firms facing financial problems and many had to seek protection under the Federal Bankruptcy Act.

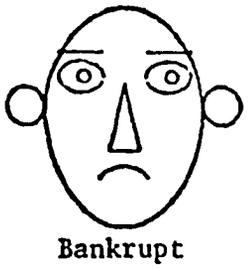
Please examine the information on the attached sheets. Based on the information you can read in the faces, classify the firms as either bankrupt or not bankrupt. You are working with different models, so your answers may differ from those of your neighbor.



Successful



Average



Bankrupt

The features of the face presented are controlled by financial ratios. The faces at the left represent ratios for a successful, an average, and a bankrupt firm. The size and shape of the head are determined by four ratios: sales/net worth, sales/inventory, sales/working capital, and current assets/current liabilities. The mouth is controlled by three ratios: net income/sales, net income/ net worth, and net income/working capital. The eyes are controlled by total debt/net worth and current liabilities/net worth. The nose is based on inventory/working capital and current liabilities/inventory. The ears depend on long-term debt/net worth and fixed assets/net worth.

FIGURE 3-3. EXPERIMENTAL COVER SHEET.

ORAL INSTRUCTION TO THE STUDENTS

You are being requested to participate in a study by a doctoral student at the University of Oklahoma. Shortly you will receive an envelope containing schematic faces which represent the financial position for several firms in the retail store industry.

You are asked to look at the faces on each sheet and separate those firms you believe went bankrupt from those you believe did not go bankrupt. Put together those which you classified as bankrupt and attach the bankrupt note. Do the same thing for those you think did not go bankrupt and attach the not bankrupt note.

Participation in this experiment is not required, but your cooperation is essential to its success. To encourage you to participate a reward of $5 will be offered to the person who does the best job on the experiment. The winner of the $5 reward will be the person who classifies correctly the largest number of firms. In case of a tie a random drawing will be held to determine the winner.

FIGURE 3-4. ORAL INSTRUCTIONS TO THE STUDENTS.

FOOTNOTES TO CHAPTER III

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CHAPTER IV

ANALYSIS AND INTERPRETATION

This chapter discusses the decision criteria chosen for the study to determine if one treatment (model) is better (worse) than the other. A discussion of the statistical methods used to analyze the data is also presented here. The findings and discussion of the results obtained will be included in the last section.

The Decision Criterion

In order to evaluate the results of the study, a decision criterion must be adopted to choose one model or another. There are several methods available in the literature for differentiating between two bankruptcy prediction models. This section discusses some of these methods and points out the one chosen for the study.

Misclassification error rate

When predicting business failure it is clear that there are two types of errors which might be made; the error of predicting that a firm will go bankrupt when it does not, and the error of predicting that a firm will not go bankrupt when it does. When bankruptcy is considered, some users of prediction models have a preference

as to which one of these two errors is more important than the other. For instance, Norton and Smith[1] studied the ability of historical cost and price-level adjusted financial statements to predict bankruptcy. In their study they assumed that the cost of misclassifying a bankrupt firm is greater than the cost of misclassifying a non-bankrupt firm. For this reason, Norton and Smith used the error rate of incorrectly classifying a bankrupt firm to choose between the two models. In addition to the error rate of misclassifying a bankrupt company, one may use either the error rate of misclassifying the non-failed firm or the overall error rate. In the latter, the percentage of incorrect classification is considered regardless of whether the error belongs to the failed or nonfailed firms. The three alternatives of misclassification error rate were used by Ketz[2] in order to differentiate between historical cost and general price level models.

Cost of misclassification

Rather than artitrarily choosing one error rate over the other, the cost involved in making each error might be estimated as a basis for selecting a model. The expected cost of misclassification depends on the a priori probability of failed and non-failed firms, the loss of investment when a bankrupt firm is misclassified and the loss of the differential return that could have been earned if a continuing firm is not misclassified.[3]

Deakin[4], in a study of business failure, based his decision as to whether one model is better than the other on the two types of individual error rates. His rationale was that ". . . a new lender to the company would find the relative cost of failure to identify a failing company far greater than the cost of failure to identify a non-failing company."[5] None of the three error rates discussed is completely appropriate for the purpose of this study. The overall error rate ignores the importance that can be attributed to the individual error rates by a decision maker. The choice between the individual error rates is not an easy task. Since it is difficult to resolve the trade-off between the costs of the two types of individual error rates, the study adopted the following criterion for comparison between treatments; one model (treatment) is better than the other only if it has smaller individual error rates of both types. That is, only if one dominates the other.

Statistical Analysis

The experimental design is a three-factor nested design. A factor B is said to be nested within the levels of factor A, if every level of B occurs with only a single level of factor A. If every level of B appears with every level of A the factors are called crossed. Table 4-1 illustrates the difference between crossed and nested factors. In the crossed design, every level of B appears

with every level of A. In the nested design, levels B_1 and B_2 appear only with level A, whereas B_3, B_4, and B_5 appear with A_2.[6]

TABLE 4-1

EXAMPLE OF (a) CROSSED AND (b) NESTED DESIGNS

	B						B				
	B_1	B_2	B_3	B_4	B_5		B_1	B_2	B_3	B_4	B_5
A A_1	x	x	x	x	x	A A_1	x	x			
A_2	x	x	x	x	x	A_2			x	x	x
	(a)						(b)				

In this study the mapping effect is nested under the ratios (i.e., mapping can be studied only within a group of ratios, e.g. mapping one under ratio group one is not the same as mapping one under ratio group two). The distribution variable is crossed with mapping and ratios. Table 4-2 illustrates the study design where each cell represent a treatment combination.

TABLE 4-2

DESIGN OF THE STUDY

	M1DB	M2DB	M1PR	M2PR		M1DB	M2DB	M1PR	M2PR
DB	1	3			DB	2	4		
N					A				
PR			5	7	PR			6	8

where N and A are the normal and actual distribution, DB and PR are Dun and Bradstreet and previous research ratios, M1DB and M2DB are mapping one and two within DB ratios and M1PR and M2PR are mapping one and two within PR ratios.

A multivariate analysis of variance (MANOVA) was used to test the null hypothesis of equal mean error rate vectors. In multivariate analysis of variance the effect of the treatments on all criteria is observed simultaneously. Each observation is a vector rather than a scalar. This analysis enables us to take into account the correlations among the variables. The general form of the null hypothesis to be tested is:

$$H_o: \ \underline{U}_1 = \underline{U}_2 = \underline{U}_3 \ . \ . \ . = \underline{U}_i$$

Where the $\underline{U}_i$ represent mean error rate vectors, and $U_i = (e_{\underline{1}}, e_{\underline{2}})$ and e_1 and e_2 represent the error rates of misclassifying a bankrupt and non-bankrupt firm respectively.

To test the null hypothesis, there are several methods than can be used. As an example, the likelihood ratio approach uses the Wilks lambda statistic:[7]

$$\Lambda = \frac{|W|}{|W+B|}$$

where W and B are the sum of squares and cross products matrix of the within cell and between group matrix respectively. An approximation Λ making use of the F distribution has been given by Rao.[8] For a two-dependent variable case that F statistic is:

$$F[K-1, \ 2(Kn-K-1)] = \frac{1 - \Lambda^{\frac{1}{2}}}{\Lambda^{\frac{1}{2}}} \times \frac{nK-k-1}{K-1}$$

where K is number of samples or groups and n is the sample size. The SAS computer program was used to obtain the

values of the test statistics.[9] Wilks lambda provides only an overall (omnibus) test of the hypothesis of no differences between mean error rate vectors. In order to determine which groups and variables warrant interpretation as the cause of observed significant differences, further tests are necessary. In this study Hotelling T^2 statistic was used to test the null hypothesis of no differences between the mean error vectors. The T^2 statistic is computed as:[10]

$$T = \frac{N_1 N_2}{N_1+N_2} \times (\bar{X}^{(1)} - \bar{X}^{(2)}) \; \Sigma^{-1} (\bar{X}^{(1)} - \bar{X}^{(2)})$$

where $\bar{X}^{(1)}$ and $\bar{X}^{(2)}$ are the mean vectors for group (1) and group (2), Σ is the pooled within group CO variance matrix, and N_1 and N_2 are group (1) and group (2) sample size. The Hotelling T^2 is distributed as F:

$$F(P, N_1 + N_2 - P - 1) = \frac{N_1 + N_2 - P - 1}{(N_1 + N_2 - 2)P} \times T^2$$

where P is the number of dependent variables and N_1 and N_2 are defined above.

The Hotelling T^2 statistics were computed using the Biomedical Computer Program (BMDP3D).[11]

Findings

Table 4-3 shows the average number of firms correctly or incorrectly classified under each treatment. The number of firms misclassified ranges from 5 to 7 in the case of the bankrupt firms and from 6 to 11 in the case of the

TABLE 4-3

CLASSIFICATION RESULTS OF TREATMENTS (AVERAGE)

Treatment	Actual Non-Bankrupt		Actual Bankrupt	
	Predict NB	Predict B	Predict NB	Predict B
1 (N,DB,M,DB)	22	6	6	8
2 (A,DB,M,DB)	19	9	5	9
3 (N,DB,M2DB)	22	6	7	7
4 (A,DB,M2DB)	19	9	6	8
5 (N,PR,M1PR)	19	9	7	7
6 (A,PR,M1PR)	17	11	7	7
7 (N,PR,M2PR)	19	9	5	9
8 (A,PR,M2PR)	17	11	5	9
9 (N,R_f,M2PR)	22	6	6	8

non-bankrupt firms. Table 4-4 converts the number of misclassifications to proportions and also gives an overall error rate of misclassification for each treatment. The overall error rate which ranges from .29 to .42 cannot be attributed to chance.[12] Plots of the number of errors under each treatment are given in Figure 4-1.

TABLE 4-4

ERROR RATES OF THE CLASSIFICATION

Treatment	Misclassify Bankrupt Firms	Misclassify Non-Bankrupt Firms	Overall Error Rate
1	.43	.22	.29
2	.37	.35	.36
3	.51	.20	.31
4	.41	.31	.35
5	.46	.35	.38
6	.48	.40	.42
7	.34	.31	.32
8	.39	.39	.39
9	.42	.22	.29

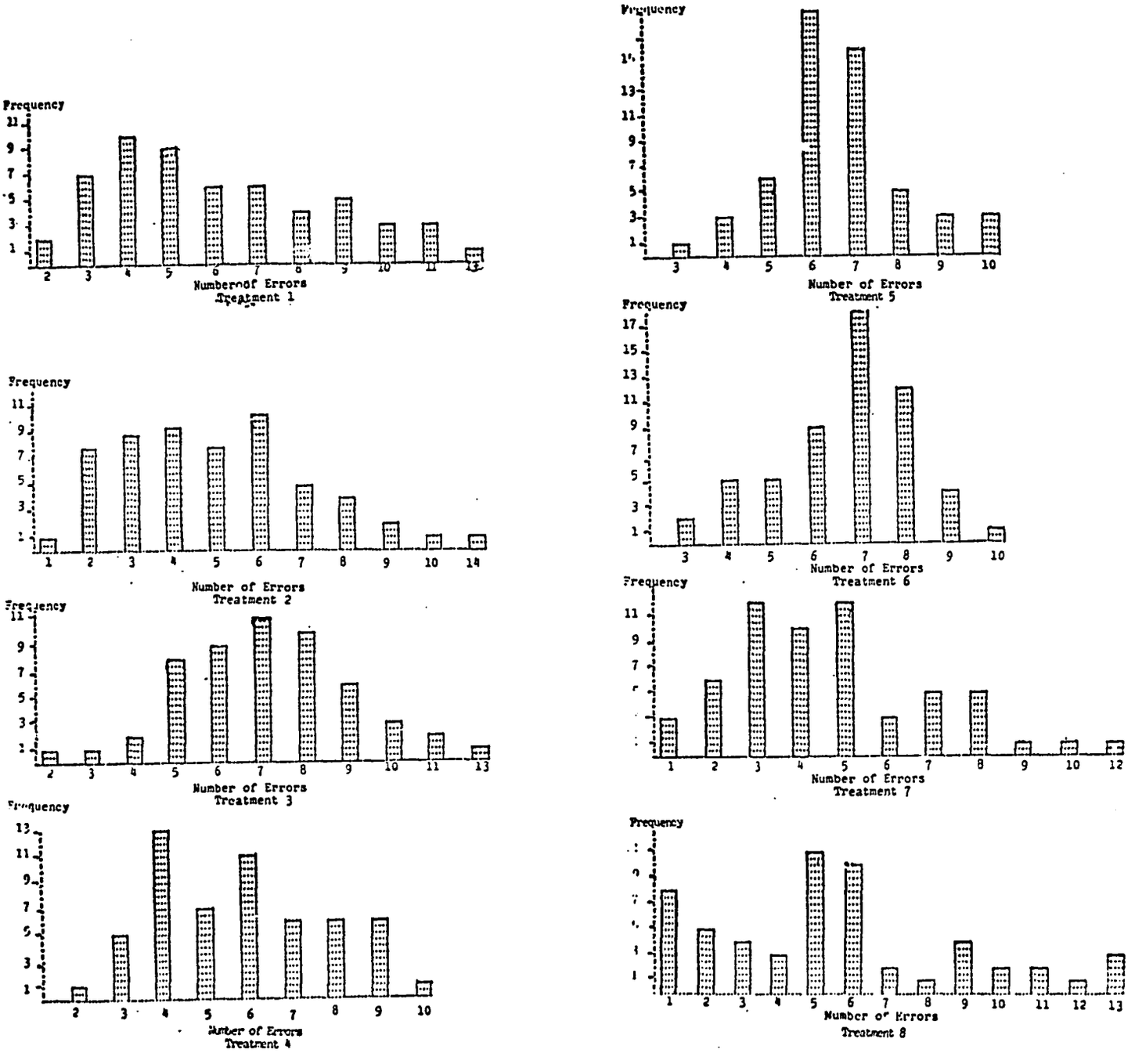
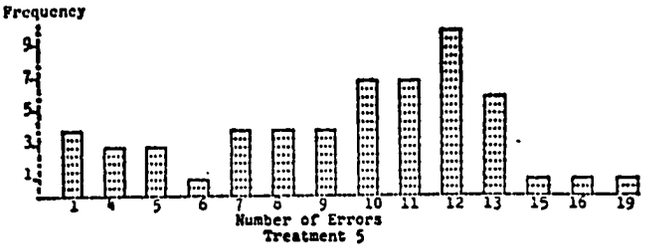
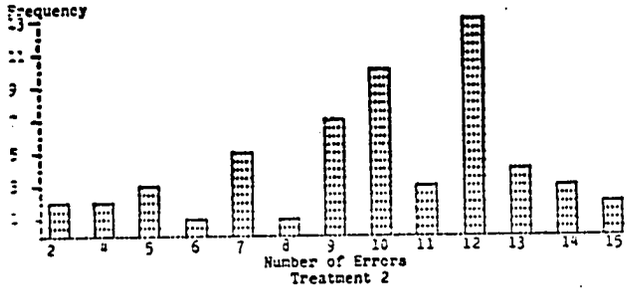
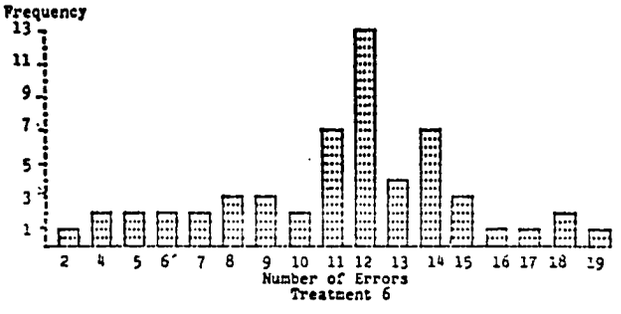


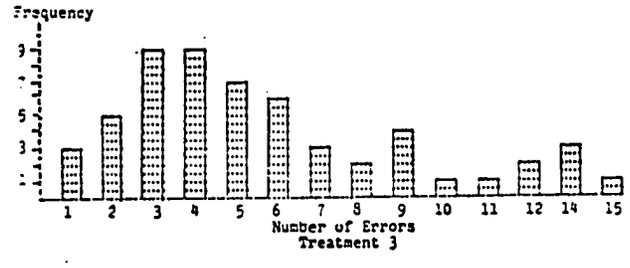
FIGURE 4-1 (a)

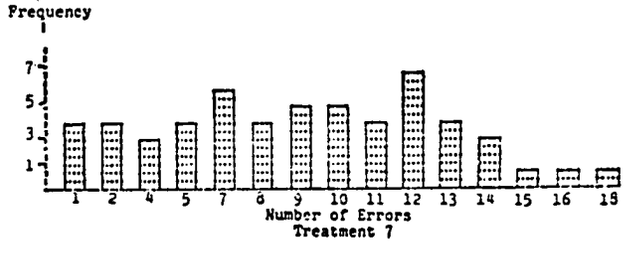
FREQUENCY CHART FOR MISCLASSIFYING BANKRUPT FIRMS

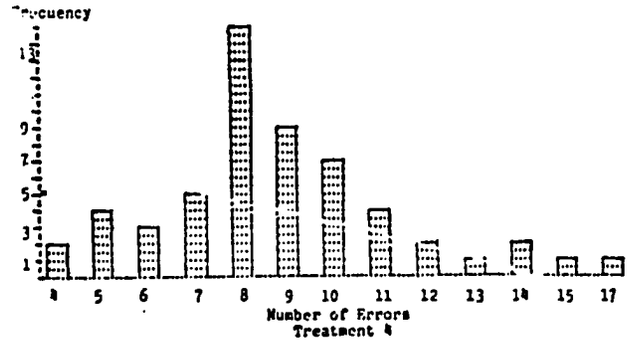












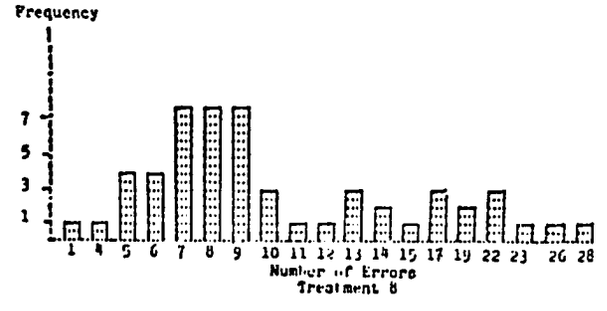


FIGURE 4-1 (b)

FREQUENCY CHART FOR MISCLASSIFYING NON-BANKRUPT FIRMS

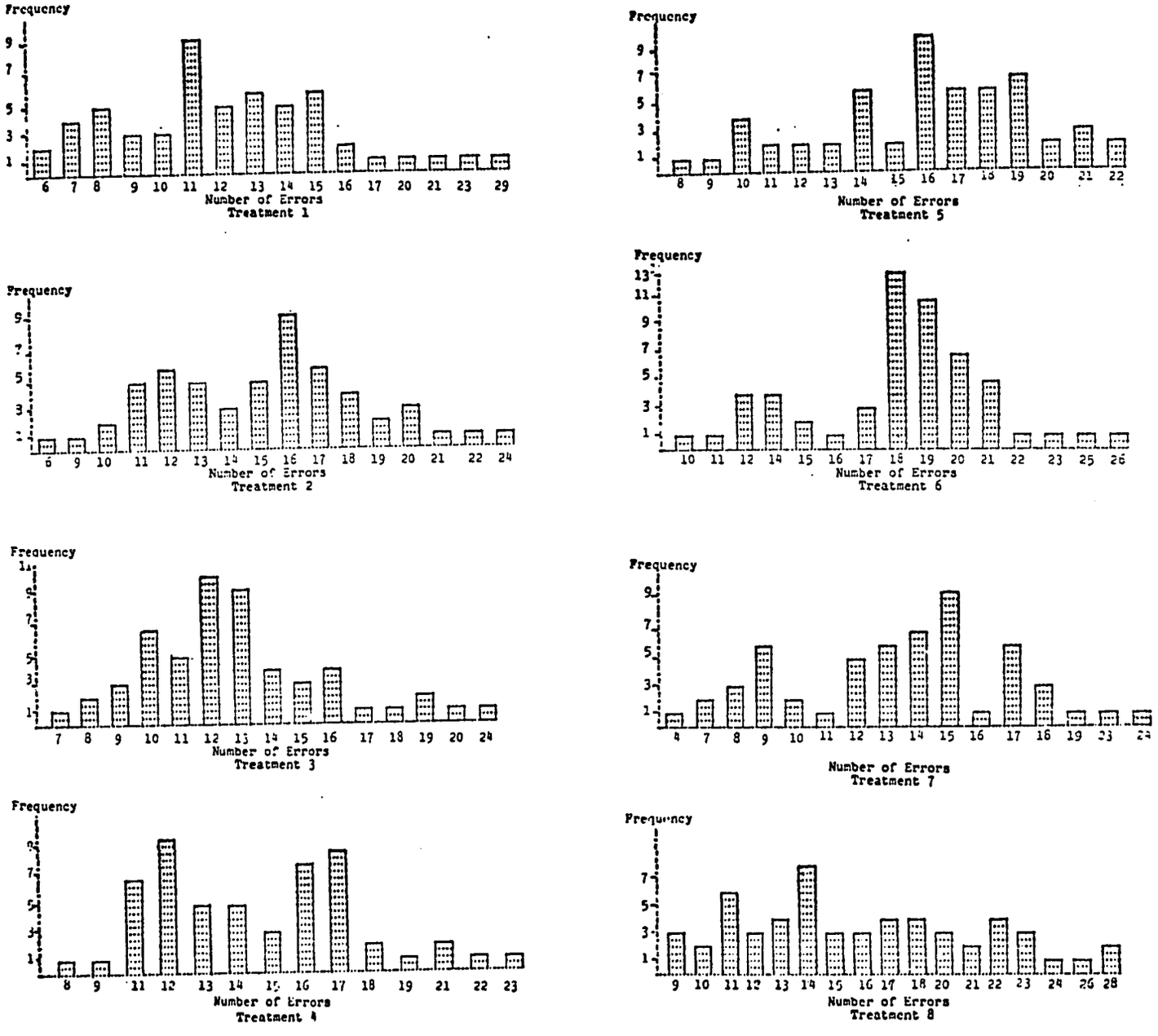


FIGURE 4-1 (c)

FREQUENCY CHART FOR TOTAL ERRORS

The overall effect of the three independent variables in the study (ratio, mapping, and distribution) was measured using the F approximation to Wilks lambda. Table 4-5 represents the Wilks criterion for each variable and the corresponding P value.

TABLE 4-5

TESTS OF OVERALL MAIN EFFECTS

Variable	Wilks' lambda	P-Value
Ratio	.9122	.0001*
Distribution	.8996	.0001*
Mapping within ratio	.9150	.0001*
Interaction of mapping and distribution	.9974	.6784
Interaction of ratio and distribution	.9745	.0035*

*Significant at $\alpha = .01$

It is clear from the table that the ratio, the distribution, and the mapping effect are significant beyond the .01 level. The interaction between ratio and distribution is also significant at $\alpha = .01$. The interaction between mapping and distribution is the only effect which is not statistically significant at $\alpha = .01$.

When the overall multivariate test statistic is significant, it is appropriate to examine the univariate F statistic for each variable to locate the individual variables which are contributing to the multivariate effect and to examine Hotelling T^2 for multivariate pairwise comparisons of groups to determine the pairs of groups which are contributing to the multivariate

effect.[13] The univariate F statistics are presented in Table 4-6.

TABLE 4-6

UNIVARIATE F STATISTICS

Variable	DF	Sum of Square	Mean Squares	F Value	P Value
Misclassification rate for bankrupt firms (E_1)	7,440	1.2658	.1808	6.64	.0001 *
Misclassification rate for non-bankrupt firm (E_2)	7,440	2.0095	.2870	13.29	.0001 *

*Significant at $\alpha = .01$

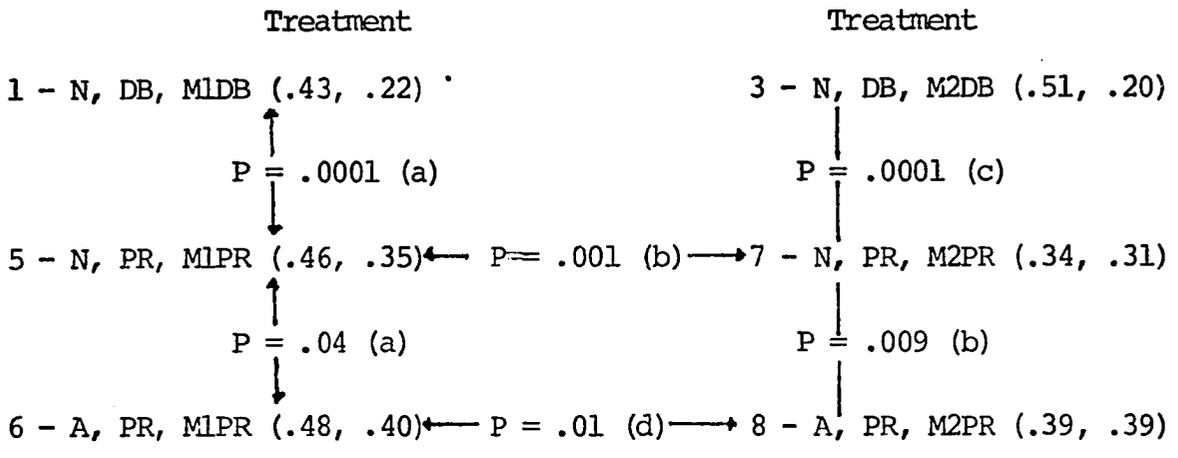
Both misclassification error rate effects are statistically significant at $\alpha = .01$. This indicates that both dependent variables are contributing to the overall effect. The next step in the analysis is, therefore, to obtain the Hotelling T^2 for pairwise comparisons of groups.

Figure 4-2 summarizes the significant mean error rate differences between the groups. The numbers in parenthesis represent the mean error rate for bankrupt and non-bankrupt firms respectively. The pairs for which there are significant differences are indicated by an arrow. Hotelling T^2 statistics are presented in Table 4-7. Only those pairwise comparisons which are statistically significant at $\alpha = .05$ are appropriate to examine. Parts of Table 4-7 will be reproduced in the discussion section whenever appropriate. To make the comparisons

more meaningful, mappings and distribution effects were paired within each group of ratios. To test for ratio effect, the pairs were compared across the two sets of ratios but within each set for distribution and mappings.

FIGURE 4-2

STATISTICS SUMMARY OF THE TREATMENTS



DB and PR are Dun and Bradstreet and previous research ratios

N and A are the normal and actual distributions

M1DB and M2DB are mapping one and two within DB

M1PR and M2PR are mapping one and two within PR

(a) = Significant error rate differences between groups with respect to E_2

(b) = Significant error rate differences between groups with respect to E_1

(c) = No dominant treatment

(d) = No significant differences between groups based on individual error rates

TABLE 4-7

HOTELLING T^2 STATISTICS

Treatments	T^2	P Value	Misclassify Bankrupt Firms		Misclassify Non-Bankrupt Firms	
			t Value	P Value	t Value	P Value
1 vs 2	25.94	.0001**	1.72	.088	-5.06	.0001**
1 vs 3	5.38	.074	-2.32	.023	.64	.525
1 vs 5	30.06	.0001**	- .99	.32	-4.59	.0001**
2 vs 4	4.97	.090	-1.45	.149	-1.89	.061
2 vs 6	28.18	.0001**	-3.89	.0001**	-2.23	.028*
3 vs 4	29.55	.0001**	3.30	.001**	-5.03	.0001**
3 vs 7	43.56	.0001**	6.30	.0001**	-4.22	.0001**
4 vs 8	3.15	.21	.09	.92	-1.68	.09
5 vs 6	8.16	.020*	-1.02	.308	-2.08	.040*
5 vs 7	39.52	.0001**	5.39	.0001**	1.36	.176
6 vs 8	9.55	.011**	1.84	.07	1.47	.146
7 vs 8	10.04	.009**	-2.14	.036**	-1.34	.182
7 vs 9	19.56	.0001**	-3.05	.003**	3.42	.001**

**significant at α = .01

*significant at α = .05

Discussion

Ratios

The study used two groups of ratios. One set of ratios represent the 13 financial ratios reported by Dun and Bradstreet (DB ratios). The other set of ratios were selected from previous research (PR ratios). The overall nested design showed that the ratio effect was statistically significant. In order to determine if one set of ratios dominates the other, Hotelling T^2 pairwise comparisons of groups are examined. Table 4-8 shows that for those pairs where there is a dominant treatment (one and two) there are significant differences in error rates between those treatment combinations using DB ratios and those using PR ratios. The Univariate t statistics reveal that the dependent variable which is contributing to the significant effect in both cases is the error rate of misclassifying the non-bankrupt firms. Comparing Treatment three to Treatment seven there is no dominant treatment because Treatment three (DB ratios) produces smaller error rates of misclassifying non-bankrupt firms, but produces higher error rates of misclassifying bankrupt firms than Treatment seven (PR ratios).

TABLE 4-8

HOTELLING T^2 STATISTICS INVOLVING RATIOS

Treatment	T^2	Misclassify Bankrupt Firms t	Misclassify Non-Bankrupt Firms t
1 (N,DB,M1DB) vs 5 (N,PR,M1PR)	30.06**	- .99	-4.59**
2 (A,DB,M1DB) vs 6 (A,PR,M1PR)	28.18**	-3.89 **	-2.23*
3 (N,DB,M2DB) vs 7 (N,PR,M2PR)	43.56**	6.30 **	-4.22**
4 (A,DB,M2DB) vs 8 (A,PR,M2PR)	3.15	.09	-1.68

*significant at α = .05
**significant at α = .01

The second method to determine which set of ratios perform better is the use of Winer formal tests.[14] Winer prepares a summary table which shows the total number of individual error rates (not the averages) under each group of ratios and under each type of distribution or mapping. For example, in Table 4-9, the DBN cell represents the total error rate scores of the students in all treatments when DB is assumed to be normally distributed (N). In this case mapping one and two were grouped together under each

TABLE 4-9

SUMMARY TABLES (TOTAL SCORES)

A

Proportions of Misclassifying Bankrupt Firms Ratios*Distributions

	DB	PR
N	52.78	45.49
A	43.92	48.35

B

Proportions of Misclassifying Non-Bankrupt Firms Ratios*Distributions

	DB	PR
N	23.81	36.30
A	37.31	44.27

C

Proportions of Misclassifying Bankrupt Firms Mapping*Ratios

	DB	PR
M_1		52.92
M_2	51.56	40.92

B

Proportions of Misclassifying Non-Bankrupt Firms Mapping*Ratios

	DB	PR
M_1	32.06	41.35
M_2	29.06	39.20

DB and PR refer to Dun and Bradstreet ratios and previous research ratios, respectively; N and A refer to normal and actual distribution and M_1 and M_2 refer to mapping one and two.

set of ratios. The formal tests for the rate of misclassifying the non-bankrupt firms are given in Table 4-10.

TABLE 4-10

WINER FORMAL TEST

Formula[15]	DF	F	P Value
$F_N = \frac{(DBN - PRN)^2}{2 \cdot n \cdot q \cdot MS \text{ (within cell)}}$	2,440	34.82	.05
$F_A = \frac{(DBA - PRA)^2}{2 \cdot n \cdot q \cdot MS \text{ (within cell)}}$			

where DB, PR, N, and A are as defined previously, N is the number of observations under each treatment and q is the number of levels in the dependent variable.

Both of these F values are significant at $\alpha = .05$, hence the tests indicate that DB ratios have smaller error rate of misclassifying non-bankrupt firms than PR ratios.

The details of the Univariate F statistics are presented in Tables 4-11 and 4-12. Table 4-11 reveals that ratios did not contribute to the overall effect. This indicates that there are no significant mean error differences between groups due to ratios when the error rate of misclassifying the bankrupt firms (E_1) is considered. From Table 4-4, the average error rate of misclassifying bankrupt firms in the first four treatments is equal to

TABLE 4-11

UNIVARIATE STATISTICS FOR MISCLASSIFICATION RATE FOR BANKRUPT FIRMS

Source	DF	Sum of Squares	Mean Square	F Value	P Value
Ratios (R)	1	.01822157	.01822157	.67	.413
Distribution (D)	1	.08035	.08035	2.95	.086
Mapping within Ratios M(R)	2	.92735	.41367	15.20	.0001
Interaction R*D	1	.30630	.30630	11.26	.0009
Interaction R*D	2	.033618	.01680	.62	.5397

TABLE 4-12

UNIVARIATE STATISTICS FOR MISCLASSIFICATION RATE FOR NON-BANKRUPT FIRMS

Source	DF	Sum of Squares	Mean Square	F Value	P Value
Ratios (R)	1	.8425	.8425	39.02	.0001
Distribution (D)	1	1.0318	1.0318	47.78	.0001
Mapping within Ratios M(R)	2	.06067	.03033	1.40	.2465
Interaction R*D	1	.06752	.06752	3.13	.0777
Interaction M(R)*D	2	.006946	.003473	.16	.8515

.43.[16] The average error rate for the second four treatments is equal to .42. A graphical analysis depicting the average individual error rate under each group of ratios is given in Figure 4-3.

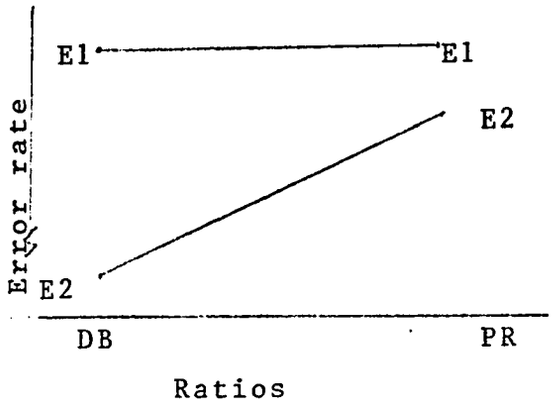


FIGURE 4-3. MEAN ERROR RATES UNDER EACH GROUP OF RATIOS.

The figure shows that considering the error rate of misclassifying bankrupt firms (E_1) there seems to be no error rate differences between DB ratios and PR ratios.

With respect to the error rate of misclassifying the non-bankrupt firms (E_2), the situation is different. Table 4-12 indicates that ratios did contribute to the overall effect. The average error rates (E_2) from Table 4-4 are .27 and .36 for the DB ratios and PR ratios. Figure 4-3 indicates the error rate differences between the two sets of ratios showing that DB ratios produce smaller error rates than PR ratios.

Distributions

Two types of distributions are used in the study: the normal and the actual. The results show that the distribution main effect was statistically significant. To detect the cause of these differences, pairwise comparison of groups is performed. Hotelling T^2 statistics in Table 4-13 indicates that for all pairs which are concerned with the distribution effect, there are significant error rate differences between the groups at $\alpha = .05$. In order to determine which dependent variable contributed to the differences between the treatments, univariate t statistics are examined. Comparing treatment one (normal distribution) with treatment two (actual distribution) indicates that the normal distribution has a smaller error rate of misclassifying the non-bankrupt firms.

TABLE 4-13

HOTELLING T^2 STATISTICS INVOLVING DISTRIBUTIONS

Treatment	T^2	Misclassify Bankrupt Firms t Value	Misclassify Non-Bankrupt Firms t Value
1 (N,DB,M1DB) vs 2 (A,DB,M1DB)	25.94**	1.72	-5.06**
3 (N,DB,M2DB) vs 4 (A,DB,M2DB)	29.55**	3.30**	-5.03**
5 (N,PR,M1PR) vs 6 (A,PR,M1PR)	8.16*	-1.02	-2.08*
7 (N,PR,M2PR) vs 8 (A,PR,M2PR)	10.04**	-2.14*	-1.34

*significant at =.05

**significant at =.01

The second significant pairwise comparisons of groups indicates that treatment three (normal distribution) is better than treatment four (actual distribution) with respect to E_2 (error rate of misclassifying the non-bankrupt firm). On the basis of E_1 treatment four is better than three; thus due to the criterion chosen for the study (complete dominance), neither treatment can be considered superior. The normal distribution continues to show smaller error rates (whenever there is a difference) than the actual distribution if one examines the pairwise comparison between treatment five (normal) and six (actual) and treatment seven (normal) and eight (actual).

The details for the univariate F statistics, Tables 4-11 and 4-12, also show that the distribution effect is significant only when the error rate of misclassifying the non-bankrupt firms is considered. From Table 4-10, Winer formal tests can be performed to show that the normal distribution dominates the actual distribution for the non-bankrupt firms only.

Figure 4-4 plots the mean individual error rate in each treatment, two variables at a time, holding the third constant. For example, in part (A) NN line represents the mean error rate (E_1) of mapping one and mapping two under the normal distribution and AA line represents the average error rate (E_2) of mapping one and two under the actual distribution. From parts C, D, I, and J of the

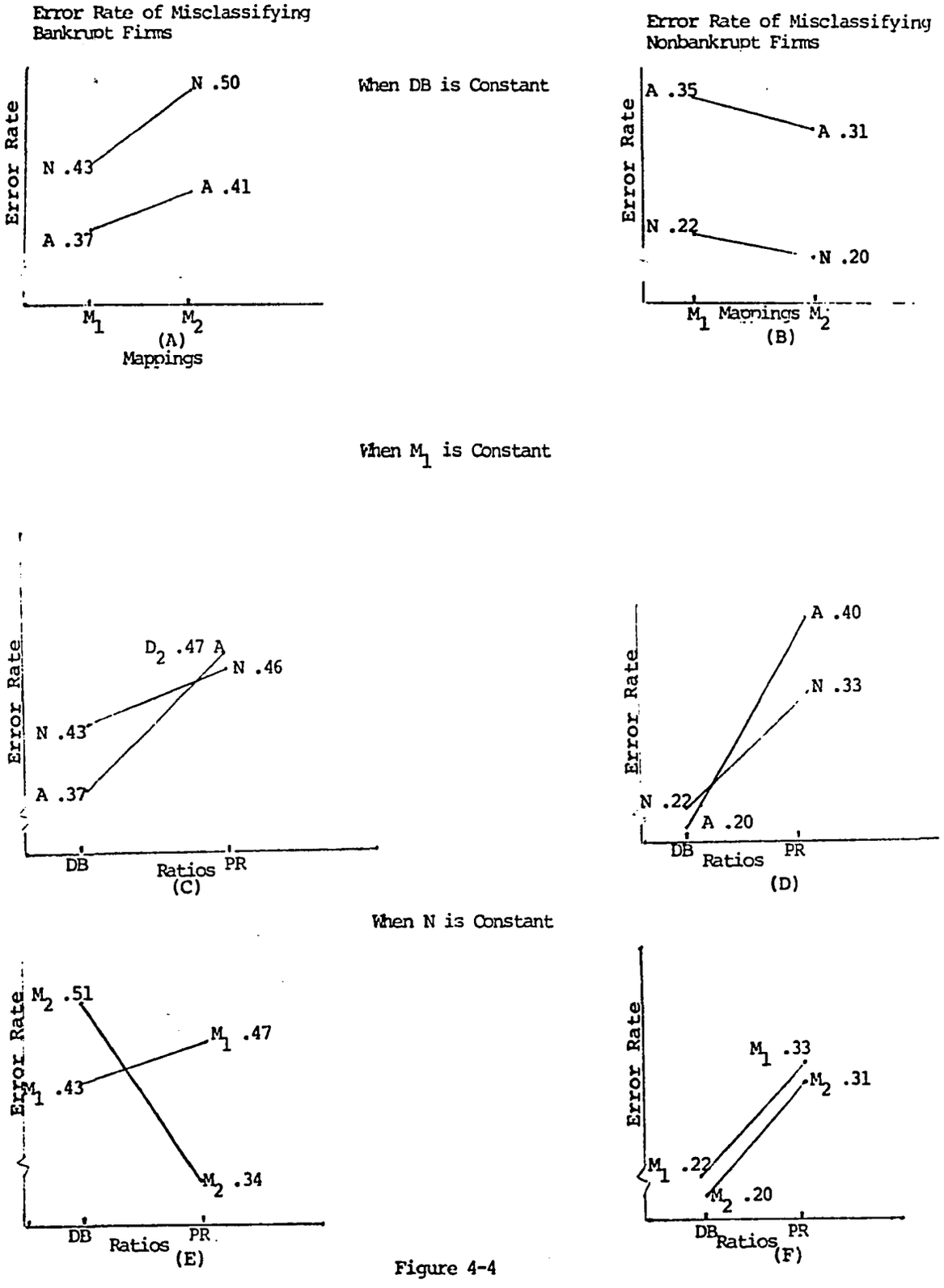
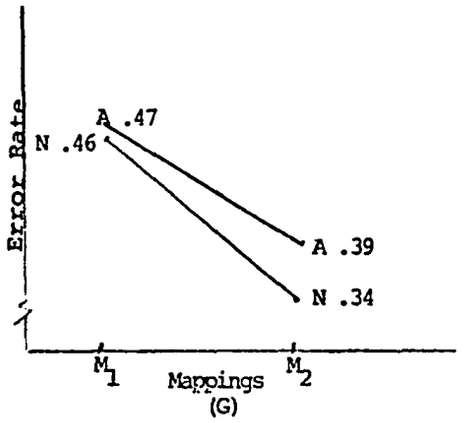


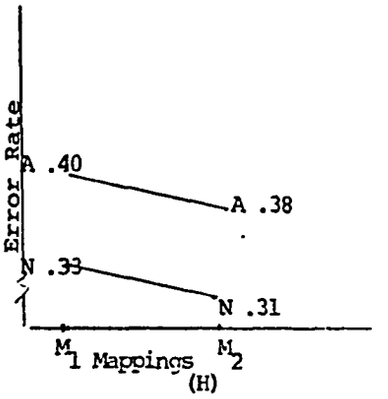
Figure 4-4

PLOTS OF THE MEAN INDIVIDUAL ERROR RATES

When PR is Constant

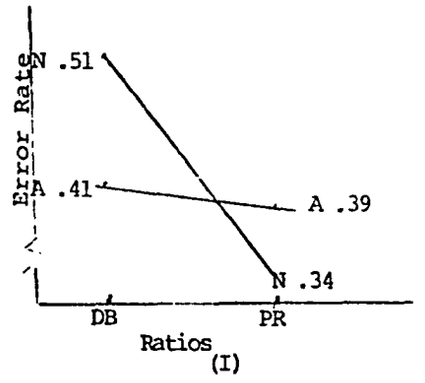


(G)

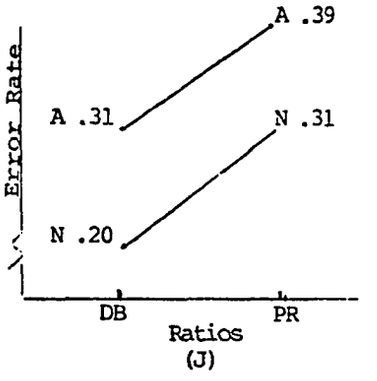


(H)

When M_2 is Constant

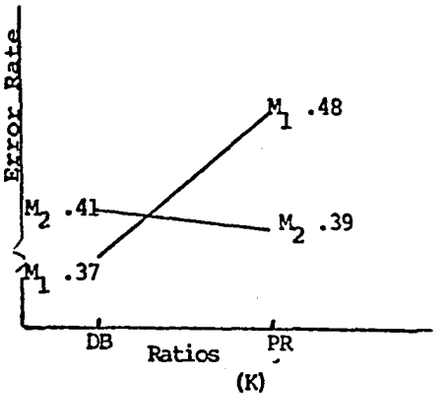


(I)

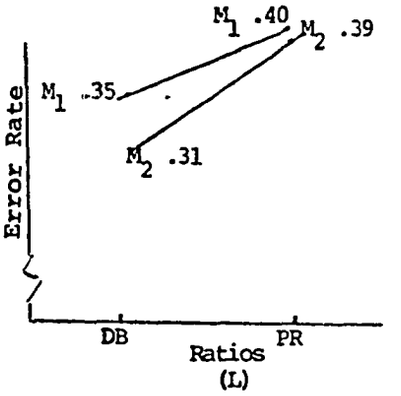


(J)

When A is Constant



(K)



(L)

FIGURE 4-4 (CONT.)

figures it is apparent that an interaction exists between ratios and distribution, especially when the error rate of misclassifying the bankrupt firms (E_1) is considered. This provides a graphic summary of the results of univariate F tests shown in Tables 4-11 and 4-12.

Mappings

The F tests presented in Tables 4-11 and 4-12 show that the association between facial features and financial ratios has a significant overall effect. The Hotelling T^2 statistics, Table 4-14, show no significant error rate differences between treatment one (mapping one) and treatment three (mapping two). This indicates that within DB ratios the two mappings produce similar results. Within the PR ratios (treatments five through eight) the Hotelling T^2 statistics indicate significant error rate differences between treatment five (mapping one) and treatment seven (mapping two), but there is no significant error rate difference between treatment six (mapping one) and treatment eight (mapping two). Both of these pairwise comparisons of treatments indicate that with PR ratios, there is no conclusive results with respect to mappings. The univariate t-statistics point out that the error rate differences between all of the treatments discussed is due to the error rate of misclassifying the bankrupt firm only. This result can also be examined in Table 4-11. The table shows that the

mapping effect is significant at $\alpha = .05$. This indicates that matching facial features to financial ratios plays a significant role in the prediction of bankrupt firms. Different mappings apparently result in significantly different results.

Table 4-12 shows that the mapping effect is not significant with respect to the error rate of misclassifying the non-bankrupt firms. This implies that alternative matching of facial features with financial ratios did not result in a drastic change in the error rates.

TABLE 4-14

HOTELLING T^2 STATISTICS INVOLVING MAPPINGS

Treatment	T^2	Misclassify Bankrupt Firms t Value	Misclassify Non-Bankrupt Firms t Value
1 (N,DB,M1DB) vs 3 (N,DB,M2DB)	5.39	-2.32	.64
2 (A,DB,M1DB) vs 4 (A,DB,M2DB)	4.97	-1.45	-1.89
5 (N,PR,M1PR) vs 7 (N,PR,M2PR)	39.52**	5.39**	1.36
6 (A,PR,M1PR) vs 8 (A,PR,M2PR)	9.55*	1.84	1.47

* significant at $\alpha = .05$
**significant at $\alpha = .01$

Parts E, F, K, and L of Figure 4-4 indicate that there is no interaction between ratios and mappings with respect to E_2 (non-bankrupt firm), but there is a significant interaction with respect to E_1.

Winer formal tests were also performed on the mapping variable. The tests confirmed that within DB ratios there were no significant error rate differences between treatments, but within PR ratios, mapping two is better for the bankrupt firms only. The formal tests on mappings are given below:

Formula[17]	DF	F	P Value
$F_{DB} = \frac{(M1DB - M2DB)^2}{2\ (n)\ (q)\ MS}$	2,440	2.10	>.05
$F_{PR} = \frac{(M1PR - M2PR)^2}{2\ (n)\ (q)\ MS}$	2,440	23.84	$\geq$.05

Where n and q are as defined above.

Of these two F values only the second is significant at P = .05. This latter results makes it hard to conclude which set of mappings perform better.

The Effect of Reducing the Number of Ratios

The study addressed, in the last treatment, the effect of using fewer ratios than the number used in the other treatments. Treatment nine used six ratios (within PR ratios), normal distribution, and mapping two within PR ratios. The treatment produced an error rate of .42 and .22 for misclassifying bankrupt and non-bankrupt firms

respectively. If this treatment is compared with treatment seven, which is different from treatment nine only in the number of ratios used, the rate of misclassifying the bankrupt is smaller in treatment seven than that in treatment nine. The number of non-bankrupt firms misclassified under treatment nine is less than that under treatment seven (error rates are .31 and .22 for treatment seven and nine respectively). This indicates that while using fewer ratios did not result in a higher error rate in classifying the non-bankrupt firms, the error rate of misclassifying the bankrupt firms was higher when fewer ratios were used. In treatment nine, the mouth curvature was not used, hence all the graphs showed a smiling face whether the firm was bankrupt or not. This made the task harder for the students to discriminate between the two groups, apparently because of the saliency of the mouth curvature. This feature might be the cause for a high error rate of misclassifying the bankrupt firms. This is not the case when the error rate of misclassifying the non-bankrupt firm is considered. This result is further evidence that mapping is significant in predicting the bankrupt firms, but it is not significant in predicting the non-bankrupt firms.

Summary of the Empirical Findings

A brief summary of the major findings of the study are presented below:

Comparisons	The Dominant Variable	
	Bankrupt	Non-Bankrupt
Actual vs Normal	Inconclusive	Normal
DB ratios vs PR ratios	Inconclusive	DB
M_1 vs M_2 (within DB)	No Effect	No Effect
M_1 vs M_2 (within PR)	M_2	No Effect

This study showed that, in general, for the non-bankrupt firms the normal distribution and Dun and Bradstreet ratios provided superior results. However, the results for the bankrupt firms were conflicting suggesting that it is the combination of factors which is most important.

FOOTNOTES TO CHAPTER IV

1. Norton, Curtis L. and Smith, Ralph E. "A Comparison of General Price Level and Historical Cost Financial Statements in the Prediction of Bankruptcy," The Accounting Review, January, 1979, p. 81.

2. Ketz, Edward J. "The Effect of General Price-Level Adjustments on the Predictive Ability of Financial Ratios", Journal of Accounting Research, Supplement to Volume 16, 1978, pp. 273-284.

3. Ketz assumed that the loss of investing in a bankrupt firm predicted to be non-failing is the complete investment. The loss of misclassifying a non-failing firm is the incremental return one could have made. For the purpose of the study, Ketz choose the incremental return as the differential between investing in the error rates of Type I and Type II as .04 and .44, respectively, the a priori probability as .97 and .03, and the differential return as 10%, the expected cost of misclassification (EC) is:

   $$EC = (.97)(.04)(.10)+(.03)(.44)(1.00) = .0171.$$

   For more details, see Ketz, Journal of Accounting Research, 1978, pp. 276-282.

4. Deakin, Edward, "Business Failure Prediction: An Empirical Analysis", Working paper, November 1975, Graduate School of Business, University of Texas at Austin.

5. Ibid., p. 5.

6. Timm, Neil, Multivariate Analysis with Application in Education and Psychology (Brooks, Cole Publishing Co., Montery, California), 1975, p. 416.

7. Winer, B.J., Statistical Principles in Experimental Design (New York: McGraw-Hill Book Company, 1971), p. 235

8. Rao, C.R., "An Asymptotic Expansion of the Distribution of Wilks' Criterion", Bulletin of International Statistics Institute, Vol. 33, 1951, pp. 177-180.

9. Barr, Anthony; Goodnight, James; Sall, John; and Helwing, Jane, A User's Guide to SAS 76 (Raleigh, North Carolina: SAS Institute, Inc., 1976).

10. Overall, John and Klett, C.J., Applied Multivariate Analysis, (New York, McGraw-Hill Book Co., 1972) p. 316.

11. Health Science Computing Facility, The Biomedical Computer Program BMDP, 1977, (Los Angeles, Calif.: University of California, 1977).

12. The chance of making a correct decision can be calculated as:

$$\text{chance (correct)} = P1^2 + P2^2$$

where P1 and P2 refer to the proportions of bankrupt and non-bankrupt firms respectively. In this study there are 14 bankrupt firms and 28 non-bankrupt firms (Or P1 = .33 and P2 = .66). Then:

$$\text{chance (correct)} = .33^2 + .66^2$$
$$= .56$$

$$\text{chance (error)} = 1 - .56 = .44$$

comparing this to the overall error rate reveals that the treatments provided better than chance results.

13. Bock, R. Darrell, Multivariate Statistical Methods in Behavioral Research (McGraw-Hill Book Co., 1975), p. 423.

14. Winer, B.J., Op. Cit., p. 468.

15. $F_N = \frac{(23.81 - 36.30)^2}{2(56)(2)(.0216)} = 34.82$

$F_A = \frac{(37.3 - 44.27)^2}{2(56)(2)(.0216)} = 10.01$

16. $E_1 = (.43 + .37 + .51 + .41) \div 4 = .43$

17. $F_{DB} = \frac{(55.13 - 51.56)^2}{2(56)(2)(.0271)} = 6.76$

$F_{PR} = \frac{(59.92 - 40.92)^2}{2(56)(2)(.0271)} = 23.84$

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This study has examined a graphic technique which may be useful as an adjunct to financial reporting. The study looked for possible improvements in the construction of schematic faces which would make them more informative.

Previous studies have provided some evidence that schematic faces drawn, based on some common financial ratios, communicated information useful for making predictions of business bankruptcy. In the same context of bankruptcy, this study examined the following potential improvements:

1. Is it possible for a different group of ratios (other than Dun and Bradstreet) to affect the accuracy of the graphic technique?

2. Would a different distribution, other than normal, produce better (worse) results?

3. Would an alternative association between facial features and financial ratios provide more informative graphs?

4. Is it the combination of ratios or is it the number of ratios and their matchings with features that matters most in the prediction process?

Summary

The study showed that the three variables investigated to improve the predictability of schematic faces had mixed effects on the results.

Ratios

This study surveyed the literature on the use of ratios in bankruptcy predictions. From this survey, a group of the ratios most often asserted to be effective was identified. The use of this group of ratios as a base for constructing schematic faces was compared to the use of Dun and Bradstreet Key Financial Ratios. The results showed that even though there were significant overall error rate differences between the groups, these differences do not exist in both types of individual error rates. For the bankrupt firms, the Dun and Bradstreet ratios produce better results when used in combination with an actual distribution and mapping one. However, the prior research ratios are preferred when used in combination with the normal distribution and mapping two. In contrast, for the non-bankrupt firms the Dun and Bradstreet ratios are clearly preferred to the prior research ratios. The Dun and Bradstreet ratios provide significantly better predictions in three out of four of the possible comparisons.

Distribution

Concerning the distribution effect, the study investigated the effectiveness of the graphic technique under the

assumption that financial ratios are normally distributed versus their actual distribution for the industry studied. The question of which distribution yields the more effective schematic faces can again be examined through pairwise comparisons. Examining those pairs of experiments for which there were significant mean error rate differences, the normal distribution is clearly preferred to the actual distribution in classifying the non-bankrupt firms. However for the bankrupt firms the normal distribution is preferred when combined with mapping two of the prior research ratios while the actual distribution yields better predictions under mapping two using the Dun and Bradstreet ratios.

The preference for the normal distribution for the non-bankrupt firms may result because with the normal distribution, small deviations from industry averages are not readily detectable in the faces. This may be attributed to the fact that when ratios are normalized, small differences from the industry mean are even further reduced and can hardly be seen. For the actual distribution, small deviations from average have more noticeable affects on the shape of the face. In addition, when using the normal distribution, a continuous scale was employed (the ratios can take the values, .25, .26, .27, and so forth). While the scale in the actual distribution was discrete (.10, .20, .30, ..., 1.00). This may further aggravate the deviations.

Mappings

The change in mappings only affects the accuracy of prediction for the bankrupt firms. The study examined four methods of mappings, two within the Dun and Bradstreet ratios and two under the previous ratios.

There was only one significant difference in the mapping comparisons. For the bankrupt firms mapping two was preferred to mapping one when combined with normally distributed prior research ratios. There were no significant differences for the other pairwise comparisons.

When the error rate of misclassifying non-bankrupt firms is examined, the MANOVA results showed that the mapping has no significant effect. This may be because healthy firms (non-bankrupt firms) maintain overall average industry ratios. Hence, no matter what ratios are assigned to any feature, the look of the schematic faces would not be much different.

The Reduction in the Number of Ratios

The amount of cost and time required to prepare the schematic faces is directly related to the number of ratios depicted in them. Reducing the number of ratios will, therefore, reduce the cost of using the faces, but presumably at the expense of a reduction in the accuracy of the predictions which can be made using them. The last treatment examined the amount of the reduction in predictive power when the number of ratios is reduced. This treatment used six ratios recommended by writers to be of good value

to the prediction of business bankruptcy. The results of this treatment are compared to treatment seven. This is done so that there would be only one difference between the two treatments. This difference is the number of ratios used. The reduction in the number of ratios used increased the error rate of misclassifying the bankrupt firms from .34 to .42 (the average number of errors increased from 5 to 6). Considering the error rate of misclassifying the non-bankrupt firms, the reduction in the number of ratios reduced the error rate from .31 to .22 (the average number of errors decreased from 9 to 6). The difference between treatment seven and treatment nine is statistically significant on both types of error rates. Even though there is no dominant treatment based on the statistical differences, one might be preferred over the other based on cost factors. The decision of which treatment is better depends on the cost attached to the misclassification errors. The increase in cost of misclassification should be compared with cost savings in the reduction of the number of ratios used.

The increase in the error rate of misclassifying the bankrupt firms may be aggravated by a mapping effect. In treatment nine, only six ratios were chosen from among the previous research ratios. The association between those ratios and the facial features were the same as those used in treatment seven. This left five features which varied in treatment seven but were fixed in treatment nine.

The fixed features were set at a mid range of each variable, making these faces look more average. As an example, the mouth curvature was not used in treatment nine because the ratio represented by this feature in treatment seven was not used in treatment nine. For this reason, all faces would show a smiling face for all firms. This might cause subjects to classify fewer firms as a bankrup due to the smiling face.

Conclusions

Based on the findings of the study, the researcher has the following conclusions to make:

1. For the non-bankrupt firms the Dun and Bradstreet ratios and the normal distribution was preferred. The mapping had little effect.
2. For the bankrupt firms the combination of variables proved important with the best results obtained from the combination of the normal distribution, prior research ratios and mapping two. Clearly further research is necessary to gain an understanding of the factors which will improve the predictions of a bankrupt firm.

Limitations of the Study

The results of the study should be considered in the light of the following limitations:

First: The study used ratios to draw the schematic faces, hence the limitations inherent in any use of financial ratios would also be limitations of this study. Ratio analysis is rarely considered completely sufficient in most decision situations, but often serves as a guide for additional investigation.[1] Foulk noted the major limitation of ratio analysis when he stated:

> ". . . .a knowledge of the significance of incorporated ratios will point out weaknesses and indicate whether a financial condition is wholly or partially good, questionable, or poor. But the great unknown is always management, which has the power to improve the condition or hasten the ruin of any business."[2]

Second: The faces represent a group of ratios, hence, this study will not report on the importance of a single ratio. It is the combination of ratios used and their mapping that affect the results of the study, not a single ratio.

Third: The graphic technique assumes that the average industry ratios are the target for each firm in that industry. Deviations from the average are captured by changes in facial features from their normal size or shape. If average industry ratios are not a proper target, the faces are miscalibrated.

Fourth: The ratios chosen for the study were selected subjectively from previous research. In other words, no statistical technique was used in choosing the ratios to be included in the study. There still may be a more effective set of ratios.

Fifth: The matching of facial features with financial variables was based on the author's judgment due to the lack of theoretical and empirical bases upon which to order the saliency of the features. Again, it is possible that a better mapping exists than that examined herein.

Sixth: The study used students as surrogates for the users of the model. The generalizabilty of the results should be approached with care because students may not be appropriate surrogates for persons who would actually make bankruptcy predictions.

Seventh: The study was restricted to the retail industry only. The conclusions should not be generalized to other industries.

Recommendations

The findings of this study indicate that future research in the following areas may be profitable.

First: The group of ratios to be used to construct the faces can be chosen through a statistical method. Factor analysis, for example, has been used to reduce the number of ratios without losing valuable information. This technique may produce a combination of

ratios which could improve the predictive ability of schematic faces to warn of pending business bankruptcy.

Second: The mapping effect cannot be determined in one or two experiments. A series of experiments can be conducted in an attempt to reach a better matching of ratios and features with more emphasis on the saliency of the mouth, the eyes, and the nose as possible features which may affect the subjects decisions.

Third: This study used deciles to scale the ratios. Another possible way of testing the effect of the distribution is to determine the distribution of ratios and to use other transformation techniques. This may result in further refining of the results.

Fourth: Research should be undertaken in contexts other than bankruptcy prediction to see if faces communicate information useful for other decisions. For example, the graphs may be used in bond ratings to determine if the faces help to discriminate between those companies with high rating bonds and those with low rating bonds. The same thing can be examined in the context of the stock growth or earnings growth.

Fifth: This study required participants to make yes/no decisions. Few would argue that ratio analysis alone should be used in most decision contexts. Rather, we might want to test if the graphs are useful in classifying clearly good, and clearly bad as opposed to questionable firms needing further analysis. This can be used in

credit analysis where firms could be classified as good or bad for granting credit or where more investigation is needed.

In summary, the variables examined in this study did have an effect on the accuracy of predictions made using schematic faces. The results discussed suggest several lines of inquiry which may further enhance the importance of this novel communication device.

Footnotes to Chapter V

1 Foulk, Roy, Practical Financial Statement Analysis, McGraw-Hill Book Co., 1968, p. 458.

2 Ibid., p. 177.

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