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**A METHODOLOGY FOR PREDICTING COMPANY FAILURE
IN THE CONSTRUCTION INDUSTRY**

by

ADNAN FADHIL ABIDALI, BAE, MSc

A Doctoral Thesis submitted in partial fulfilment
of the requirements for the award of
Doctor of Philosophy
of the
Loughborough University of Technology

August 1990

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DEDICATION

To the soul of my father FADHIL, a great father, who gave
me inspiration and moral support

and

My Mother

* * * * *

DECLARATION

No portion of the research referred to in this thesis has been submitted in support of an application for another degree or qualification at this or any other university or other institution of learning.

ACKNOWLEDGEMENTS

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Special thanks are expressed to the project supervisor, Professor F Harris for his guidance and encouragement who went beyond mere supervision of this study. His enthusiasm for the research provided a source of inspiration to the author.

The author also wishes to thank Mrs Janet Smith for her help in typing the thesis.

Finally, to my family I extend my love, and to my wife I extend my sincere thanks for her encouragement and patience during the preparation of this report.

ABSTRACT

This thesis develops the theory of failure prediction for UK construction companies. The research aims were directed towards an evaluation of several methods namely:

1. Multivariate discriminant analysis: This technique is widely employed in the commercial sector with much of the work concentrated on failed and healthy companies. Altman [8], Deakin [25], Taffler [11]. The different characteristics of two or more groups are analysed to create a model that best differentiates between them. The end result transforms these characteristics into a single variable, normally called a Z-score.

This method was particularly well demonstrated in this thesis by the successful prediction of failure of Rush and Tomkins plc three years before the recent announcement.

Secondly the multiple regression second version was enthusiastically employed by the London Borough of Camden for vetting contractors on tender lists.

Generally the first model performed well on the data for quoted and unquoted companies, while the second was better for unquoted companies, particularly those private companies dealing with LBC.

2. Traditional financial ratios: The use of financial ratios to predict failure is not new, indeed Merwin [2] analysed 6 years trends of ratios for a number of failed and non-failed companies and found that three ratios were particularly sensitive predictors of failure. Further work was later reported by Beaver [3] and Pinches [6].

In this study, 31 financial ratios were calculated and statistically examined as potential indicators. Three were found to be important at the following limits:

- current assets/current liabilities 1.0
- net assets/current liabilities 1.0
- pre-tax profit/payable interest 2.0

Ratios alone, however, were not sufficiently reliable to predict failure and the research concluded that it was essential to use at least two different methods before firm indications of failure of a suspect company can be substantiated.

3. The A-score method: The concept behind the A-score is based on the belief that if a company is in financial difficulty the reason generally relates to inadequate management ability and errors perpetrated earlier, the A-score is designed to address this aspect of failure prediction e.g. Argenti [7].

A questionnaire was devised and included 17 questions related to failure for both an "at risk" group classified as vulnerable, i.e. those scoring negatively by the Z-score model and a positively scoring "solvent" group.

The existence of managerial factors related to failure was investigated in the questionnaire using a multiple choice method. Both groups proved adequate for comparison purposes, and were therefore included in the A-score model.

The A-score for a company is obtained by adding the weight of all factors and errors together, and a cut-off value determined. The model was statistically verified by the t-test method at 1% significant level and further examined by the Willcoxon (Rank Sum) tests null hypothesis rejected at 5% level of significance.

An attempt was also made to relate A-score and Z-score values, unfortunately statistical analysis indicated only 67.7% intercorrelation between A-score and Z-score i.e. not very strong. However, the Z-score value of zero corresponded to an A-score cut-off value of about 50, these being critical values in both modes.

Finally, trend analysis was shown to be a suitable extra check in objective evaluation of company performance, and an improved method of systematically appraising contractors was produced. However, the developed models should only be used as part of an overall assessment of company stability. Any predictions should be interpreted with caution as the models require further testing on a broader range of companies. It is also important to appreciate that the use of such models to exclude companies from tender lists could accelerate or even cause failure.

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CHAPTER 1

GENERAL INTRODUCTION

- 1.1 Introduction
- 1.2 Objectives
- 1.3 Methodology
- 1.4 Achievements
- 1.5 Organisation of the Thesis

CHAPTER 1
GENERAL INTRODUCTION

1.1 INTRODUCTION

The number of construction company liquidations has been, perhaps surprisingly higher in recent years than in the low output years of 1977 and 1982. This could indicate that many which started up in the boom years have since failed due to inadequate finance and managerial skills.

Figure 1 plots the number of insolvencies in construction companies in England and Wales. It can be seen that during the period 1979-1985 an increase of insolvencies followed by a rapid decrease in 1985 probably starting with the boom in construction in 1986.

The fall in insolvencies in 1987 corresponds with the increase in output in 1987. A fall in overall demand always seems to be accompanied by a rise of insolvencies and vice versa.

It is clear that the number of firms becoming insolvent between the period of 1983-1986 was nearly twice as much as before.

Although the number of insolvencies went up however, there was a large entry of firms into the construction industry and many may not have possessed all the attributes required to ensure success.

There are also, fairly high numbers of insolvencies with compulsory and voluntary liquidations among construction companies accounting for around 13% of all liquidations.

FIGURE 1.1: THE TREND OF INSOLVENCIES IN THE CONSTRUCTION INDUSTRY

Activity	1982	1987	% Increase
1 General builders	57565	68947	19.8
2 Building and Civil Engineering Contractors	3242	3917	20.8
3 Civil Engineers	2357	2946	25.0
4 Plumbers	13286	15207	14.5
5 Carpenters & Joiners	9341	11741	25.7
6 Painters	14267	14898	4.9
7 Roofers	4469	6145	37.5
8 Plasterers	3590	4137	15.2
9 Glaziers	3036	4871	60.4
10 Demolition Contractors	523	634	21.5
11 Scaffolding Specialists	623	1081	73.5
12 Reinforced Concrete Specialists	435	597	37.2
13 Heating & Ventilation Engineers	7469	8751	17.2
14 Electrical Contractors	13176	16402	24.5
15 Asphalt & Tar Spreaders Plant Hires	3260	3819	17.11
16 Flooring Contractors	1272	1495	17.5
17 Construction Engineers	1154	1756	52.2
18 Insulating Specialists	1076	1379	28.0
19 Floor & Wall Tiling	963	1259	30.7
20 Miscellaneous	1866	3189	70.9
Total	144395	175095	21.3

TABLE 1.1: NUMBER OF PRIVATE CONTRACTORS BY ACTIVITY
(Source: House and Construction Statistics (keynote))

Table 1.1 shows the number of private contractors by activity for the years 1982 and 1987, in which 45% are single employee operations.

The rate of appearance and disappearance of small building firms in particular is high, with about 3000 new VAT registrations and roughly the same number of de-registrations each year. Therefore in this research it was decided to concentrate on general builders, building and civil engineering contractors or civil engineers who employ more than fifty employees medium-size to large companies and are also recorded in Company House. The companies are classified by numbers of employees, for example, small and medium companies, employing less than 50 and 250 employees respectively, and over 250 for large companies [1].

Construction has always been a high risk business and clearly there is a need for an early warning system of bankruptcy. Furthermore potential company failures should be recognised at the earliest possible opportunity in order to minimise the costs to the public, especially as the majority of Government contracts are awarded to firms that appear on selected tendering lists. Also since under the Local Government Act 1988 reasons for rejecting potential contractors in competitive tendering need to be substantiated as necessary to set standard financial appraisal requirements.

In this context a London wide survey (see Appendix D) revealed that while the majority of authorities (24 out of 25) examine firm's financial accounts only eleven authorities prefer to see accounts for the last three years, a further eleven prefer to see the last two years and the remaining two base their appraisal on the most recent years results alone.

Twenty authorities out of twenty five use ratio analysis to assess the financial appraisal which relies heavily upon an assessment of liquidity. Of the twenty authorities using ratios six use Z - Score analysis (mainly Altmans Z-Score developed in 1968 in the USA) to assess the solvency of potential contractors.

Furthermore, twenty two of the twenty five authorities impose some form of limit on the value of contracts which may be awarded.

In conclusion, the objectives behind the use of financial limits seem to be:

- Firms should not be encouraged to overtrade and consequent receivership.
- Firms should not be encouraged to become over-reliant on Council business.
- The council should not allow firms to become over-dependent upon a few contracts.
- There should be as wide a choice of firms as possible to ensure tenders are competitive and Councils get value for money.
- The use of financial limits based upon standard criteria ensure that applicants are treated fairly.

Obviously it would not be practicable under current circumstances to adopt a limit on the value of work, because of the impossibility of enforcement and monitoring adherence to the limits.

Therefore, some other methods are needed which will give a quantitative indication of the solvency of companies.

This research work successfully developed several Z-Score models that were able to classify companies into solvent and insolvent groups, by giving each company a score related to its degree of solvency.

Until now, no other construction based system has been produced in the UK and the motivation for the development of a separate construction based system is that, in the UK, the characteristics of such firms differ from those of manufacturing concerns. The main difference being that civil engineering and construction companies practices are dominated by the contracting firm, with a contractor directly responsible to the client. The hypothesis of the thesis to prove that bankruptcy prediction for construction companies is both empirically feasible and theoretically explainable was largely achieved.

1.2 OBJECTIVES

1. To assist Local Authorities in the selection of an approved list of contractors for competitive tendering.
2. To provide bankers, lenders and investors with an early warning system of financial difficulty for construction companies.
3. To minimise the danger of corporate failure of companies making take-over bids of other companies possessing potential failure characteristics.
4. To develop a model able to predict the failure of companies in the construction industry on a financial basis.

5. To develop a model that is able to predict the failure of companies in the construction industry on a non-financial basis.
6. To investigate reasons for failure by using different methods of prediction before coming to a conclusion.
7. To develop a practical system that is able to classify companies into solvent and insolvent groups.

1.2.1 Secondary Objectives

1. To review the economic situation of the construction industry during the period of project.
2. To review the reasons for failure by case study method.
3. To review the previous studies of predicting failure in the construction industry and other sectors.
4. To develop a computer package for the calculation of financial ratios.

1.3 METHODOLOGY

The method which attempts to achieve the thesis objectives was made possible by using a combination of two techniques, "Financial Ratio Analysis" and a statistical technique known as "Multivariate Discriminant Analysis". The object being to distinguish between two groups, namely "Solvent" and "Insolvent" firms by selecting from a collection of "discriminating variables" measures which characterise the expected differences.

The "discriminating variables" used to form the model are traditional financial ratios, calculated from The Construction Companies published balance sheets.

Because of complexities of calculation involving many different ratios for a large number of companies it was impractical to achieve this manually, because of time restrictions and precision of calculations.

Therefore, a computer program "ADNAN.FOR" was developed for the purpose. Questionnaires concerning companies and interviews of individuals were also incorporated. New data revisions were continuously made to collection methods and analysis techniques, also a second regression analysis model was developed and tested, and ultimately adopted in the selection of healthy contractors by London Borough of Camden.

Further analysis was made of companies classified as potential failures but not failing in the short term and the reasons for their survival considered.

A new tool "A-SCORES" was developed based on non-financial features which identifies the items of failure extracted from case studies and company literature.

Questionnaires were also designed to achieve this goal followed by an evaluation of management deficiencies weighted for importance.

Finally, a linkage between Z-Scores and traditional ratios with A-Scores was developed to provide a practical system that is able to predict the failure of companies in the construction industry. In conclusion the research work proved how the developed system offers a contribution to failure prediction in the construction industry.

1.4 ACHIEVEMENTS

The research successfully achieved the following:

1. Failure prediction based on financial features using financial ratios and Z-Scores as indicators of approaching failure.
2. Failure prediction based on non-financial features which indicate failure long before the signs of financial difficulties.
3. Identification of the factors influencing failure in construction companies.
4. Identification of the mistakes companies made which may lead to failure.

Finally, a significant achievement was that the model was adopted by London Borough of Camden as an aid in the selection of healthy contractors.

To support this research existing models of predicting failure were reviewed and criticised. Also case studies of failed major construction companies were investigated and the reasons ascertained.

Furthermore, the research successfully developed a new system to aid Local Authorities in vetting construction companies in tender lists.

1.5 ORGANISATION OF THE THESIS

Figure 2 illustrates the various steps taken in this research to achieve the stated objectives. These steps are presented in eleven chapters which are briefly described as a guide to the thesis.

Guide to The Thesis

- Chapter 2: Presents a detailed literature review of previous studies relating to models for predicting the failure of a company. Methods for prediction of bankruptcy are also discussed.
- Chapter 3: This chapter provides the background knowledge of "Multivariate Discriminant Analysis" and how the technique can be utilised to classify companies into "Solvent" and "Insolvent" groups.
- Chapter 4: Presents the data collection and company groups used to establish the models including the data collected for testing the models.
- Chapter 5: Presents a full description of the models together with the constituent variables, relationships between variables and contribution of each variable to the model, also included are the statistical techniques and computer packages used.
- Chapter 6: Presents the resultant models including prior probability and misclassification estimation method, also cut-off value for the models are discussed.

- Chapter 7: Presents the results from the models which support the "prediction" power of the technique and includes Z-Scores, trends and financial ratios as tools for predicting failure.
- Chapter 8: Presents an attempt to validate the "MDA" technique and ascertain the capabilities of the model regarding discrimination between "solvent" and "insolvent" companies. Also validation of the regression model at London Borough of Camden is included. Finally validation of financial ratios as a tool of predicting failure is included.
- Chapter 9: Presents non-financial features of failure and what they might indicate, management characteristics, management mistakes contributing to failure and not covered by any financial tool such as Z-Scores or financial ratios are illustrated, furthermore, a questionnaire was designed to identify the managerial factors related to failure.
- Chapter 10: Presents a full description of the A-Scores model and method of scoring as a tool of predicting failure, the results are also described. Finally, relationships between the A-Scores and the Z-Scores are discussed.
- Chapter 11: Presents conclusions drawn from the research and how the developed system offers a contribution to the construction industry as an early warning system of failure and gives advice on corrective action to avoid failure. Also these findings are included altogether with recommendations for implementation in vetting construction companies for tender lists.

The Appendices contain graphical presentations of the Z-Scores and tables of results obtained from individual companies. —

A manual for use with the computer package ADNAN.FOR and an example of the programme application are included.

A manual for use with statistical computer package and sample of the output are also included.

A sample of the questionnaire and basic statistical tests is also contained in the appendices.

FIGURE 1.2: THESIS LAYOUT DIAGRAM

CHAPTER 2

REVIEW OF PREVIOUS STUDIES

- 2.1 General Introduction
- 2.2 The Traditional Financial Ratios
- 2.3 The Z-Score
- 2.4 Other Methods of Failure Prediction
- 2.5 Summary and Conclusions

CHAPTER 2
REVIEW OF PREVIOUS STUDIES

2.1 GENERAL INTRODUCTION

Experience suggests that failure of a company may be defined as its having entered into receivership or voluntary or compulsory liquidation or having received government assistance. Previous studies proved that bankruptcy prediction is both empirically feasible and theoretically explainable, with much of a financial analyst's time spent intuitively making judgements, assessing likelihoods, forecasting etc.

2.1.1 Introduction to Failure Prediction

This chapter reviews the development of an operational method which has been used for the identification of companies in danger of failure.

Section 2.2 begins with the traditional financial ratios as a tool to predict company failure. Section 2.3 includes all the Z-score models. Section 2.4 deals with other methods of failure prediction. The final section briefly discusses the above methods, their weaknesses and advantages and utility.

2.2 THE TRADITIONAL FINANCIAL RATIOS

2.2.1 Introduction

The use of financial ratios to predict failure is not new. Ratios were first used in the USA in the late 1920s.

In 1942 Merwin [2] also in the USA, analysed six years trends of ratios of a number of failed and non-failed companies. He found that three ratios were particularly sensitive predictors of failure.

Other work was later carried out on the same subject by Beaver [3,4,5] and Pinches [6].

Finally, John Argenti [7] compared the financial ratios of two companies which enjoyed approximately the same turnover and employed a similar volume of capital, one of them considered successful and the other a troubled one. He concluded that ratios will not on their own, infallibly predict failure, his study is discussed in more detail in Section 2.2.4 because it relates to British industry and is considered the latest study in this field.

2.2.2 Merwin's Study

Merwin defined failure of a company "as those that had ceased filing tax returns". This definition includes not only bankrupt or economically unsuccessful firms but also those which had ceased operations voluntarily or changed their form of business organisation.

Merwin analysed a large number of financial ratios calculated from the financial data of a large sample of small corporations in five manufacturing industries [2]. The sample included continuing and discontinuing companies during the period 1926-1936 in the USA.

The following ratios were shown to be good discriminators between failed and non-failed companies are:

1. Current ratio: i.e. a ratio of current assets to current liabilities.
2. Net assets/total liabilities.
3. Working capital/total assets.

By comparing the industry mean ratios, Merwin found that the current ratios of the discontinued firms were lower than those of the continuing firms and moreover were shown to have declined three to five years prior to cessation of business.

Empirical studies in the USA have subsequently reinforced the view that the current ratio is a significant indicator of financial difficulties.

Merwin also highlighted higher debt in the failed companies. Using the ratio of net asset to debt, he found that whereas only 26 percent of continuing firms had a ratio less than unity, in 65 percent of failed ones debt was greater than unity.

In over 70 percent of the failed firms the ratio of net assets to debt declined whilst in the continuing companies it remained fairly stable.

Also working capital/total assets ratios showed the ratio in failed firms, a year prior to bankruptcy was negative whilst in continuing firms positive.

2.2.3 Beaver Study

Beaver defined failure of a company "as those defaulting on interest payments, overdrawing their bank accounts or declaring bankruptcy".

Beaver [3] analysed the ratios of 79 failed US firms in the period 1954-1964 and a corresponding number of non-failed firms.

The following ratios show there to be good discriminators between failed and non-failed companies:

1. Total liability/total assets (leverage ratio)
2. Net profit/total assets (profitability ratio)
3. Cash flow/total debt (liquidity ratio).

The mean of the total debt/total assets ratio of the continuing companies was 0.79 compared to 0.37 in the failed firms, one year before failure. Also his study pointed to a sharp increase in the mean of the debt/total assets ratio of failed companies over the five years to failure. During the same period the means of the ratio remained unchanged in the continuing firms.

Also, in Beaver's study, the low net profit/total assets ratio proved to be one of the three major characteristics of failed firms. The mean of this ratio in the failed companies was substantially lower than that of the continuing firms period to failure.

Cash flow/total debt ratio also showed that the mean of the ratio in the failed firms a year prior to bankruptcy was negative (less than - 0.15), whereas in the continuing firms it was +0.45.

2.2.4 John Argenti Study

John Argenti [7] analysed the main financial ratios as performance ratios as follows:

1. The Acid Test Ratio on the Quick Ratio

Quick assets/current liabilities: this is considered the "ultimate test" by most financial specialists because it shows whether the company has sufficient cash to meet its immediate liabilities. Quick assets is defined as only current assets minus stock.

Current liabilities is any short-term liability including creditors and provisions, taxation dividends and overdraft. This ratio is considered to be one of the most important single failure prediction tools. Finance specialists traditionally like to see this ratio at or above 1.

2. Current Ratio

$$\frac{\text{current assets}}{\text{current liability}}$$

This is the twin brother of the quick ratio but is a little stringent, a little less 'quick'. The only difference is that in this one stock, or inventory are included in current assets definition. Nevertheless the current ratio is much favoured. Financial specialists traditionally like to see the current ratio at 2 to 1.

3. Capital Gearing 'Leverage' Debt/Equity

Debt includes long-term debt and short term. This definition includes all debt on which interest is payable, i.e. debt means total borrowings. The ratio of 1 to 1 is high by British standards.

4. Income Gearing or "Interest Cover" Ratio

$$\frac{\text{Profit before tax and interest}}{\text{Interest}}$$

This is the amount of interest the company is committed to pay on its long- and short-term loans, as a ratio of its pre-tax profits. A company could quite happily carry on immense debts so long as:

- a) its profits were high
- b) interest rates were low.

Results show that most companies with a ratio of 5 to 1 are in a comfortable situation.

5. Stock Turnover Ratio = Sales/Stocks

or

$$\frac{\text{Stocks}}{\text{Sales}} \times 52$$

This ratio measures how skilfully the company is controlling its stock (which includes inventory, work in progress etc) in relation to turnover. Conversely rising stocks and decrease of turnover leads to a tightening cash flow position.

(Argenti considers the numerator the cost of sale instead of turnover, and very often this ratio is expressed in weeks - i.e. the number of weeks stocks at the current rate of turnover).

It might be dangerous if the ratio falls i.e. turnover falls and stocks rise, but it can also be dangerous if it rises under certain conditions. If turnover rises much faster than stocks this could

indicate a condition known as "overtrading" where turnover expands but the company does not have the resources available to finance the expansion and runs out of cash.

6. Debtors Ratio or "Collection Period"

$$\text{Sales/Debtors or } \frac{\text{Debtors}}{\text{Sales}} \times 52$$

Most finance specialists like to see a collection period well below 6 or 7 weeks would be exceptionally good; 8 or 9 is common. More than 10 is beginning to look lax. Once again it depends on the nature of the business.

7. Return on Capital

$$\frac{\text{Profits before interest and tax}}{\text{Capital employed}}$$

or

$$\frac{\text{Earnings}}{\text{Shareholder}}$$

These are most important ratios as measuring profitability, both of which indicate the overall return earned on all the capital employed including loans as well as equity. (Return on equity or shareholders capital). Capital employed is taken as the average capital employed in the year, return on capital, however measured is obviously the prime criterion by which any company's performance should be judged. No company can however continue in existence for long unless the return on the capital it employs exceeds the cost of borrowing.

8. Profit Margin Ratio

$$\frac{\text{Profit and Loss}}{\text{Sales}}$$

The version proposed here is probably the simplest and widest because it compares trading profit and sales turnover.

An overall profit margin of 10 percent on sales turnover is good by most standards today. This ratio should be compared with the average of similar sectors.

Argenti concluded that a profit margin of 1 percent will almost always indicate trouble, however, some companies deliberately operate a high-volume, low-margin strategy and thrive for years on margins as low as a few percent.

Falling margins do not always spell approaching doom and could merely reflect a change in strategy, or the maturing of an industry (margins normally fall as an industry matures) or simply that the company is growing. Thus, while there is no fixed norm for this ratio, it is possible to come to a rational and useful conclusion for any given company in a given industry.

9. Assets Turnover Ratio

$$\frac{\text{Sales}}{\text{Capital employed}}$$

The aim is to determine how effectively the company's assets are being employed. Argenti concluded that a company with expensive capital assets (either fixed or working) lying unused may be heading into danger.

2.2.5 Summary and Conclusions on Traditional Financial Ratios as Predictive Tools of Failure

The table below gives the results of the financial ratios used as discriminators between failed and non-failed companies.

Researcher and Year of Publication	Merwin 1942	Beaver 1968	John Argenti 1983
Country Studied	USA	USA	GB
No of companies studied	200	79	2
No of ratios tested	Not known	30	Not known
The ratios			
A. Liquidity Ratios:			
1. The quick ratio; quick asset/current liability			x
2. Current ratio current asset/current liability	x		x
3. Cash flow/total debt		x	
B. Gearing Ratios:			
1. Capital gearing: debt equity			x
2. Income gearing: EBIT/INT			x
3. Net assets/total liability	x		
4. Total liabilities/total assets		x	
C. Working Capital Ratios:			
1. Sales/stocks			x
2. Debtors/sales x 52 weeks			x
3. Working capital/total assets	x		
D. Profitability Ratios:			
1. Profit ratio: Ebit/capital employed			x
2. Profit margin: profit/sale			x
3. Asset turnover ratio: Sale/capital employed			x
4. Net profit/total assets		x	
TOTAL DISCRIMINATOR RATIOS:	3	3	9

TABLE 2.1: RESULTS OBTAINED FROM PREVIOUS STUDIES OF TRADITIONAL RATIOS AS PREDICTIVE TOOLS OF FAILURE

It is difficult to obtain a clear picture of the risk involved in an individual company from a study of the financial ratios.

It is not sufficient for the analyst to know the failed firm had lower ratios prior to bankruptcy, irrespective of whether this knowledge is the result of multivariate analysis. A firm may fail as a result of declining profits even if five years previously it had reported a relatively high profitability. Similarly a firm suffering temporary losses or low profits at a certain time may subsequently improve its records as a result of new investment, and the previous studies commonly conclude that:

1. One can be misled by relying on only one or two ratios.
2. One can be misled by comparing the same ratios between companies even in the same industry.
3. Using a small portfolio of key ratios may reflect the change in a company's financial strength from one year to another.

Finally, predicting failure by ratio methods is mainly performed on the basis of the dichotomous classification technique whereby the firms are arbitrarily divided into two groups and arranged (for each ratio) in ascending order. An 'optimal cut-off point' is chosen through trial and error as the demarcation line for failing, i.e. any firm below it being categorised as a failed firm. The results are then compared with actual data to find the percentage of incorrect predictions. Often many trials are repeated before the optimal cut-off point is reached. This test is criticised because it decides the cut-off point after looking at the actual status of the firms whereas in a real situation the user of financial ratios has to make decisions without access to this information and of course the set of firms is

different from that used in the original sample to decide the cut-off point. Thus predictions are always being made on a set of firms, other than the set from which the cut-off point was derived.

The percentage error is calculated between the predicted status, failed or non-failed, and the actual status. The ratio with the smallest percentage of misclassification is considered the best predictor of failure. Therefore, the ratio with the smallest error of misclassification is considered to be the best. In contrast, the MDA method does not suffer such a weakness, hence its interest to analysts.

2.3 Z-SCORE

2.3.1 Introduction

It was shown in the previous section that the analysis of failed firms based on a consideration of single ratios may present a confused and unreliable indicator of financial difficulties.

The Z-score overcomes these difficulties. A company's Z-score is calculated by adding together a number of ratios, each ratio having been weighted according to its usefulness. Because the Z-score comes out as one single figure, it is possible to set one simple pass mark above which a company may be considered safe, but below which it must be considered at risk of failure.

As the likely most appropriate statistical technique for Z-score Altman in 1968 chose multiple discriminant analysis (MDA) using financial ratios for failure prediction.

A large number of Z-score models now exist and although they all follow the concepts of the original one devised by Altman, they are all different.

It is not yet possible to estimate how accurately and how far ahead each of these models can be expected to predict failure. However, there is a wide acceptance that the Z-score represents an important innovation, one that will surely play an increasingly useful role in failure prediction.

Because of the weakness of the financial ratios method described earlier, it is strongly recommended that in addition to examining the trends of the traditional ratios for any suspect company, the observer should also calculate the company's Z-scores for the past few years. The calculations are simple to make and the result will either confirm the story told by the financial ratios or it will not.

In either case an extra dimension will have been added to the observer's knowledge. The various models so far developed are now described leading to the latest work described in this thesis.

Section 2.3.2 begins with Altman's Z-score.

Section 2.3.3 includes a brief description of Taffler's model.

Section 2.3.4 covers the Mason and Harris' model.

Section 2.3.5 deals with the Castagra and Matolcsy model.

Section 2.3.6 includes Van Frederikstust model.

The final section briefly discusses the above models and draws conclusions.

2.3.2 Altman's Z-score

Two samples of sixty-six US companies were chosen, half being failed firms during the period 1946-1965, the non-bankruptcy firms were chosen carefully on a stratified random basis [8] to match the failed ones.

All the non-bankrupt companies were still operating in 1966 and had assets between \$1 and \$25 million which corresponded to the size of the failed companies. This range of size eliminated the giant firms, as these rarely fail, and small firms for which data are usually not available. Twenty-two ratios were considered represented by liquidity, profitability, leverage, solvency and performance ratios.

Five variables were selected as providing the best combination of ratios for the prediction of bankruptcy and the final discriminant function is as follows:

$$Z = 1.2 X_1 + 1.4 X_2 + 3.3 X_3 + 0.6 X_4 + 1.0 X_5$$

$$X_1 = \frac{\text{Working capital}}{\text{Total assets}}$$

$$X_2 = \frac{\text{Retained earnings}}{\text{Total assets}}$$

$$X_3 = \frac{\text{Profit before interest and tax}}{\text{Total assets}}$$

$$X_4 = \frac{\text{Market capitalisation}}{\text{Book value of debts}}$$

$$X_5 = \frac{\text{Sale}}{\text{Total assets}}$$

As can be seen Altman's equation consists of five terms, each of which is a financial ratio and each ratio is given a weighting. Professor Altman developed a computer programme which determined that it was this set of ratios with just these weightings, that best discriminated between failed and non-failed companies over quite a range of size and industry in the USA but not for retail, banks or railroads.

The definitions of financial terms are as follows:

Working capital	= current assets less current liabilities.
Total assets	= fixed assets + investments + current assets = equity + loan + current liabilities.
Retained earnings	= accumulated reserves.
Market capitalisation	= number of shares x share price.
Book value of debt	= all debts short- and long-term.

The pass mark for Altman's Z-score is 3. Companies scoring above that level should be safe while companies scoring below 1.8 will be classified as potential failures. Altman believes this equation can discriminate between "solvent" and failure candidates up to 2 or 3 years before the event.

Note: Altman added a ratio of market value as shown in term 4 in his model. It appears to be a more effective predictor of bankruptcy.

2.3.3 Taffler's Z-Score

Equal size samples of 46 failed and 46 financially sound (non-failed) manufacturing enterprises were used and a list of 80 financial ratios were employed in analysis. The model was originally developed in 1977

[11]. Although Taffler has not published the detailed mathematical equation, he has stated that:

- a) A 53 percent contribution to the model is made by the "profitability" measure:

$$\frac{\text{Profit before tax}}{\text{Average current liabilities}}$$

- b) A 13 percent contribution is made by the "working capital" measure:

$$\frac{\text{Current assets}}{\text{Total liabilities}}$$

- c) An 18 percent contribution comes from the "financial risk" measure:

$$\frac{\text{Current liabilities}}{\text{Total assets}}$$

- d) A 15 percent contribution comes from the "liquidity" measure no credit interval i.e. the number of days a company can finance its operations from its immediate assets if it can no longer generate revenue.

The Taffler model is valid for manufacturing companies, there is a further equation for distribution companies. The pass mark for Taffler's Z-score is zero.

2.3.4 Mason and Harris' Z-score

Equal size samples of 20 failed (which failed between 1970-1977) and 20 non-failed companies, construction companies were used, and a list of 28 financial ratios was employed in analysis.

The model was published in 1979 [17] and contains six terms. It was originally designed for use in the construction industry. The equation contains six terms as follows:

$$Z = 25.39 - 51.18 X_1 + 87.81 X_2 - 4.84 X_3 - 14.52 X_4 \\ - 9.10 X_5 - 4.47 X_6$$

where:

$$X_1 = \frac{\text{Earnings before interest and tax}}{\text{Net assets}}$$

$$X_2 = \frac{\text{Earnings before interest and tax}}{\text{Net capital employed}}$$

$$X_3 = \frac{\text{Debtors}}{\text{Creditors}}$$

$$X_4 = \frac{\text{Current liabilities}}{\text{Current assets}}$$

$$X_5 = \text{Log}_{10} \text{ days debtors}$$

$$X_6 = \text{Trend debtors}$$

The definitions of financial terms are as follows:

$$\text{Net capital employed} = \text{net assets} + \text{short term loan}$$

For net assets and net capital employed, the opening balance sheet figure is used in preference to closing sheet figure.

Short term loans are taken as being the loan and overdraft.

$$\text{Trend Debtors}_n = \frac{\frac{\text{Debtors}_n + \text{Debtors}_{(n-1)} - \text{Debtors}_{(n-2)}}{2}}{\text{Debtors}_{(n-2)}}$$

The calculation of days debtors is as follows:

$$\text{Days Debtors} = \left\{ \frac{\text{Debtors}(\text{opening}) + \text{Debtors}(\text{closing})}{\text{Turnover}} \right\} \times \frac{365}{2}$$

The pass mark for Mason and Harris' Z-score is 2.94. Companies scoring above that level should be safe while companies scoring $\pm$ 2.94 within these limits cannot be confidently classified and can only be considered as "vulnerable".

2.3.5 Other 'Z-Score' Models

- Castagna and Matolsky developed a model specifically designed for use in the Australian economy.
- Van Frederikslust in the Netherlands.
- Marais in conjunction with the Bank of England.
- Altman himself are all actively engaged in the developing Z-score technology.

2.3.6 Summary and Conclusions to 'Z-Score' Model

Table 2.2 gives the results of the Z-score models which are used as discriminators between failed and non-failed companies:

Generally, the Z-score approach is viewed as an extremely powerful financial analysis tool in finance and credit management areas where they are perhaps best placed of all to exploit the full potential of the methodology.

Generally academics are lagging behind practitioners in the creative application of the technique particularly for investment analysis. In particular, the approach does not suffer from methodological weakness leading to poor performance, because the Z-score model possesses true operational utility in practical applications.

One final statistical issue that is worthy of note here is raised in the recent paper of Mensah [18] [1984]. The author explores the degree of stationarity of bankruptcy models over time by comparing functions developed for different periods.

He concluded (page 391) on the basis of his evidence, that "bankruptcy prediction models are fundamentally non-stationary, at least insofar as the stability of the models' coefficients are concerned". Mensah, in fact, shows that distance in time from when a model is developed rather than state of the economy (recession, expansion) is more important in determining the propensity for structural shift.

Taffler concluded that "Any researcher in this area would agree that Z-score models need redevelopment when they grow old and tired". However, in contrast, the continuing efficiency of Altman's 1968 original Z-score model demonstrates after almost 20 years when applied to US data (but not UK data) longevity appears to be a hall mark. Also some consideration needs to be given to the quality of a model in predicting failure well before bankruptcy.

Researcher and Year of Publication	Altman 1968	Taffler 1977	Mason & Harris 1978
Country Studied	USA	UK	UK
No of companies studied	66	92	40
No of ratios tested	22	80	28
Type of Industry	Manufac- turing Non-retail	Manufac- turing	Construc- tion
A. Liquidity Ratio			
1. Current assets/total liabilities		X	
2. Log ₁₀ days debtors			X
B. Gearing Ratios			
1. Market capitalisation/ book value of debts	X		
2. Current liabilities/ total assets		X	
3. Current liabilities/ current assets			X
C. Working Capital Ratios			
1. Working capital/total assets	X		
2. No credit interval		X	
3. Debtors/creditors			X
4. Trend debtors			X
D. Profitability Ratios			
1. Retained earnings/total assets	X		
2. Earnings before tax and interest/total assets	X		
3. Sales/total assets	X		
4. Earnings before tax and interest/current liability		X	
5. Earnings before tax and interest/net assets			X
6. Earning before tax and interest/net capital employed			X
TOTAL DISCRIMINATOR TERMS IN MODEL:	5	4	6

TABLE 2.2: RATIOS SHOWN TO DISCRIMINATE BETWEEN FAILED AND NON-FAILED COMPANIES IN PREVIOUS STUDIES

Table 2.3 (taken from Taffler, 1984) summarises what happened in the six years subsequent to model development to 115 out of the 825 (14%) listed industrial companies on EXSTAT at risk of financial distress as at the end of 1976. No fewer than 43% had suffered financial distress in some sense and a further 29% were still at risk with less than 3 out of 10 appearing to have effected a permanent recovery.

Event	No. of Companies	% of Companies
<u>Financial distress</u>		
Receivership	17	15
Going concern, government, bank or other emergency support	12	10
Acquisition etc as alternative to bankruptcy	13	11
Major closures and disposals	8	7
	—	—
	50	43
Still at risk ($Z \leq 0$)	33	29
Recoveries ($Z > 0$)	32	28
	—	—
	115	100

TABLE 2.3: COMPANIES WITH AT RISK Z-SCORES AT THE END OF 1976. A SUMMARY OF SUBSEQUENT EVENTS

Further, the writer tested Mason and Harris' model for companies predicted at risk in 1976 after 10 years. The result shows that 33% failed, the others changed their names [17].

These statistics provide another useful benchmark for the potential utility of such techniques in practice.

Finally we can conclude that:

1. Multivariate discriminant analysis (MDA) is an appropriate technique.
2. Multivariate discriminant analysis is completely free of methodological and statistical flows. Any problems are mainly due to the lack of in depth knowledge by business researchers of the statistical properties of discriminant analysis [Pinches, 1980, p429].
3. Discriminant functions are robust and can work well, and do so over quite a long period of time without requiring specification.

2.4 OTHER METHODS OF FAILURE PREDICTION

2.4.1 Introduction

There are essentially two methods of forecasting failure, one is to study the suspect company's finances, the other is to study its non-financial features.

The previous sections (2.2 and 2.3) have taught us to treat ratios and Z-scores with considerable respect. These finance-based tools suffer, however, from two major defects namely they:

- are dependent upon the availability of financial information
- may suffer from creative accounting problems especially in small companies.

However, two statements can be made about the accounts of failing companies. Firstly, the company may be late publishing accounts. Secondly the company may have practised "creative accounting". This section is concerned with the non-financial features of failure.

As a company fails it might display non-financial signs of deterioration [7] as well as financial ones. Argenti has illustrated a means of ascertaining the influence of the latter and this method is summarised because it is the latest development. However the model's predictive value has not been adequately tested in the field. In this thesis the writer has thus taken the initiative to test the model on construction companies data.

The last and final section briefly discusses the above method and gives guidance for further research work which is more fully described in Chapter 9.

2.4.2 A-Score

The concept behind an A-score developed for this research is based on the belief that if a company is in financial trouble, it is because of the management defects and errors that were perpetrated a long time previously, and that these defects and errors could have been corrected by a careful observer before - maybe long before - the signs of financial distress became visible.

The lists of these non-financial indications include typically "bad management". The A-score is an attempt to:

- a) make a list of those non-financial indications
- b) rank the items in order of importance
- c) place the items in sequence.

The A-score has been designed to introduce a measure of quantification of weighted scores according to importance in the failure process and can be produced as illustrated in the following example [7].

<u>Defects</u>	<u>Weighting</u>
1. Autocrat	8
2. Chairman and Chief Executive (same person)	4
3. Passive Board	2
4. Unbalanced skills	2
5. Weak Finance Director	2
6. Poor management depth	1
7. No budgetary control	3
8. No cash flow plan	3
9. No costing system	3
10. Poor response to change	<u>15</u>
Total for defects:	43
Pass mark for defects:	10

Mistakes

- High leverage	15
- Overtrading	15
- Big project	<u>15</u>
Total:	45
Pass mark for mistakes	15

Symptoms

- Financial signs	4
- Creative accounting	4
- Non-financial signs	3
- Terminal signs	<u>1</u>
Total for symptoms:	<u>12</u>
Overall maximum possible:	<u>100</u>
Pass mark:	25

Research conducted by Argenti [7] in the commercial sector found that companies scoring above 25 showed many of the signs which precede failure, whereas companies that are not at risk score below 25 overall pass mark.

While the observer may have insufficient reasons to make firm conclusions on failure, A-scores coupled with a close and very careful examination of the company's ratios and Z-scores, prediction becomes much more reliable.

2.4.3 Conclusions to A-Score

The predictive value A-score has been explored in this research, but some doubt still remains regarding absolute reliability, nevertheless its power has been convincingly demonstrated.

2.5 SUMMARY AND CONCLUSIONS

Early methods illustrate fairly useful approaches to the subject of corporate collapse, but in the past decade researchers realised that failure does not occur suddenly. Failure takes years, therefore an evaluation of the strengths and weaknesses of financial and non-financial features of companies becomes necessary to obtain a sufficient early warning to take action.

There are several methods of observing the approach of failure, firstly, financial ratios. We have noticed that companies with continuing problems will have:

- a) a low or negative working capital
- b) a high level of liabilities relative to total assets
- c) low current assets to current liabilities

but the deterioration of certain well-known ratios is not sufficient an indicator of company failure.

Secondly, the Z-score technique for assessing corporate failure appears to be a reliable technique for the commercial sector and could prove equally suited to the construction situation.

Thirdly A-scores show promise. While none of the above methods is completely accurate i.e. sometimes give false signals in certain circumstances, the use of a combination of these different methods has been demonstrated in this research to give fairly confident predictions.

CHAPTER 3

THE TECHNIQUE OF MULTIVARIATE DISCRIMINANT ANALYSIS

- 3.1 Introduction
- 3.2 The General Concept of Multivariate Discriminant Analysis (MDA)
- 3.3 The Mathematical Theory Behind MDA
- 3.4 Derivation of Computational Formula
- 3.5 Statistical Computer Package and its Use
- 3.6 Summary and Conclusions

CHAPTER 3
THE TECHNIQUE OF MULTIVARIATE DISCRIMINANT ANALYSIS

3.1 INTRODUCTION

A problem that arises frequently in the social and behavioural sciences as well as in the biological sciences is that of classifying an object into one of a number of possible categories. Linear discriminant function analysis is a related approach for examining between-group differences on a set of measures. However, this approach focuses more on understanding between-group differences than on developing rules to classify units one population or another.

The discriminant analysis technique is a useful tool for the mechanistic assignment of observations from unknown groups or populations to one of two or more mutually exclusive groups or populations.

The related technique of linear discriminant function analysis involves finding one or more linear combinations of the original variables that maximise the between-group differences relative to within-group differences.

If there are more than two groups, then more than one discriminant function may be necessary to characterise group differences completely. In general, the number of discriminant functions necessary to characterise between group differences completely is equal to the number of groups minus one ($g-1$).

For two groups, then, there will be one discriminant function that will exhaust all between group differences, regardless of the number of variables.

Although (MDA) had been used in the Biological and Behavioural Sciences since 1930, it was not until the 1960s that MDA was used in conjunction with financial ratio analysis. The leading pioneer in this field at that time was Edward Altman [8] who developed several models using USA data, which he claimed could predict bankruptcy.

Several other researchers have done work in the same field over the past decade, the majority of them in the USA [19,20,21].

It is surprising, however, that the only extensive work to have been carried out in Britain is by Dr Richard Taffler at City University Business School [11,12,13,14,15]. The major part of his work has been conducted using UK based data and he has produced several predictive models for manufacturing companies.

In cooperation with the London stockbrokers, Laurence Prust and Company, he also produced separate models for various industries [22], one of these industries was the construction industry. In 1978 Mason and Harris also developed a model to predict bankruptcy for construction companies.

The next few sections of the thesis attempt to direct a path beginning with the simplest illustration of the general concept of MDA in Section 3.2. Section 3.3 illustrates the mathematical theory behind MDA, Section 3.4 presents derivation of computational formula with illustrative example, and Section 3.5 deals with the statistical computer package and its use. The final section briefly discusses the application of linear discriminant analysis.

3.2 THE GENERAL CONCEPT OF MDA

The objective of linear discriminant function analysis is to derive linear functions of the original variables that maximise between-group variation relative to within-group variation.

The mathematical objective of the analysis is to weight and linearly combine the discriminant variables in a function so that the groups are forced to be as statistically distinct as possible. For example, taking a number of variables and mathematically combining them in a discriminant function results in a relationship of the following form:

$$Z = C_0 + C_1V_1 + C_2V_2 + \dots + C_nV_n \quad (1)$$

where: Z = the score on the discriminant function

C_1 to C_n = the weighting coefficients

C_0 = a constant

V_1 to V_n = the discriminant variables.

The statistical theory of discriminant analysis assumes that the discriminant variables have a multivariate normal distribution and that they have equal variance-covariance matrices within each group [Donald G Morrison [23] on "The Interpretation of Discriminant Analysis" Journal of Marketing, Vol 6, No 2, May 1969]. Covariance analysis is used for the purpose of increasing precision, however, the practical research worker and the theoretical statistician take different views of this case. The research worker sees it as an opportunity for introducing experimental controls in a non-experimental field, and the statistician sees it as a reason for exercising the utmost caution and, often, as a sufficient reason for

refusing to carry out analysis of covariance at all [Introduction to Multivariate Analysis, George H Dunteman, [29].

As has been shown in previous works, in practice these conditions are not always satisfied [O. Maurice Joy and John O. Tollefson, [24] "On the Financial Applications of Discriminant Analysis", Journal of Marketing Research, Vol 6, No 2, May 1969, pp 156-163], but the technique has been found to be very robust which means the assumptions need not be strongly adhered to [Edward B. Deakin, [25] "Distribution of Financial Accounting Ratios: Some Empirical Evidence", the Accounting Review, Vol 51, No 1, January 1976, pp 90-96].

In the company bankruptcy situation we have two group cases where samples of solvent and failed firms are used to form the classificatory models. Once a set of variables has been found which provides satisfactory discrimination for the cases with known group membership, a classification function can then be derived which will permit the classification of new cases with unknown memberships. The discriminant variables used to form the model are typical financial ratios, calculated from the companies published financial accounts.

More recently some researchers have adopted a quadratic discriminant function (QDF) methodology in an attempt to overcome some perceived difficulties with (LDA) and currently conditional probability model formulations (Logit and Probit) are enjoying much attention (e.g. Zavgren, [26] 1985; Ohlson, 1989; Mensah, [18] 1984; Marais et al, 1980 and Zmijewski, [27] 1984). However the underlying model building approach does not differ significantly.

3.3 THE MATHEMATICAL THEORY BEHIND MDA

Before discussing the multivariate situation, let us discuss a hypothetical univariate situation in which two possible categories are involved and one measure is available on the object to be classified.

Let us assume that these two populations are normally distributed. From Figure 3.1 we can see that there is overlap in the two distributions and that any rule we use for classifying into one of these two categories. The optimal classification rule in this situation is to classify the membership belonging to each group as shown in Figure 3.1. For example, if a score is less than B then population 1 applies and if the score is greater than B the subject belongs to group 2. The reason for choosing B as the decision point is that it is the score that has the same relative frequency for each of the two populations. The mathematical theory behind MDA is complicated, but well documented [28,29].

FIGURE 3.1: THE TWO GROUP-ONE VARIABLE

FIGURE 3.2: THE TWO GROUP-TWO VARIABLE DISCRIMINANT MODEL

Further conceptualising the approaches to consider the case of the two group population with two discriminating variables V_1 and V_2 . In the case of failed companies if we plot the values of V_1 and V_2 for the companies in the continuing and failed groups, we arrive at Figure 3.2 (see Cooley [28], pp 245).

Each ellipse on the diagram is the locus of points of equal density (or frequency) for a group. For example, each of these ellipses may define the regions within which say 95% of each set of observations lie. The two points at which these ellipses intersect define a straight line AB. If the second line OZ is drawn perpendicular to AB and the points in the two-dimensional space are projected onto OZ labelled Z-axis, the overlap between the two groups will be smaller than for any other line, that the points could be projected onto. This is the same as saying that the centroids of the two groups have been pushed as far apart as possible, thus giving maximum discrimination.

By projecting the groups onto a single axis, in this way, each company's set of variables is transformed into a single Z-score by vector algebra. The point B then divides the discriminant axis into two regions, the solvent on one side and the failed on the other. A company with a Z-score below B would then be assigned to membership of the failed population and vice versa for a Z-score above the B point. In this way company two-dimensional data is transformed into a single Z-score.

With more than two variables the concepts become too difficult to express visually. In this situation the intersection of the two groups changes from being a straight line, AB, to being a plane. The derivation of the discriminant coefficients is therefore done

mathematically. In general terms, it requires solving the general eigenvector problem:

$$\lambda \cdot Wv = Bv \quad (2)$$

where: B and W are respectively the "between-" and "within-" groups sums of squares and cross products matrices [28]
is known as Wilks' Lambda

The most discriminating function is achieved by maximising the ratio B/W. This is another way of saying that we wish to make the "between groups variable differences" large in comparison to the "within groups differences".

This is where the theoretical importance of having equal variance-covariance matrices, for the two groups, enters into consideration. This can be highlighted if we refer back to Figure 3.2. If either the variances of V_1 and V_2 or the V_1V_2 covariance, were different for the two groups, the contours (ellipses) of the two groups would not be the same shape or orientation, and therefore AB would not appear as straight line. This can lead to errors giving a classification bias in the function.

In previous works the need for adherence to the "equal variance-covariance matrices" and "separately distributed multivariate populations" rules have been the subject of argument. Whilst Morrison [23] insists on adherence, Deakin [25] points out that:

"The ultimate test of a model lies not in adherence to certain data assumptions but rather in its adherence to its usefulness as a decision model".

In this study it was felt that Deakin's viewpoint was quite valid and this was taken into consideration when investigating the distributions of the discriminating variables.

3.4 DERIVATION OF COMPUTATIONAL FORMULA

The mathematical derivation of the computational formula for the two-variables case is that developed by Paul [34] Lecturer at the University of Alabama, as follows. First define two groups, Group I and Group II and two variables, X_1 and X_2 .

Let X_{pij} represent the value of X_p for the j th observation in the i^{th} group,

where $p = 1, 2$

$i = 1, 2$

$j = 1, \dots, n_i$ and

$n_i =$ the number of observations in i^{th} group.

Let $\bar{X}_{pi}$ represent the mean value of X_p for the n_i individuals in that group.

1. Define $Z_{ij} = a_1 X_{1ij} + a_2 X_{2ij}$

2. Then $\bar{Z}_1 = a_1 \bar{X}_{11} + a_2 \bar{X}_{21}$

and $\bar{Z}_2 = a_1 \bar{X}_{12} + a_2 \bar{X}_{22}$

3. Let "A" be the variation between groups, then $A = (\bar{Z}_1 - \bar{Z}_2)^2$

Substituting 2 in 3 we obtain:

$$A = [a_1 (\bar{X}_{11} - \bar{X}_{12}) + a_2 (\bar{X}_{21} - \bar{X}_{22})]^2$$

4. Let "B" be the variation within groups, then

$$\begin{aligned}
 B &= \sum_{i=1}^2 \sum_{j=1}^{n_i} (z_{ij} - \bar{z}_i)^2 \\
 &= \sum_{i=1}^2 \sum_{j=1}^{n_i} [a_1 (x_{1ij} - \bar{x}_{1i}) + a_2 (x_{2ij} - \bar{x}_{2i})]^2 \\
 &= \sum_{i=1}^2 \sum_{j=1}^{n_i} [a_1^2 (x_{1ij} - \bar{x}_{1i})^2 \\
 &\quad + 2 a_1 a_2 (x_{1ij} - \bar{x}_{1i}) (x_{2ij} - \bar{x}_{2i}) \\
 &\quad + a_2^2 (x_{2ij} - \bar{x}_{2i})^2]
 \end{aligned}$$

$$5. \quad d_p = \bar{x}_{p1} - \bar{x}_{p2}; \quad d_1 = \bar{x}_{11} - \bar{x}_{12}; \quad d_2 = \bar{x}_{21} - \bar{x}_{22}$$

$$6. \quad S_{pq} = \sum_{i=1}^2 \sum_{j=1}^{n_i} (x_{pij} - \bar{x}_{pi}) (x_{qij} - \bar{x}_{qi})$$

$$p = 1, 2; \quad q = 1, 2; \quad S_{pq} = S_{qp}$$

7. Substitute 5 in 3 to obtain:

$$\begin{aligned}
 A &= (a_1 d_1 + a_2 d_2)^2 \\
 &= a_1^2 d_1^2 + 2 a_1 a_2 d_1 d_2 + a_2^2 d_2^2 \\
 &= a_1 d_1 (a_1 d_1 + a_2 d_2) + a_2 d_2 (a_1 d_1 + a_2 d_2)
 \end{aligned}$$

8. Substitute 6 in 4 to obtain:

$$\begin{aligned}
 B &= a_1^2 S_{11} + 2 a_1 a_2 S_{12} + a_2^2 S_{22} \\
 &= a_1 (a_1 S_{11} + a_2 S_{12}) + a_2 (a_1 S_{12} + a_2 S_{22})
 \end{aligned}$$

$$9. R = \frac{A}{B}$$

The objective of the computation is to maximise the variation between groups relative to the variation within groups. The desired plane is therefore the plane for which a_1 and a_2 determine the maximum, thus

$$\text{Set } \frac{\partial R}{\partial a_1} = 0 \quad \text{and} \quad \frac{\partial R}{\partial a_2} = 0$$

$$10. \frac{\partial R}{\partial a_1} = \frac{B \frac{\partial A}{\partial a_1} - A \frac{\partial B}{\partial a_1}}{B^2} = 0$$

$$11. \frac{B \frac{\partial A}{\partial a_1}}{\frac{\partial B}{\partial a_1}} = \frac{A \frac{\partial B}{\partial a_1}}{\frac{\partial A}{\partial a_1}}$$

$$12. \frac{\frac{\partial B}{\partial a_1}}{B} = \frac{\frac{B \frac{\partial A}{\partial a_1}}{A \frac{\partial A}{\partial a_1}}}{A}$$

$$13. \text{Similarly, } \frac{\frac{\partial B}{\partial a_2}}{B} = \frac{\frac{B \frac{\partial A}{\partial a_2}}{A \frac{\partial A}{\partial a_2}}}{A}$$

$$14. \frac{\frac{\frac{\partial B}{\partial a_1}}{B}}{\frac{\partial B}{\partial a_2}} = \frac{\frac{\frac{B \frac{\partial A}{\partial a_1}}{A \frac{\partial A}{\partial a_1}}}{A \frac{\partial A}{\partial a_2}}}{\frac{B \frac{\partial A}{\partial a_2}}{A \frac{\partial A}{\partial a_2}}}$$

$$15. \frac{\frac{\partial A}{\partial a_1}}{\frac{\partial A}{\partial a_2}} \cdot \frac{\frac{\partial B}{\partial a_2}}{\frac{\partial B}{\partial a_1}} = \frac{\frac{\partial B}{\partial a_1}}{\frac{\partial B}{\partial a_2}} \cdot \frac{\frac{\partial A}{\partial a_2}}{\frac{\partial A}{\partial a_1}}$$

$$16. \frac{\partial A}{\partial d_1} = 2 a_1 d_1^2 + 2 a_2 d_1 d_2$$

$$= 2 d_1 (a_1 d_1 + a_2 d_2)$$

$$17. \frac{\partial A}{\partial a_2} = 2 a_1 d_1 d_2 + 2 a_2 d_2^2$$

$$= 2 d_2 (a_1 d_1 + a_2 d_2)$$

$$18. \frac{\partial B}{\partial a_1} = 2 a_1 S_{11} + a_2 S_{12}$$

$$19. \frac{\partial B}{\partial a_2} = 2 (a_1 S_{12} + a_2 S_{22})$$

Substitute 16 through 19 in 15 and obtain:

$$2 d_1 (a_1 d_1 + a_2 d_2) - 2 (a_1 S_{12} + a_2 S_{22})$$

$$= 2 d_2 (a_1 d_1 + a_2 d_2) - 2 (a_1 S_{11} + a_2 S_{12})$$

$$a_1 d_1 S_{12} - a_1 d_2 S_{11} = a_2 d_2 S_{12} - a_2 d_1 S_{22}$$

$$a_1 (d_1 S_{12} - d_2 S_{11}) = a_2 (d_2 S_{12} - d_1 S_{22})$$

$$20. \text{ Thus } \frac{a_1}{a_2} = \frac{d_2 S_{12} - d_1 S_{22}}{d_1 S_{12} - d_2 S_{11}}$$

A set of simultaneous linear equations can also be derived in the following manner. From 12

$$\frac{\partial B}{\partial a_1} = \frac{B \partial A}{A \partial a_1}; \text{ note that } \frac{B}{A} = \frac{1}{R}$$

$$21. \text{ Then } 2 (a_1 S_{11} + a_2 S_{12}) = \frac{1}{R} 2 d_1 (a_1 d_1 + a_2 d_2)$$

$$22. \text{ Let } C = \frac{1}{R} (a_1 d_1 + a_2 d_2)$$

$$23. a_1 S_{11} + a_2 S_{12} = C d_1$$

$$24. \text{ Similarly } a_1 S_{12} + a_2 S_{22} = C d_2$$

For the a_1 and a_2 case determined from equations 23 and 24, and in which the unknown factor "C" cancels out when the values for "a,s" are substituted in 9.

Illustrative Example

The simple problem is one of classifying insects as to race on the basis of mean numbers of teeth in proximal combs and mean number of teeth in distal combs. The individual values are presented in Table 3.1. The first group belongs to race A, and the second group to race B. There are eleven insects in the first group and twelve in the second. The equations to be solved are:

$$S_{11} a_1 + S_{12} a_2 = d_1$$

$$S_{12} a_1 + S_{22} a_2 = d_2$$

where X_1 = mean number of teeth on proximal comb

X_2 = mean number of teeth on distal comb

$$\bar{X}_{11} = 6.46545$$

$$\bar{X}_{21} = 5.32364$$

$$\bar{X}_{12} = 5.550$$

$$\bar{X}_{22} = 4.72667$$

$$d_1 = \bar{X}_{11} - \bar{X}_{12} = 6.46545 - 5.55 = 0.91545$$

$$d_2 = \bar{X}_{21} - \bar{X}_{22} = 5.32364 - 4.72667 = 0.59697$$

$$S_{11} = \sum_{i=1}^2 \sum_{j=1}^{n_i} (x_{11j} - \bar{X}_{11})^2 = 2.67650$$

$$S_{12} = S_{21} = \sum_{i=1}^2 \sum_{j=1}^{n_i} (x_{11j} - \bar{X}_{11}) (x_{21j} - \bar{X}_{21})$$

$$S_{22} = \sum_{i=1}^2 \sum_{j=1}^{n_i} (x_{21j} - \bar{X}_{21})^2 = 1.75454$$

Substituting the data from the sample gives:

$$2.675 a_1 + 1.2942 a_2 = .91545 \quad (1)$$

$$1.294 a_1 + 1.754 a_2 = .5967 \quad (2)$$

The solution $a_1 = .27597$ and $a_2 = .13671$.

The linear discriminant function is as follows:

$$Z = .2759 X_1 + .1367 X_2$$

The "Z" values are listed in order of magnitude in Table 3.2. The mean of the "Z" values in the first group is 2.5118 and the standard deviation is 0.09372. The mean of the Z values in the second group is 2.17754 and standard deviation is 0.14966.

Statistical Test

The F-ratio indicates a significant difference between the two groups. The tabular value of F is 5.85 with degree of freedom $DF_1 = 2$ and $DF_2 = 20$ at the 1% significance level. The computed value of "F" is 19.18.

The F-ratio is the ratio between two variances and is used to test for homogeneity of variances and equivalence of two groups.

A value of "F" larger than the tabular value for the degrees of freedom in the numerator (DF_1) and the degrees of freedom in the denominator (DF_2) at an indicated level of significance leads to the rejection of the hypothesis that the two groups are samples from the same population with a confidence level of 1% level of significance. An increase in differences between the means of the variables or decrease in the variability of the variables improves the ability of discriminant function to differentiate between groups.

No	Race A		Race B	
	X_1	X_2	X_1	X_2
1	6.36	5.24	6.0	4.88
2	5.92	5.12	5.60	4.69
3	5.92	5.36	5.64	4.96
4	6.44	5.64	5.76	4.80
5	6.4	5.16	5.96	5.08
6	6.56	5.56	5.72	5.04
7	6.64	5.36	5.64	4.96
8	6.68	4.96	5.44	4.88
9	6.72	5.48	5.04	4.44
10	6.76	5.6	4.56	4.04
11	6.72	5.08	5.48	4.2
12	-	-	5.76	4.8

TABLE 3.1: DATA FOR SAMPLE PROBLEM

Rank	First Group Values	Second Group Values	First Group Item No
1	2.63085		10
2	2.60341		9
3	2.57020		6
4	2.56493		7
5	2.54873		11
6	2.54082		4
7	2.52128		8
8	2.47137		5
9	2.47127		1
10	2.36626		3
11		2.33902	
12	2.33345		2
13		2.32272	
14		2.26733	
15		2.24556	
16		2.24556	
17		2.23432	
18		2.23432	
19		2.17953	
20		2.16819	
21		2.08627	
22		1.99767	
23		1.81054	

TABLE 3.2: "Z" VALUES FOR THE SAMPLE PROBLEM

3.5 STATISTICAL COMPUTER PACKAGE AND ITS USE

There are a number of software packages that can be used to conduct a linear discriminant function analysis. The most popular package, is probably SPSS, this package produces the following key outputs: the standardised coefficients for each discriminant function, the centroids of the groups in the discriminant function space, and the multivariate test to determine statistical significance of successive discriminant functions.

The discriminant analysis performed for this research work was done using the (SPSS version 10) subprogram 'DISCRIMINANT' through the Computer Centre at Loughborough University. For this research the most interesting facility of the Discriminant program was the several "stepwise methods" which enabled reduction of the number of discriminating variables in the "function" from the original 31 to 7. Later the writer reduced the number to 5 using the Minitab computer package.

Since we need to select the variables which discriminate most, the stepwise procedure available in the program was of advantage. The program begins by selecting the single best-discriminating variable according to a user-determined criterion.

Several criteria are available to the user but in our case the criterion is the "overall multivariate F-ratio for the test of differences among the group centroids".

The variable which maximises the F-ratio also minimises "Wilks Lambda" a measure of group discrimination. The test takes into consideration the differences between the group centroids and the cohesion within the groups. The Wilks Lambda mentioned here is the same measure that appeared in equation (2) in Section 3.3.

3.6 SUMMARY AND CONCLUSIONS

Discriminant analysis is utilised to classify individuals into one of two or more classes by means of an index number called Z-score. The purpose of the computation is to maximise the difference between means of the groups relative to the variance of the groups. A cut-off point "Z-score" is established in the two groups, for example, a company

with a Z-score above the cut-off point B would be assigned to membership of the non-failed population and vice versa for a Z-score below the B point.

The analysis of failed firms based on the consideration of single ratios may present a confused and unreliable indicator of financial difficulties. In contrast the statistical technique MDA attempts to derive a linear combination of these ratios which will best discriminate between the groups. Also the model will have to indicate which ratios are the most important indicators predicting failure, what weight should be attached to each ratio and how to establish them objectively. Thus the advantages of MDA may be summed up as follows:

- a) Considers an entire profile of characteristics common to the relevant firms and their inter-relationship;
- b) Reduces the analysts space dimensionality i.e. from the number of different independent variables to $(g-1)$ dimensions where (g) equals the number of original a priori groups. The discriminant function of the form $Z = V_1X_1 + G_2 X_2 + \dots V_nX_n$ transforms individual variable values to a single discriminant score of Z value which is then used to classify the object.
- c) MDA results of multicollinearity sometimes yield an overall small group of ratios [29].
- d) The primary advantage of MDA is in dealing with classification problems, one sees the entire variables profile rather than individual ratios.

Problems that might arise if the basic assumptions of MDA related to the main statistical issues are not met, embrace the following:

- a) Multivariate normality is an important assumption [Pinches, [6] 1980, pp 431-433] although in sample-based research it is the presence of extreme observations (outliers) rather than the general shape of the multivariate distribution that is the key. Techniques are available to handle such problems in practice (e.g. Taffler, 1982]. Nonetheless concerns over the distributional form, inter alia, led to the adoption of conditional probability model formulations (Logit, Probit) in a number of cases [e.g. Ohlson, [30] 1980] which do not depend on independent variable distributional assumptions.
- b) A multicollinearity problem could occur because of the high inter-correlation among the variables. Researchers have found difficulties in handling multicollinearity problems, in certain cases tending to overfit models. This led to serious sample bias and poor performance on out of sample data [as illustrated by Mensah, [18] 1984, pp 392-3] despite theoretical arguments this should not be so [e.g. Eisenbeis, [31] 1977 but see Pinches, [6] 1980]. In addition variable coefficients may be highly unstable between different samples. Some researchers circumvent multicollinearity problems by transforming the original variables to principal components since they are uncorrelated. This transformation does not help much, however, if we are interested in the effects of the original variables (Dunteman [29] pp 177).
- c) Other key issues that are commonly not addressed relate to the need to incorporate prior probability estimates of population membership into the discriminant function and also differential

misclassification costs [Pinches, [6] 1980]. Such issues are typically ignored leading to serious errors in interpretation [e.g. see the discussion in Taffler, [12] 1982, p351 and poor out of sample performance [e.g. see Taffler, [14] 1984].

(One of the perceived benefits of a conditional probability approach is the lack of need to specify prior probabilities).

There is no reason to believe, for example, that there are equal numbers of potential failure and solvent companies in the population.

- d) Finally, in all studies researchers have viewed continuing companies as possessing distinct characteristics from their failed companies. This is clearly incorrect as many presently live companies possess financial profiles similar to failed ones [Taffler, [12] 1982].

The statistical problems that can arise are not taken to account for the non-failed group of such firms before developing the statistical model.

This research work will try to avoid the conceptual and methodological weaknesses which appeared in previous studies since potentially the Z-score model has very convincing statistical and associated evidence that a properly developed model, based on its track record in practice, has strong ex-ante predictability and high operational utility. However, any researcher in this area would agree that Z-score models need redevelopment when they grow "old and tired" [see Mensah (18) pp 391].

We may conclude finally that, in practice, at least most concerns regarding the statistical underpinning of the traditional linear discriminant model Z-score approach are unfounded. For good reasons such discriminant functions are robust and can work well and do so over quite a long period of time without requiring respecification.

CHAPTER 4

DATA COLLECTION AND FORMATION OF THE DATA GROUPS

- 4.1 Introduction
- 4.2 Data Analysis
- 4.3 Formation of Data Groups
- 4.4 Summary and Conclusions

CHAPTER 4

DATA COLLECTION AND FORMATION OF THE DATA GROUPS

4.1 INTRODUCTION

This section is concerned with the data collection, data sources, data analysis and formation of the data groups used to develop and verify the discriminant model for construction companies.

The data analysed in this report was obtained mainly from the following sources;

1. Extel Statistical Services Ltd (Extel)
2. Companies Registration Offices (CRO)
3. Published data on the Business Ratio Reports.

Extel cards were used for the following reasons:

- Extel cards have very reliable data
- Sufficient financial information is included on Extel cards
- Discrepancies in data presentation from different sources are considerably reduced.

Extel cards were mainly limited to public companies while the Companies Registration Office was suitable for private companies. Some adjustments were needed to allow for "creative" accounting of some small companies.

4.2 DATA ANALYSIS

Both failed and non-failed companies were selected on a random basis. Some exceptions were allowed, however, in the non-failed group, for example, well known companies were included to increase the discriminating power of the model and decrease the misclassifications of non-failed companies as "failed". This point was first recognised by Altman and Loris [10] and Taffler [11] and Mason [17].

Financial data used for both groups were the latest ones available. The data for failed companies were obtained for the period 1978 and 1986 and included the data for the last three years before failure. Failure being defined as voluntary or compulsory liquidation, entry into receivership but excluding companies re-organised for financial reasons like taken over companies. These were treated as a separate group. Some researchers have included taken over companies as failed, e.g. Mason [17]. Such inclusions decrease the discriminatory power of the model. Furthermore, including data from the last six years before failure also decreases discriminating power generally because the last three years is considered to be the most critical period.

In this research data for the non-failed group is mainly concentrated on the four years prior to failure and included 1986. Some further points of note are:

- Altman [8] initially matched his "failed" and "non-failed" groups by industry and company size.
- Taffler [11] initially constructed models without matching companies by industry and company size or financial year

Mason [17] limited his study to the construction industry and avoided matching company size and financial year considerations. This study adopted the Mason approach for two reasons:

Firstly, empirical evidence indicates that financial ratios are uncorrelated with company size [3]. Indeed the use of ratio transforms removes the company size dimension. Also, a construction company generally depends on secondary sub-contractors which sometimes facilitates expansion of business activity according to the market situation.

A similar argument applies to matching by financial year for both groups, i.e. for non-failed companies some can be selected on their historical performance and past reputation as being regular and well known, typically public companies. Small companies cannot be selected on this basis because:

- they are not well-known i.e. background information is incomplete.
- most were formed in boom periods where entry to construction work was freely available without qualification of past experience.

Clearly therefore small companies do not provide a good standard and would not be representative of a non-failed group.

4.3 FORMATION OF DATA GROUPS

Six groups of companies were used in this study as follows:

1. Failed 11 group
2. Non-failed 20 group
3. Taken-over 9 group

4. Test "Continued 70" group
5. Test "failed 11" group
6. All 90 group.

The "Failed 11" and "Non-failed 20" groups were used to establish the model and the remaining groups used to verify and validate the model adequacy.

4.3.1 The "Failed 11" and "Test 11" Groups

The bankrupt set of companies from which the model was derived consisted of companies which failed between 1978 through to 1986, a period of 8 years, while the verification and validation groups included companies failing up to 1988.

There was a general problem in obtaining the required information for a large number of failed companies caused mainly by a lack of information or change of company name and after take-overs etc. These were generally excluded from the model.

Thus finally only 22 companies could be found which met the "failed" criteria from which a "Failed 11" group were used to derive the model and "Test 11" used for verification purposes.

A list of companies included in these two groups can be seen in Tables 4.1 and 4.2.

Company	Date of Last Published Accounts	Reasons for Conclusion as Failed
Beechwood Group plc	30.6.83	Receiver appointed 1985
Cocksedge Holdings plc	22.11.84	Receiver appointed 1985
Crouch Group plc	24.8.83	Receiver appointed 1984
David Charles Ltd	5.11.75	Voluntary liquidation 1977
James H Dennis plc	1.9.83	Receiver appointed 1984
Mears Bros Ltd	7.2.78	Voluntary liquidation 1979
Milbury plc	19.7.84	Compulsory liquidation 1985
Modern Engineering of Bristol (Holdings) plc	7.6.83	Receiver appointed 1985
Moss Engineering Group plc	1.12.81	Receiver appointed 1983
Southern Construction Ltd	29.5.79	Receiver appointed 1982
S W Farmer	31.3.86	Receiver appointed 1986

TABLE 4.1: COMPANIES IN THE "FAILED 11" GROUP

Company	Date of Published Accounts
A.C. and K. Builders Ltd	31.3.1986
Allied Construction Ltd	31.3.1986
Bowmate Construction Ltd	31.3.1986
Bright Brook Builders Ltd	31.3.1985
Comber Construction Ltd	31.3.1986
Pevland Construction Ltd	31.3.1982
Sphinx Building Construction Ltd	31.3.1985
Staines Construction Ltd	31.3.1985
Stevens and Sons Building Ltd	31.3.1983
Stott Mills Building Ltd	31.3.1986
Stream Star Construction Ltd	31.3.1985

TABLE 4.2: COMPANIES IN THE "TEST FAILED 11" GROUP

4.3.2 "Non-failed 20" Group

The "non-failed 20" group and "Failed 11" group used data extracted from Extel in order to reduce the discrepancy in data presentation in cases using different information sources and to increase the discriminant power of the model.

However it is stressed that the model was constructed without matching companies by size, or financial years. The non-failure was defined as continuing in business for at least four years and also had to have continued in operation for two years after the focal year of 1986.

The selection criterion adopted for the "non-failed 20" group, resulted in not all the members of the "non-failed" 20 identified being selected on a random basis. In this way an increase in the discriminating power of the model together with a decrease in the misclassifications of the "non-failed" companies as failed was achieved, principally by making assessments of solvency on a qualitative ratio analysis basis.

Accounts used for the "non-failed" group covered the period of 1982-1986. A list of companies in this group can be seen in Table 4.3.

Company	Date of Published Accounts
Aberdeen Construction Group plc	July 1987
Barratt Development plc	November 1986
Benlox Holdings plc	July 1987
Benbailly Construction plc	December 1986
C H Beazer Holdings plc	December 1986
BIOC plc	May 1987
Brown and Jackson plc	August 1987
Bryant Holdings plc	November 1986
Boulton and Paul plc	October 1987
M J Geeson Group plc	January 1987
George Wimpey plc	July 1987
Henry Boot and Sons plc	June 1987
A Monk and Company plc	August 1985
Newarthill plc	June 1987
Rush and Tompkins Group plc	August 1986
Taylor Woodrow plc	July 1987
Tarmac plc	June 1987
Tilbury Group plc	July 1987
Turriff Corporation plc	June 1987
Wilson Connolly Holdings plc	May 1987

TABLE 4.3: COMPANIES IN THE "NON-FAILED 20" GROUP

4.3.3 The "Taken-Over 9" Group

Some attempt was also made to discriminate with a further group namely a "taken-over 9" group together with the "failed 11" group and "non-failed 20" group, see Chapter 6. Little was achieved and this group was ultimately combined to form part of the verification process. It should also be noted that previous studies included in their definition of failure reorganisation for financial reasons, such as take-over companies. These were excluded in this research work to increase the power of discrimination. A list of this group can be seen in Table 4.4.

Company	Date of Published Accounts
Braithwaite Group plc	4.7.1985
C H Pearce and Sons plc	21.10.1985
Fairclough Construction Group plc	15.4.1982
Glossop plc	6.7.1983
Marchwill plc	8.3.1983
Mitchell Cotts Group Ltd	11.11.1981
Richard Costain Ltd	25.5.1978
Robert Adlard plc	14.5.1986
Rowlinson Construction plc	27.6.1983

TABLE 4.4: COMPANIES IN THE "TAKEN-OVER 9" GROUP

4.3.4 The "Test Continued 70" Group

The companies in the "Test 70" group which were used to verify the model were selected randomly from different sources. These companies consisted mainly of construction and civil engineering companies.

The complete list of companies in this group can be seen in Table 4.5.

Company	Company
Bellway Builders Ltd	Sunley Holdings plc
Bryant Construction Ltd	John E Wiltshire plc
Bovis Construction Ltd	Babcock Construction Ltd
Charnwood Construction Ltd	Balfour Beatty Ltd
Dalton Construction Ltd	Peter Birse Holdings
Danbury Construction Ltd	Bowmer and Kirkland Ltd
Davco Construction Ltd	A F Budge Construction Ltd
Gargan Construction Ltd	Cementation Construction Ltd
Tarmac Homes Midlands	Croudace Holdings Ltd
Tarroch Construction Ltd	Hollandsche Beton Ltd
Tarmac Construction Ltd	J M Jones and Sons Ltd
CBI Construction Ltd	Kyle Stewart Ltd
Charles Gray Builders	James Longley and Co Ltd
Haymills Holdings Ltd	R Mansell Ltd
Ogilvie Holdings Ltd	May Gurney Holdings Ltd
Eve Construction plc	The Miller Group Ltd
Alfred McAlpine Construction	Norwest Holst Ltd
R J McLeod Construction	Seddon Group Ltd
Shepherd Building Group	G Percy Tretham Ltd
Reema Construction Ltd	Trollope & Colls Construc. Ltd
Andrew Scott Ltd	Wates Construction Ltd
Simons Construction Ltd	Willetts Ltd
Whittaker Ellis Builders Ltd	Willmott Dixon Holdings Ltd
Amec plc	City of Aberdeen Ass. Ltd
Amco Industrial Holdings plc	Condor Group plc
Costain Group plc	Consolidated Term Invest. Ltd
Robert M Douglas plc	Dencora plc
Galliford plc	Dean and Bowes Group Ltd
Higgs and Hill plc	Dunton Group plc
Johnston Group plc	Exeter Building & Constr. Ltd
John Laing plc	London and Clyde Holdings Ltd
Walter Lawrence plc	McLaughlin and Harvey Ltd
F J C Lilley plc	Gilbert House Investments Ltd
Y J Lovell Holdings plc	Bellway plc
John Mowlem and Company	John Elliott Group plc

TABLE 4.5: COMPANIES IN THE "CONTINUED 70" GROUP

4.3.5 The "All 90 Non-Failed" Group

In trying to determine the proportion of companies "at risk" in the total population of quoted companies, the combined population of the "non-failed 20" group and the "test continued 70 " group called the "all 90 non-failed" group, was also considered. These can be seen in Tables 4.3 and 4.5.

4.4 SUMMARY AND CONCLUSIONS

The statistical problems that arise if care is not exercised before developing the model can lead to poor model performance. For example, all previous researchers viewed continuing companies as possessing different characteristics from their failed counterparts. This conclusion would appear to be dubious as many presently active companies possess financial profiles similar to failed companies and may in due course fail.

This research therefore adopted companies for the "non-failed" group as those appearing to be solvent, but not necessarily healthy companies. Thus not all the members of this group were selected on a random basis. The companies in the "failed" group were those which had entered into receivership, voluntary liquidation, winding up by order of the court. Thus companies with name changes or those that had been reorganised for financial reasons such as taken-over companies were excluded and considered as a separate group.

In summary the best problems for discriminant analysis appear to be those in which the group definitions are distinct and non-overlapping, also efforts made to avoid arbitrary grouping.

CHAPTER 5

THE DEVELOPED MODEL AND REGRESSION CHARACTERISTICS

- 5.1 Introduction
- 5.2 Financial Ratios used in the analysis
- 5.3 Financial Ratios Calculations and Data Manipulation
- 5.4 Statistical Computer Package
- 5.5 Regression Analysis for Predicting Bankruptcy
- 5.6 Summary and Conclusions

CHAPTER 5

THE DEVELOPED MODEL AND REGRESSION CHARACTERISTICS

5.1 INTRODUCTION

This section describes the development of an operational model for the identification of UK construction companies in danger of failure. The model was developed using a combination of two techniques, Financial Ratio Analysis and a statistical technique known as "Multivariate Discriminant Analysis".

All aspects of the model's development are described, from the financial ratios analysis, through to the computer analysis, including a short description of the computer package used to calculate the financial ratios, and computer package "SPSS X" involved in developing the model.

5.2 FINANCIAL RATIOS USED IN THE ANALYSIS

Altman selected 22 financial ratios in forming his model.

Taffler claimed 80 financial ratios in forming his model.

Mason and Harris selected 28 different variables including 23 conventional ratios and 5 trend measures.

Laurence, Prust and Company reported 500 ratios in forming their construction model.

The first model attempted in this research considered 82 different variables and was not successful because of the sensitivity of some growth ratios [see Appendix A]. As a consequence of these trials

variable selection became very important, and their effectiveness either in previous studies and their popularity in the literature was one of the criteria adopted to guide the author.

In this manner a total of 31 different variables were subsequently adopted consisting of 24 conventional financial ratios and seven trend measures all computed from balance sheet information contained on the "Extel cards". These variables are shown in Tables 5.1 and 5.2 where several aspects of company structure are portrayed.

Furthermore empirical studies [39,40] in various countries showed that firms operating in different industrial sectors tend to have different financial ratios. This obliged the author to relate the firm being examined to the ratios existing in its particular industry.

Also previous research by Deakin [25] indicated that financial ratios very rarely fit a normal distribution. However, the population of companies within a particular industry exhibited more normal distribution than a population of companies from several industries.

Since this research concerned the construction industry only problems of non-normality were able to be removed.

In addition the distribution was smoothed by averaging the accounts of "failed" and "non-failed" companies for the last three and four years respectively. Nevertheless, strict adherence to the rules of normality had to some extent to be disregarded in view of Deakin's conclusion [25] i.e. "probability statements from a model based on financial ratios may be subject to question because of the distributions characteristics. A user may thus be better off with a

No	Variable Description	Financial Structure
1.	EBIT/NA	PROFITABILITY
2.	EBIT/EQITY	
3.	EBIT/CL	
4.	EBIT/NCE	
5.	EBIT/TU	
6.	PAT/NCE	
7.	PAT/EQITY	
8.	FA/EQITY	WORKING CAPITAL
9.	LA/CL	
10.	WC/NCE	
11.	DR/CL	
12.	INT/EBIT	
13.	CL/NA	FINANCIAL LEVERAGE
14.	CL/NCE	
15.	DEBIT/NCE	
15.	CA/CL	
16.	CA/CL	
17.	CA/NA	
18.	CA/EQITY	
19.	CA/NCE	
20.	LA/NA	LIQUIDITY
21.	LA/EQITY	
22.	Log ₁₀ (DAYS-DEBTORS)	
23.	TV/NA	ACTIVITY
24.	STL/EBIT	LIQUIDITY
25.	TAX-TREND	TREND MEASUREMENT
26.	PAT-TREND	
27.	DR-TREND	
28.	CRD-TREND	
29.	INT-TREND	
30.	STL-TREND	
31.	LA-TREND	

TABLE 5.1: FINANCIAL RATIOS EMPLOYED IN THE ANALYSIS

EBIT:	Earnings before interest and tax
NA:	Net assets (total assets - current liabilities)
EQUITY:	Share capital and reserves
CL:	Current liabilities
NCE:	Net capital employed (net assets + short term loan)
TU:	Turnover
PAT:	After tax profit
FA:	Fixed assets
LA:	Liquid assets
CL:	Current liabilities
WC:	Working capital (current assets - current liabilities)
DR:	Debtors
INT:	Interest charged on all loans (payable interest)
DEBIT:	Medium + long term loans (over one year)
DAYS DEBTORS:	Av. DR x 365/TU
STL:	Short term loan
CRD:	Creditor

The trend ratios are calculated on the basis of the following formula:

$$T_n = \frac{\left\{ \frac{P_n + P_{n-1}}{2} \right\} - P_{n-2}}{\text{ABS. } (P_{n-2})}$$

where: T_n is the trend ratio for year n

The P's are the balance sheet figures for years n, n-1 and n-2 of the trend being computed, e.g. Creditors, Tax etc.

Note: The denominator is taken as the absolute value, i.e. the sign is ignored.

TABLE 5.2: KEY TO TABLE 5.1

rough estimate than no estimate at all". However, as the model was developed, the more discriminant ratios appeared to be those which displayed near normal distributions.

5.3 FINANCIAL RATIOS CALCULATIONS AND DATA MANIPULATION

5.3.1 Introduction

One major difficulty in the calculation of financial ratios, concerns the large number needed in developing and testing the model. A computer package was thus developed to speed up the process and precision analysis in the form of a Fortran programme, ADNAN.FOR, which included:

- The User Manual
- The Programme Documentation

See Appendix A.

5.3.2 Computer Package ADNAN.FOR

ADNAN.FOR is a computer programme written in the programming language FORTRAN 77 for use on a PC-IBM, core space required (169, 646) bytes. The computer programme was written and developed for specific use in the calculations required for the research.

The User Manual sets out how the programme may be used to perform the calculations and the Programme Documentation section allows the programme to be understood.

The programme calculates, from 18 pieces of financial information obtained from company financial reports, a series of financial ratios and measured 46 in all relevant to this study.

The programme is in two parts:

- the 18 pieces of financial information are read by the computer and printed out for checking
- the programme calculates the 46 financial ratios and measures of performance for a six year period as a maximum. The programme asks the user the required number of years and name of file for output.

Also, the programme calculates the financial ratio means over the required period, and prints the trend and change in growth ratios for the 18 pieces of data together with the means of the results. See Appendix A.

5.4 STATISTICAL COMPUTER PACKAGE

5.4.1 Introduction

Altman [8] appears to be the leading pioneer in applying the multivariate discriminant analysis technique for financial ratios as evidenced in his general equity models using (USA) data claiming bankruptcy prediction capabilities.

Subsequently several other researchers published in the same field. Indeed the technique is now considered to be a most reliable predictive tool. This research builds on this evidence and uses the particular computer package (SPSS X) available at the Computer Centre at Loughborough University of Technology for the analysis process.

5.4.2 Statistical Computer Package (SPSS X)

The programme was originally produced at Chicago University, but is now a commercial product belonging to SPSS Inc of Chicago. It has powerful multivariate procedures for discriminant analysis. The original 82 variables were initially reduced to 31 and subsequently to a smaller, more easily handled 7. This was achieved by an

interactive process whereby the programme selects the variables which discriminate most using the stepwise procedure i.e. the best discriminating variable is selected according to user-determined criteria.

Several criteria are available to the user but in our case the principal criterion was "Wilks Lambda", as mentioned in equation (2) in Section 3.3. The method establishes the "F-ratio" and tests differences among group centroids, whereby the variable maximising the F-ratio also minimises "Wilks Lambda", thereby measuring group discrimination.

The test takes into consideration the differences between the group centroids and the cohesion within the groups. Once the best discriminating variable has been found using the selection rule "minimise Wilks Lambda", the programme continues by pairing this variable with each of the other variables in turn and computing Wilks Lambda again.

The new variable which, in conjunction with the initial variable gives a lower Wilks Lambda, is then selected as the second variable to enter the function.

These two variables are then combined with each of the remaining variables to form triplets, which are again evaluated on the criterion. The triplet with the lowest Wilks Lambda value determines the third variable to be selected for the function.

This procedure of locating the next variable that would yield the least Wilks Lambda score gives the variables already selected. This continues until all the variables are selected.

As variables are selected for inclusion some already in the function may lose their discriminating power. This occurs because the information that contained group differences is now better defined by some combination of the other included variables. Such variables thus become redundant and are therefore removed from the equation. As a consequence, at the beginning of each step each of the previously selected variables is tested to determine if it still makes a sufficient contribution to the discrimination. If any are eligible for removal, the least useful is eliminated. Nevertheless a variable removed at one step may re-enter at a later step if it satisfies the least Wilks Lambda at that stage.

So, by eliminating the poor discriminators, a small number of variables accounting for most of the discrimination are eventually determined. This result is an optimal, rather than a maximal solution. The assumption being that the stepwise procedure is an efficient way of approximately locating the best set of discriminating variables. In this research variables were ultimately identified as being powerful discriminators.

Figure 5.1 shows one particular step in the stepwise method. As can be seen, at step 5, for example, 5 variables were entered into the equation, together with remaining variables waiting to enter. The "F to enter" is the value of the "F-ratio" needed to give access to the equation. "F to remove" is the value of the "F-ratio" of that variable when entering the equation. It can be seen from this example that variable 23 was included in the equation at this step.

The variable with the highest "F to enter" will be the next to enter the equation, provided the "F to enter" value is greater than the minimum stipulated. In this case it will be variable 26.

Figure 5.2 shows a summary of all the steps in the particular analysis. The information here shows the variables entered or removed at each step, and shows that variable 12 which entered at step 3 was removed at step 9.

Figure 5.3 illustrates the final step of analysis at the value of the "F to remove" and also the value of "Wilks Lambda". Both the "F to remove" and the "Wilks Lambda" values are indications of how much each variable contributes to the discrimination where it may be observed that 7 variables give good discrimination, at a "Wilks Lambda" of 0.175. The variables adding most to discrimination are those with the highest "F to remove" values.

The programme also calculates the "standardised" and "unstandardised" discrimination function coefficients. The "unstandardised" coefficients are the most useful when multiplied by the raw values of the associated variables to arrive at "discriminant Z-score".

The programme further calculates the "discriminant function evaluated at group means (group centroids)". See Figure 5.4 for unstandardized coefficients.

In order to use the model as a classification tool, the discriminant function coefficients have to be adjusted by calculating the mean value of discriminant function coefficient for two groups and multiplying throughout by two ignoring the sign.

As an extra check, the programme tests the adequacy of the derived discriminant function. By classifying the cases used to derive the function in the first place and comparing the predicted group membership with the actual group membership, it empirically measures the success of the discrimination by observing the proportion of correctly classified.

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AT STEP 5, V23 WAS INCLUDED IN THE ANALYSIS.

		DEGREES OF FREEDOM	SIGNIF.	BETWEEN GROUPS
WILKS' LAMBDA	0.21584	5 1	29.0	
EQUIVALENT F	18.1655	5	25.0	0.0000

----- VARIABLES IN THE ANALYSIS AFTER STEP 5 -----

VARIABLE	TOLERANCE	F TO REMOVE	WILKS' LAMBDA
V6	0.7391182	18.359	0.37434
V12	0.7750358	10.117	0.30318
V17	0.4613530	22.483	0.40995
V23	0.4833676	4.4010	0.25383
V25	0.7099661	9.4367	0.29731

--- ----- VARIABLES NOT IN THE ANALYSIS AFTER STEP 5 -----

VARIABLE	TOLERANCE	MINIMUM TOLERANCE	F TO ENTER	WILKS' LAMBDA
V1	0.1624146	0.1624146	1.8039	0.20075
V2	0.3136713	0.3136713	0.66703E-01	0.21524
V3	0.3806102	0.3493684	.34391	0.21279
V4	0.7955813	0.4604161	0.11050E-01	0.21574
V5	0.2347246	0.2347246	.27893	0.21336
V7	0.1832067	0.1832067	0.23031E-03	0.21584
V8	0.8222385	0.4537360	0.46010E-01	0.21543
V9	0.8045114	0.4254221	1.5414	0.20281
V10	0.8997728	0.4502239	0.12391E-01	0.21573
V11	0.9506934	0.4613444	.47651	0.21164
V13	0.5104290	0.3739778	1.0383	0.20680
V14	0.5289365	0.3717586	.15397	0.21444
V15	0.6667331	0.4297505	0.16095E-03	0.21584
V16	0.4778423	0.4351789	0.48119E-03	0.21583
V18	0.5911171	0.3124255	0.21271E-01	0.21565
V19	0.3161685	0.3161685	0.26953E-01	0.21560
V20	0.7993289	0.4276886	.27434	0.21340
V21	0.7842791	0.3921431	0.35405E-01	0.21552
V22	0.9299162	0.4513463	.79972	0.20888
V24	0.1964195	0.1902891	.12793	0.21469
V26	0.5981619	0.3136296	5.5418	0.17535
V27	0.9581067	0.4613283	.15811	0.21443
V28	0.7964755	0.4472866	.20464	0.21401
V29	0.8785336	0.4613127	.42074	0.21212
V30	0.8329811	0.4611340	2.7651	0.19354
V31	0.9338558	0.4576507	0.14736E-03	0.21584

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FIGURE 5.1: ONE PARTICULAR STEP IN STEPWISE METHOD

SUMMARY TABLE

STEP	ACTION ENTERED REMOVED	VAR IN	WILKS' LAMBDA	SIG.	LABEL
1		1	.66258	.0000	
2		2	.47336	.0000	
3		3	.35081	.0000	
4		4	.25383	.0000	
5		5	.21584	.0000	
6		6	.17535	.0000	
7		7	.15087	.0000	
8		8	.13503	.0000	
9	V12	7	.13517	.0000	

CANONICAL DISCRIMINANT FUNCTIONS

FUNCTION	EIGENVALUE	PERCENT OF VARIANCE	CUMULATIVE PERCENT	CANONICAL CORRELATION	AFTER FUNCTION	WILKS' L
\cAMB	CHI-SQUARED	D.F.	SIGNIFICANCE			
				:	0	0.1351
\c694	51.031	7	0.0000			
1*	6.39813	100.00	100.00	0.9279627	:	

FIGURE 5.2: THE SUMMARY OF ALL THE STEPS IN THE STEPWISE METHOD

WAS REMOVED FROM THE ANALYSIS.

		DEGREES OF FREEDOM	SIGNIF.	BETWEEN
WILKS' LAMBDA	0.13517	7 1	29.0	
EQUIVALENT	21.0224	7	23.0	0.0000

----- VARIABLES IN THE ANALYSIS AFTER STEP 9 -----

VARIABLE	TOLERANCE	F TO REMOVE	WILKS' LAMBDA
V6	0.5602124	29.295	0.30734
V17	0.447527	29.648	0.30941
V23	0.2829541	16.182	0.23027
V24	0.434045	13.928	0.21703
V25	0.3113777	19.161	0.24778
V26	0.3479918	8.5112	0.18519
V30	0.3915605	6.8454	0.17540

----- VARIABLES NOT IN THE ANALYSIS AFTER STEP 9 -----

VARIABLE	TOLERANCE	MINIMUM TOLERANCE	F TO ENTER	WILKS' LAMBDA
V1	0.546806	0.1546806	.46462	0.13237
V2	0.1903695	0.2306829	0.32042E-03	0.13517
V3	0.1526145	0.2643240	.80408	0.13040
V4	0.3003164	0.2795612	.45011	0.13246
V5	0.2270301	0.1956506	.50261	0.13215
V7	0.1747145	0.1747145	.13911	0.13432
V8	0.3036324	0.2810149	0.49684E-01	0.13486
V9	0.5767617	0.2801188	.69035	0.13106
V10	0.3359510	0.2828644	0.85963E-01	0.13464
V11	0.3100130	0.2795873	.28084	0.13347
V12	0.1695183	0.1491418	0.23381E-01	0.13503
V13	0.4297389	0.2194048	.49203	0.13221
V14	0.332572	0.2365650	0.85672E-02	0.13511
V15	0.1735249	0.2715193	0.31954E-04	0.13419
V16	0.1735249	0.2652799	.17501	0.13419
V18	0.5415379	0.2417479	.11248	0.13448
V19	0.1171498	0.2593306	0.45041E-01	0.13487
V20	0.7387956	0.2726227	.12648	0.13440
V21	0.7220602	0.2716766	.11060	0.13449
V22	0.3627341	0.2793084	.68119	0.13111
V27	0.3404892	0.2826655	0.69288E-02	0.13513
V28	0.7182636	0.2748877	0.13368E-01	0.13509
V29	0.3042650	0.2795671	.44794	0.13247
V31	0.3175061	0.2792637	0.67571E-01	0.13476

F LEVEL OR TOLERANCE OR VIN INSUFFICIENT FOR FURTHER COMPUTATION.
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FIGURE 5.3: SHOWS THE FINAL STEP OF ANALYSIS IN THE STEPWISE METHOD

CASE	MIS	ACTUAL	HIGHEST PROBABILITY	2ND HIGHEST	DISCRIM
SEQNUM	VAL	SEL	GROUP P(D/G) P(G/D)	GROUP P(G/D)	SCORES
1		1	1 0.7082 1.0000	2 0.0000	-1.4401
2		1	1 0.1939 1.0000	2 0.0000	-3.1135
3		1	1 0.6821 1.0000	2 0.0000	-2.2240
4		1	1 0.0371 0.9179	2 0.0021	0.2700
5		1	1 0.1307 0.9952	2 0.0040	-0.3030
6		1	1 0.8858 1.0000	2 0.0000	-1.9579
7		1	1 0.8725 1.0000	2 0.0000	-1.9749
8		1	1 0.2105 1.0000	2 0.0000	-3.0666
9		1	1 0.8708 1.0000	2 0.0000	-1.6517
10		1	1 0.1115 0.9929	2 0.0071	-0.2229
11		1	1 0.8525 1.0000	2 0.0000	-1.6284
12		1	1 0.8702 1.0000	2 0.0000	-1.9778
13		1	1 0.1149 1.0000	2 0.0000	-3.3910
14		1	1 0.3247 1.0000	2 0.0000	-2.7992
15		1	1 0.3745 1.0000	2 0.0000	-2.7024
16		1	1 0.2483 0.9992	2 0.0008	-0.6598
17		1	1 0.4542 0.9999	2 0.0001	-1.0660
18		1	1 0.4065 1.0000	2 0.0000	-2.6437
19		1	1 0.9687 1.0000	2 0.0000	-1.7752
20		1	1 0.8847 1.0000	2 0.0000	-1.9594
21		2	2 0.4487 1.0000	1 0.0000	4.0570
22		2	2 0.8445 1.0000	1 0.0000	3.4950
23		2	2 0.4115 0.9999	1 0.0001	2.4775
24		2	2 0.0307 0.8843	1 0.1157	1.1400
25		2	2 0.2252 1.0000	1 0.0000	4.5116
26		2	2 0.4623 1.0000	1 0.0000	4.0330
27		2	2 0.4354 0.9999	1 0.0001	2.5189
28		2	2 0.8504 1.0000	1 0.0000	3.1102
29		2	2 0.9364 1.0000	1 0.0000	3.3787
30		2	2 0.8765 1.0000	1 0.0000	3.4541
31		2	2 0.4165 1.0000	1 0.0000	4.1112

CLASSIFICATION PROCESSING SUMMARY

31 CASES WERE PROCESSED.
 0 CASES WERE EXCLUDED FOR MISSING OR OUT-OF-RANGE GROUP CODES.
 0 CASES HAD AT LEAST ONE MISSING DISCRIMINATING VARIABLE.
 31 CASES WERE USED FOR PRINTED OUTPUT.

FIGURE 5.5: THE DISCRIMINANT CORES

Classification is achieved by using classification functions, one for each group. These functions are derived from the pooled within groups covariance matrix and the centroids of the discriminating variables.

The resulting classification coefficients are to be multiplied by the raw variable values, summed together, and added onto a constant. The classification function for one group would appear as:

$$C_1 = C_{11}V_1 + C_{12}V_2 + \dots + C_{1n}V_n + C_{10}$$

where C_1 is the classification score for group 1
 $C_{11} \dots C_{1n}$ are the classification coefficients
 C_{10} is the constant
 $V_1 \dots V_n$ are the raw values of the discriminant variables

There is always a separate equation for each group. Similarly, classification functions for group 2 appear as:

$$C_2 = C_{21}V_1 + C_{22}V_2 + \dots + C_{2n}V_n + C_{20} \dots$$

Thus in this research each case has two scores. The case would be classified into the group for which it had the highest score, see Figure 5.5.

Under the assumptions of multivariate normal distributions the classification scores can be converted into probabilities of group membership. The rules of assigning a case to the group for which it has the highest score is then equivalent to assigning the case to the group for which it has the greatest probability of membership.

Figure 5.5 shows the highest probability with discriminant scores. Further results of computer print outs are shown in Appendix 5.

5.5 REGRESSION ANALYSIS FOR PREDICTING BANKRUPTCY

5.5.1 Introduction

Two further predicting models were developed in the form of regression techniques, less complicated than the discriminant models, as follows.

The first was developed from the same financial ratios of "failed" and "non-failed" groups which applied in the discriminant model described in the previous section. The dependent variables were calculated from the same Z-score as the developed model. This procedure further reduced the number of discriminant variables from 7 to 5.

The second model was also developed from the same financial ratios but used the dependent variables calculated from the Mason and Harris' model published in 1979, updated for operational use.

5.5.2 The Multiple Regression Model 1

A simple regression analysis between Z-scores calculated from the developed model and financial ratios, of "failed 11" and "non-failed 20" groups, was carried out. After using the stepwise technique available in the Minitab programme, the following results were obtained (by taking the value of Z-scores from discriminant scores and converting the sign) (+) to (-):

$$Z = 2.81 - 2.84 C_{17} + 15.3 C_6 - 2.08 C_{12} + .581 C_{25} + .282 C_{23}$$

where: C_{17} - as a ratio of current assets to net assets

C_6 - as a ratio of earning after tax and interest to net capital employed

C_{12} - as a ratio of interest to earning before tax and interest

$$C_{25} = \text{Tax trend: } \frac{\frac{T_n + T_{(n-1)}}{2} - T_{(n-2)}}{T_{(n-2)}}$$

C_{23} - as ratio of turnover to net assets.

See Appendix C.

5.5.3 The Regression Model 2

A second regression analysis was performed between Z-values calculated from Mason's model and financial ratios of "non-failed 20" groups. Again after using the stepwise technique the following results were obtained:

$$Z = 3.47 + 74.5 C_4 - 14.7 C_{11} + 3.37 C_{26} - 5.17 C_{13}$$

where: C_4 is ratio of earnings before tax and interest to net capital employed

C_{11} is a ratio of debtor to current liabilities

C_{13} is a ratio of current liabilities to net assets

C_{26} : Earnings after tax trend

See Appendix C.

5.6 DISCUSSION

The multivariate methodology used in this research is based upon the following goals:

1. The variables used should be multivariate normal distributed.

The solution suggested in the previous studies is that the data should be transformed on a univariate basis to improve univariate normality and this should have the desired effect of increasing the probability of multivariate normality.

2. The individual variable should measure different financial characteristics.

Correlation between variables has been tested in a way that any ratio which is highly correlated with other ratios that describe similar aspects of the company's financial structure should be discretised as a result when the correlation between variables was 0.7 or more. One of them was selected for inclusion in the analysis. In this way the large number of variables was reduced from 82 to 31.

Despite arguments that multicollinearity is not important in LDA (e.g. Eisenbeis, 1977 [31]) it was considered for the purpose of this study to be appropriate to limit the variables to measure different financial structures.

3. A stepwise linear discriminant package SPSS-X was utilised and after many runs the model developed.

The procedure presented here is based on the unstandardised coefficient. They are most useful when their values are multiplied by the raw values of the associated variables to arrive at a "discriminant Z-score" taking into account that the function has to be multiplied by twice the mean of classification scores for each group as an adjustment factor.

The "standardised coefficients" which are related to weight of regression analysis were rejected and not taken into account. Instead the "inter-correlations in the variables set" were used to form the model. "Standardised Coefficients" however are still accepted in some literature [36] and further discussion will follow in a later section.

Two additional predictive models were developed during the research based on the multiple regression technique, aimed at reducing the number of discriminant variables in the final model and also to update the Mason model to fit the changes in economy after ten years of operational use.

Finally, the use of multiple regression should not be considered as a substitute for LDA and should be viewed as a method for unravelling the complexities of LDA .

CHAPTER 6
THE RESULTANT MODEL

- 6.1 Introduction
- 6.2 The Resultant Model
- 6.3 The Constituent Variables
- 6.4 The Relationships between the Ratios
- 6.5 Contribution of Each Ratio to the Model
- 6.6 The Cut-off Between Groups and Grey-Area
- 6.7 Summary and Conclusions

CHAPTER 6

THE RESULTANT MODEL

6.1 INTRODUCTION

This section includes a description of the discriminant model, and its constituent variables, together with the relationship between the ratios and contribution of each ratio to the model. The cut-off value for the model is also included.

The final prediction model produced in the research is made up of seven variables, measuring five distinct aspects of a company's financial structure. Good discrimination between "solvent" and "failed" companies was evident. Considerable effort was made to reduce the number of discriminating variables in the function from seven to some smaller, more easily handled, say five variables, using regression techniques.

6.2 THE RESULTANT MODEL

The following seven variable linear function resulted:

$$Z = C_0 + C_6V_6 + C_{17}V_{17} + C_{23}V_{23} + C_{24}V_{24} + C_{25}V_{25} + C_{26}V_{26} + C_{30}V_{30}$$

where $C_0, C_6, C_{17}, C_{23}, C_{24}, C_{25}, C_{26}, C_{30}$ denotes the coefficients.

$V_6, V_{17}, V_{23}, V_{24}, V_{25}, V_{26}, V_{30}$ denotes the discriminant variables.

$$\begin{aligned}
C_0 &= 14.6 \\
C_6 &= 82 \\
C_{17} &= -14.5 \\
C_{23} &= 2.5 \\
C_{24} &= -1.2 \\
C_{25} &= 3.55 \\
C_{26} &= -3.55 \\
C_{30} &= -3
\end{aligned}$$

The model is:

$$\begin{aligned}
Z = 14.6 + 82V_6 - 14.5V_{17} + 2.5V_{23} - 1.2V_{24} \\
+ 3.55V_{25} - 3.55V_{26} - 3V_{30}
\end{aligned}$$

6.3 THE CONSTITUENT VARIABLES

The constituent variables in the developed model are as follows:

1. V_6 : Ratio of earnings after tax and interest charge to net capital employed.

This is a profitability measure, and takes into account all the net assets plus the short term loan which is used to finance the company. The net capital employed may be defined as fixed assets plus working capital, and is often used for (ROCE) in published accounts. i.e. return on capital employed (ROCE)

This ratio is a valuable guide to the profitability of the companies. The values appear positive in solvent companies and tend towards the negative in failed companies.

2. V_{17} : Ratio of current assets to net assets:

This is a financial leverage measure. Failed firms consistently have less current assets including cash than non-failed firms. However, some failed firms also have a high ratio since net assets decrease continuously leading to an increase in this ratio. The ability of a firm to meet its short-term financial obligations without having to liquidate its long-term assets is an important factor in the consideration of lenders, the extreme case of such an inability is bankruptcy.

3. V_{23} : Ratio of turnover to net assets

This ratio is one measure of how well a company has used its productive capacity which is usually considered in failed firms rather than solvent companies, due to lack of response to market situation. However, some failed firms also have high ratios. An experimental ratio may be that for increasing turnover/net assets accompanied by decline in net assets. Also some failed companies may be increasing turnover by overtrading, a usual phenomenon in failed companies.

4. V_{24} : Ratio of short term loan to earnings before tax and interest charges

Short term loans are taken as being the loan and overdrafts appearing in the company's current liabilities statement. It shows the relative safety of short-term loans compared to earnings before tax and interest charges. This ratio is one measure of a company's liquidity.

5. V_{25} : Tax trend

The tax trend tends towards the negative in failed companies. As a company becomes "better off" the trend increases, becoming negative in failed companies. In the author's case tax is a portion of profit paid to the Government, thus when a company does not achieve profitability, no tax is paid.

6. V_{26} : Earnings after tax trend

The earnings after tax trend tends towards the negative in failed companies. Again as a company becomes "better off" the trend increases, becoming negative in the failed companies.

7. V_{30} : Short term loan trend

The short term loan trend has the advantage of measuring the liquidity over several years. The majority of construction companies are dependent on short-term loans. In practice long-term nature, for example, the bank overdraft which a firm obtains or the credit extended to it by its trade creditors, will be available to the company without any further negotiation, unless drastic changes occur in the company or in the general economy. Generally, failed companies are highly dependent on short-term loans more than non-failed firms. As a company becomes "worse off" the trend increases, reaching crisis level before the collapse.

Table 6.1 shows the constituent ratios and financial aspect measurements.

Ratio No	Description of Ratio	Finanical Aspect Measurement
6	PAT/NCE	PROFITABILITY
17	CA/NA	FINANCIAL LEVERAGE
23	TURN/NA	ACTIVITY/ASSETS TURNOVER
24	STL/EBIT	LIQUIDITY
25	TAX-TREND)	TREND MEASUREMENT
26	PAT-TREND)	
30	STL-TREND)	

TABLE 6.1: THE CONSTITUENT RATIOS IN THE MODEL

6.4 THE RELATIONSHIPS BETWEEN THE RATIOS

As mentioned previously, the resultant model consists of seven discriminant variables measuring four financial aspects. The profitability measures were found to contribute much to the discrimination followed by the financial leverage measure, asset turnover and liquidity measure. The last three discriminators representing the trend measures are the least discriminant of the variables.

It seems that trend measurement was significant and confirmed in this research, when the trend measurements were included. By comparing the resultant model with previous studies, the author concludes that the

profitability measure contributes the most because a firm earning profit almost never fails. Also it may be concluded that inclusion of TURN/NA ratio in the author's model produced similar results to Altman, using the numerator of the ratio, turnover. The major difference from all other models was its measures of profit after tax and interest omitted elsewhere. Taffler [11] stipulated that only ratios measuring different aspects should be in the same model. These restrictions were postulated to reduce the likelihood of sample bias being present in the model construction. Not all previous works, however, have agreed with these views [19][21]. Indeed Mason included two ratios measuring a similar dimension and, therefore, these two ratios are highly correlated.

The author-derived model contained several measures of trends apparently without detrimental effects. Table 6.2 shows the correlation matrix of the constituent variables.

It is interesting to note the lack of correlation between the variable set used to form the model since the purpose of this kind of study is to limit the variables to measure different financial structures.

	PAT/NCE	CA/NA	TURN/NA	STL/EBIT	TAX- TREND	PAT- TREND	STL- TREND
PAT/NCE	1.0						
CA/NA	0.18239	1.0					
TURN/NA	-0.1858	0.5950	1.0				
STL/EBIT	-0.0261	-0.1759	-0.2075	1.0			
TAX-TREND	-0.1461	0.2572	0.1206	0.2221	1.0		
PAT-TREND	-0.1117	0.0340	0.4180	0.0316	0.2356	1.0	
STL-TREND	0.2399	0.1034	0.0399	-0.0886	0.0489	-0.0193	1.0

TABLE 6.2: POOLED WITHIN-GROUP CORRELATION MATRIX

Ratios	Altman	Taffler	Mason	Abidali	Financial Aspects Measurement
EBIT/CL		X			Profitability
EBIT/NCE			X		
EBIT/NA			X		
EBIT/Total assets	X				
PAT/NCE				X	
<u>Retained Earnings</u>					Liquidity
Total assets	X				
No credit interval		X			
Log (Day Debtors)			X		
STL/EBIT				X	
Turnover/EBIT				X	Activity
Sales/total assets	X				
Dr/Cr			X		Working Capital
Current assets/ Total liability		X			
<u>Market Value of Equity</u>					Financial risk
Book value of debt	X				
CL/Total asset		X			
CL/CA			X		
CA/NA				X	
Tax trend				X	
PAT trend				X	
STL trend				X	
Debtor trend			X		

TABLE 6.3: SHOWS THE DESCRIPTION OF RATIOS AND FINANCIAL ASPECTS MEASUREMENTS ACHIEVED BY PREVIOUS STUDIES AND THIS STUDY

6.5 CONTRIBUTION OF EACH RATIO TO THE MODEL

There are three methods to measure the contribution that a ratio makes to the overall discriminating power of the model as follows:

1. Standardise coefficients:

This is a conventional method measuring the standardised coefficient, as weights of constituents, of the model. The main disadvantage concerns not taking into account the "inter-correlations" in the variable set used to form the model [11]. The value of using "standardised coefficients" however, is still accepted in some literature [36].

2. Mosteller and Wallace's Method [35]:

This model measures relative discriminant power as follows:

$$R_j = \frac{C_j(\bar{X}_{j1} - \bar{X}_{j2})}{\sum_{i=1}^n C_i(\bar{X}_{i1} - \bar{X}_{i2})}$$

where: R_j = the relative proportion of discrimination that variable j accounts for

$\bar{X}_{j1}$ = the mean value of variable j for group 1

$\bar{X}_{j2}$ = the mean value of variable j for group 2

C_j = the standardised coefficient of variable j

n = the total number of variables in the model

There has been much debate on this approach which was adopted by Taffler using the C_j 's signed (+ or -), with R_j 's not summed to 1.

Others believe that in practice the $C_j(\bar{X}_{j1}-\bar{X}_{j2})$'s must all have the same sign and if they do not, due to multicollinearity, then it is not possible to interpret the associated variables in any meaningful way. This concept was valuably demonstrated by Mason [17], where the variables measuring profitability showed high correlation. On this evidence, the relative contributions of the different variables, using the Mosteller and Wallace method, are questionable.

Similar conclusions can thus be made on why Taffler made the restriction that only ratios measuring different aspects should be in the same model.

3. Conditional deletion:

Qualitatively measures method of the additional contribution of each variable to the discriminant function with the other variables included, resulting in a ranking of the constituent variables, from F to inter of remove values. Altman adopted this method.

The results for the three methods are shown in Table 6.4.

	Using standardised coefficients method	Using Mosteller & Wallace method	Conditional deletion method (F-value ranking)
V ₆ PAT/NCE	15	9	2 (29.295)
V ₁₇ CA/NA	20	11	1 (29.648)
V ₂₃ TURN/NA	19	15	4 (16.182)
V ₂₄ STL/EBIT	12	40	5 (13.928)
V ₂₅ TAX TREND	14	15	3 (19.161)
V ₂₆ PAT TREND	11	8	6 (8.5112)
V ₃₀ STL TREND	9	2	7 (6.845)

TABLE 6.4: SHOWS CONTRIBUTION OF RATIOS TO MODEL

Both Taffler [11] in his multivariate study, and Beaver [3] in his univariate study conclude that short term liquidity is less important in determining a firm's solvency than permanent aspects. It appears Altman's method of using conditional deletion is more convincing than Taffler's method in measuring the contribution of each variable to discriminant function. Furthermore, the standardised coefficients are used when the variables are standardised to a mean of zero and a standard deviation of one, which is impossible in financial ratios. Therefore, the unstandardised coefficient method seems more reliable. However, the magnitude of the unstandardised coefficients is not a good index of relative importance when the variables differ in the units in which they are measured. Nevertheless variables with large coefficients are thought to contribute more to the overall discriminant function (see pp 91 [36]).

6.6 THE CUT-OFF BETWEEN GROUPS AND GREY-AREA

6.6.1 Introduction

The aim of this section is to determine the cut-off between groups in order to minimise the total number of misclassifications by locating the Z-value for which the company cannot be classified as belonging to failed or solvent groups. The overlap between the distribution of "Z" values for both failed and non-failed groups where misclassification can occur. In this region two types of error occur, namely type I errors, are defined as misclassification of "failed" company as "non-failed", and type II errors as misclassifications of "non-failed" as failed. Ignoring the cut-off between groups gives rise to serious errors in interpreting the results from application of a derived discriminant function, for example, Altman and Eisenbeis [33] show that when the prior probabilities are arbitrarily set to 0.01 and 0.99 for a bankrupt and non-bankrupt firm respectively, then the type I error (misclassification of a bankrupt as a non-bankrupt occurs).

Experience with the Tisshaw (1976) [37] model for the analysis of privately owned manufacturing companies in practical application provides a low type I error rate but a wide number of type II errors.

Taffler (1982) suggested for privately owned manufacturing and construction enterprises a cut-off point of (-1.6), though in one of his previous studies in 1976 he suggested a zero cut-off point.

Altman (1968) suggested a cut-off point of -2.99. The procedure which was adopted in this study to determine the cut-off point was based on two methods:

- mathematical methods
- prior probabilities and misclassification costs estimation method.

After determining the cut-off point, furthermore, there will be a need to set "grey area" limits in order to minimise the total number of misclassifications.

6.6.2 Mathematical Derivation of the Cut-Off Point

The mathematical derivation of the computational formula of the cut-off point for the two groups, presented here, was developed by Paul [34]. In order to set the cut-off point mathematically it is possible to determine the desired value if the distributions of "Z" values are known on the assumption that the distributions are normal, the cut-off point which minimises the total number of misclassifications is found by locating the "Z" value for which the ordinates are equal. The area of misclassification is the sum of the integrals of the two density functions evaluated from the cut-off point to positive infinity for the distribution having lesser mean and from negative in infinity to cut-off point for the distribution having the greater value as shown in Figure 6.1.

This area can be minimised by setting the first derivative of the function so is defined equal to zero, and solving for the cut-off point. The derivative of the definite integral above is the difference between the two density functions at the cut-off point, the computations are as follows:

μ_1 = mean of the first group

μ_2 = mean of the second group

σ_1 = standard deviation of the first group

σ_2 = standard deviation of the second group

Z_c = cut-off point "Z" value.

as shown in Figure 6.1.

FIGURE 6.1

$$1. \frac{1}{\sqrt{2\pi} \cdot \sigma_1} e^{-1/2 \left(\frac{z_c - u_1}{\sigma_1} \right)^2} - \frac{1}{\sqrt{2\pi} \cdot \sigma_2} \cdot e^{-1/2 \left(\frac{z_c - u_2}{\sigma_2} \right)^2} = 0$$

$$2. \sigma_2 \cdot e^{1/2 \left(\frac{z_c - u_2}{\sigma_2} \right)^2} = \sigma_1 \cdot e^{1/2 \left(\frac{z_c - u_1}{\sigma_1} \right)^2}$$

3. By logarithmizing both sides:

$$\log \sigma_2 + \frac{1}{2} \left(\frac{z_c - u_2}{\sigma_2} \right)^2 = \log \sigma_1 + \frac{1}{2} \left(\frac{z_c - u_1}{\sigma_1} \right)^2$$

$$4. \log \sigma_1 - \log \sigma_2 = \frac{z_c^2 - 2z_c u_2 + u_2^2}{4\sigma_2^2} - \frac{z_c^2 - 2z_c u_1 + u_1^2}{4\sigma_1^2}$$

$$5. \left(\frac{1}{4\sigma_2^2} - \frac{1}{4\sigma_1^2} \right) z_c^2 + \left(\frac{u_1}{2\sigma_1^2} - \frac{u_2}{2\sigma_2^2} \right) z_c + \left(\frac{u_2^2}{4\sigma_2^2} - \frac{u_1^2}{4\sigma_1^2} - \log \sigma_1 + \log \sigma_2 \right) = 0$$

This equation can be solved by use of the quadratic formula.

where:

$$a = \left(\frac{1}{4 \sigma_2^2} - \frac{1}{4 \sigma_1^2} \right)$$

$$b = \left(\frac{u_1}{2 \sigma_1^2} - \frac{u_2}{2 \sigma_2^2} \right)$$

$$c = \left(\frac{u_2^2}{4 \sigma_2^2} - \frac{u_1^2}{4 \sigma_1^2} - \log \sigma_1 + \log \sigma_2 \right)$$

To determine Z_c :

$$Z_c = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

A graphical representation of the distribution of "Z" values actually computed for the individuals in the sample problem is made in Graph 6.2.

The range of "Z" values is divided into segments of 3 units, and the frequency indicated on the graph is the number of "Z" values falling within a particular segment.

The histograms closely resemble the superimposed normal curves as shown in Figure 6.2 which represent the distribution of "Z" values based on the assumption that the population are normal, and that the samples means and standard deviation are the population means and standard deviations (see Appendix E).

There is only a very slight overlap in the "Z" value over two graphs and the F ratio indicates a significant difference between the two groups. Statistical test is shown in Appendix E.

The determine the cut-off point mathematically, by applying the formula:

$$\begin{aligned} & \left(\frac{1}{4 \sigma_2^2} - \frac{1}{4 \sigma_1^2} \right) z_c^2 + \left(\frac{u_1}{2 \sigma_1^2} - \frac{u_2}{2 \sigma_2^2} \right) z_c + \\ & + \left(\frac{u_2^2}{4 \sigma_2^2} - \frac{u_1^2}{4 \sigma_1^2} - \log \sigma_1 + \log \sigma_2 \right) = 0 \end{aligned}$$

where

$$a = \left(\frac{1}{4 \sigma_2^2} - \frac{1}{4 \sigma_1^2} \right)$$

$$b = \left(\frac{u_1}{2 \sigma_1^2} - \frac{u_2}{2 \sigma_2^2} \right)$$

$$c = \left(\frac{u_2^2}{4 \sigma_2^2} - \frac{u_1^2}{4 \sigma_1^2} - \log \sigma_1 + \log \sigma_2 \right)$$

$$z_c = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$$u_1 = 9.60$$

$$u_2 = -14.3$$

$$\sigma_1 = 6.324$$

$$\sigma_2^2 = 6.123$$

$$a = 0.00042$$

$$b = 0.11977 + .1908 = 0.310$$

$$c = \frac{204.5}{150} - \frac{91.5}{159.7} - 0.8 + 0.7869 = 0.777$$

$$= 1.3633 - 0.5729 - .80 + 0.7869 = 0.777$$

Therefore $Z_c = -3.48$.

FIGURE 6.2: THE CUT-OFF BETWEEN "NON-FAILED 20" AND "FAILED 11" GROUPS

6.6.3 Prior Probability and Misclassification Costs Estimation Method

Previous studies discussed these issues. Tollefson [24] and Morrison [23], Pincher (1980), Taffler (1982, 1984) all concluded that ignoring such issues leading to serious errors in interpreting the results from application of a derived discriminant function.

The classification procedure used in this study takes into account differential prior probability estimates and misclassification costs in determining an appropriate cut off.

The assignment functions used are those used in many previous studies and are of the form:

$$P(g) = \frac{e^Z}{e^Z + L} \quad \text{and} \quad P(f) = \frac{e^{-Z}}{e^{-Z} + \frac{1}{L}} \quad (1)$$

where: $P(g)$ = probability with which the company under investigation should be classed as resembling the "non-failed 20" group

$P(f)$ = probability with which the company under investigation should be considered to resemble the "failed 1'1" group

L = the 'likelihood' or 'probability-cost' ratio

= odds ratio x costs ratio

$$= \frac{P_2}{P_1} \times \frac{C_{21}}{C_{12}} \quad (2)$$

where P_1 and P_2 are the prior probability estimates (failed:solvent).

C_{12} and C_{21} are the estimated costs of misclassification of a "solvent" firm as "insolvent" and vice versa respectively (type I:type II errors).

In the two groups linear discriminant model that if $f_1(X)$ and $f_2(X)$ are the multivariate normal distributed probability density functions for the "solvent" and "insolvent" populations and the conventional equality of dispersion matrices assumption holds then

$$\frac{f_1(X)}{f_2(X)} = e^Z$$

By applying Bayesian formula, if H_1 represents the statement that a firm belongs to the "solvent" population and H_2 that it belongs to the "insolvent" population then the posterior probability $p(H_1/X)$ taking into account differential prior probabilities and misclassification costs is given by

o

$$\begin{aligned} p(H_1/X) &= \frac{P_1 C_{12} p(X/H_1)}{P_1 C_{12} p(X/H_1) + P_2 C_{21} p(X/H_2)} \\ &= \frac{P_1 C_{12} f_1(X)}{P_1 C_{12} f_1(X) + P_2 C_{21} f_2(X)} \end{aligned}$$

$$\text{Therefore } p(g) = \frac{e^Z}{e^Z + L}$$

and $p(H_2/X) = 1 - p(H_1/X)$

$$\text{Therefore } p(f) = \frac{e^{-z}}{e^{-z} + \frac{1}{L}}$$

In practice the prior odds ratio can be gained from statistical evidence, but the misclassification costs ratio is more difficult to estimate and is generally reached through subjective estimation. The costs ratio used in previous work has varied but has generally been of the same magnitude. Laurence, Prust and Company and Taffler [12] in their studies used a cost ratio of 40/1 and Altman [9] in one of his studies suggested a ratio of 35/1.

The prior odds ratio has been approximated using the information in Table 6.5.

Year	Approx No of Insolvencies (A)	Approx No of Firms in the Industry (B)	A/B
1982	1422	63169	1/44
1986	1914	75810	1/39

TABLE 6.5: SHOWS THE INSOLVENCIES IN THE CONSTRUCTION INDUSTRY

The average ratio for two years is approximately 1/41.5.

If we considered a "costs ratio" of 40:1 as used in previous studies, we arrive at a "probability-cost" ratio L of unity, the same as concluded by Mason [17]. In this study the cut-off point is specified as the point where there is equal probability of belonging to the "failed" and "non-failed" groups or equal numbers of potential failures and solvent companies in the population. That is to say:

$$P(g) = P(f) = 50\%$$

and from

$$P(g) = \frac{e}{e^Z + L}$$

where $L = 1.0$.

We arrive at a cut-off point of $Z=0$. This is a mathematical proof for Z-model based on prior probability and misclassification costs. By comparing this result with the mathematical approach it seems too cautious in determining the cut-off value from -3.48 to zero.

Therefore, any company having a positive Z-score on the model will have a higher probability of membership of the "non-failed" group than the "failed" group and will be classified as "non-failed". Similarly, a negative Z-score will classify a company as "failed".

6.6.4 Grey-Area

Previous studies specified "grey-areas" for example Altman [8] and Mason [17]. This 'area' is one within which an accurate classification of a company is not possible, i.e. the overlap region where misclassification can occur. This is to say that the difference between the probabilities of group membership $D = P(g) - P(f)$ is small.

Some advocates of this system appear to be too cautious in setting their "grey-area" limits. Their limits were set at $P(g) = 95\%$ and $P(f) = 95\%$. However these limits mean that companies confidently classified in a particular group have to have odds of 19 to 1 or more of belonging to that group.

These odds seem very restrictive and odds of 10 to 1 or 5 to 1 might be more appropriate. Laurence, Prust and Co [22] in one of their studies used an "odd ratio" 1:10 and commented "this will of course

vary over time with economic situation". Therefore, it needs subjective estimation based on the economic environment. Furthermore the "grey-area" limits should be set by users of the model.

This study set two probabilities at 95%. The limits are calculated using the same function used in calculating the cut-off value:

$$P(g) = \frac{e^Z}{Z^Z + 1} \quad \text{and} \quad P(g) = \frac{e^{-Z}}{e^{-Z} + 1}$$

By putting $P(g) = 95\%$ and $P(f) = 95\%$ the "grey-area" limits are ± 2.94 .

6.7 SUMMARY AND CONCLUSIONS

The results from applying the linear discriminant analysis technique produced a linear discriminant model made up of seven variables, measuring five distinct aspects of a company's financial structure, namely profitability, liquidity, activity, financial leverage and three trend measurements, as shown in Table 6.1.

The computed F-statistic for the overall model was 40.5 and tabular ratio was 5.42 where degree of freedoms were 2 and 29 at the 1% significance level. Therefore it has been concluded that the ability of the discriminant model to differentiate between groups is good (see Appendix E).

Two issues should thus considered. Firstly, the influence of each variable in a model. Previous studies suggested a number of methods which were attempted to determine the relative importance of individual variables. Five such methods were considered by Eisenbeis,

Gilbert, and Avery [32]. A sixth method had been suggested by Mosteller and Wallace [35] and Joy and Tollefson [24]. Therefore the selection of methods which were used in this research study were based on their credibility among the model builders. Three methods were employed in this research programme as shown in Table 6.4. It was concluded that the F-deletion method was suitable for discriminant analysis.

As can be seen from the results (see Table 6.4) both profits after tax trend and short term loan trend are the least discriminant of the variables, while tax-trend is relatively more important than the other trends. Whereas the profit after tax as a ratio to net capital employed and current assets as a ratio to net assets are consistently good discriminators. Short term loans as a ratio to pre-tax profit is less important compared to other fundamental aspects of company financial structure such as profitability and financial leverage ratios.

The second issue to be considered is the cut-off and grey-area of the model. Two approaches were undertaken in determining the cut-off between two groups, as demonstrated in Section 6.6.

Clearly it was concluded that the mathematical approach indicated validation of the technique. The cut-off value of the distribution of Z-values for both the "non-failed 20" and "failed 11" groups as shown in Figure 6.2 are approximately equal to the calculated value of the cut-off point derived from this equation $Z_c = -3.48$. The Z-value is that a company cannot be classified to belong to a failed or solvent group. This is the critical approach to the classification of a company, in order to use the model for operational classification purposes.

It is necessary to specify "grey-areas". The "area" within which an accurate classification of a company is not possible, the overlap region in the original sample where misclassifications can occur. As shown in Figure 6.2 there is only a very slight overlap in the "Z" value over two distributions, in this region two types of error can occur. Type I errors, defined as misclassification of failed company as non-failed and type II errors, defined as misclassification of non-failed companies as failed.

By considering prior probability and misclassification costs estimates arriving to cut-off zero-value, this was reached through subjective estimation and grey-area limits of ± 2.94 . Thus any company having a Z-score within these limits cannot be confidently classified and can only be considered "vulnerable"

The Lachenbruch U-test errors indicated no type I errors and two type II errors for both models within these limits. This is a clear indication of the success in the selection of the limits. The type II errors were not considered to be misclassifications. As the sample of "non-failed" firms was not restricted to healthy firms, one would expect to find a few weak firms in the "non-failed" sample and it is these firms that have been assigned low Z-scores.

Finally, the existence of such a "grey-area" does not detract from the usefulness of the LDA method, it simply obliges the analyst to make further and more detailed analysis of the firm in this range of Z-scores.

CHAPTER 7

RESULTS OBTAINED FORM THE MODELS

- 7.1 Introduction
- 7.2 Results Obtained from the "Non-Failed 20" and "Failed 11" Groups
- 7.3 Results Obtained from the "Taken-Over 9" Group
- 7.4 Results Obtained from the "Non-Failed 20" and "Failed 11" Groups
by Using an Alternative Regression Model
- 7.5 Results Obtained from the "Non-Failed 20" and "Failed 11 " Group
by Using an Updated Mason Model
- 7.6 Trend Analysis
- 7.7 Financial Ratios as a Means of Predicting Failure
- 7.8 Summary and Conclusions

CHAPTER 7
RESULTS FROM THE MODELS

7.1 INTRODUCTION

The model was verified using the data described in Section 7.2, and includes the results obtained from the "Non-failed 20" and "Failed 11" groups.

The model also deals with prior year Z-score analysis for both "Non-failed 20" and "Failed 11" groups, and briefly illustrates the characteristics of both groups.

Section 7.3 includes the results obtained from the failed and non-failed group by using the alternative regression model.

Section 7.4 includes the results obtained from the failed and non-failed groups by updating Mason's model.

Section 7.5 illustrates the trend analysis for all groups.

Section 7.6 explains the use of financial ratios as a means of predicting failure.

The final section briefly discusses the results and summarises results in graphical and tabular form.

A comprehensive listing of results for all the companies used in the study appears in Appendix D.

7.2 RESULTS OBTAINED FROM THE "NON-FAILED 20" AND "FAILED 11" GROUPS

7.2.1 Introduction

The model was first examined with the data used to form the model in order to check the performance of each company added to the model itself. This procedure was carried out for two reasons: firstly, to identify the companies in danger of failure. Secondly, because of the difficulty in obtaining financial information suitable to explore such a model.

The following summarises the results.

7.2.2 The Results of "Non-Failed 20" and "Failed 11" Groups

The results obtained from the "non-failed 20" and "failed 11" groups used to form the model are shown in Tables 7.1 and 7.2 and further portrayed in histogram form in Figure 7.1.

Ignoring the 'grey area' developed in Section 6.6 and using the cut-off as a classification boundary, we can see that 18 out of 20 in solvent area and all companies in the failed-11 group were correctly classified respectively.

However taking into account the 'grey area' limit (± 2.94) we reach the situation, shown in Table 7.3 where 90% were correctly classified with confidence in the "non-failed group" and 10% classified as 'vulnerable' 100% of "failed 11" group were correctly classified. No misclassification existed in both groups.

	1983	1984	1985	1986	Mean
Aberdeen Const Ltd	15.5	12.8	14.8	10.0	13.27
Barratt Development	1.19	4.28	-14.3	13.19	3.59
Benlox Holdings plc	18.14	4.15	26.0	11.4	14.9
Benbailly Const plc	22.0	12.3	21.0	2.84	14.53
C H Beazer Holds	6.8	11.0	5.9	1.96	6.4
BICC plc	7.7	4.8	7.4	8.8	7.1
Brown and Jackson	4.3	4.5	2.5	2.8	3.52
Bryant Holdings	10.3	7.5	5.7	4.8	7.07
Boulton & Paul plc	15.9	23.4	15.3	18.3	18.22
M J Geeson Group	18.24	32.0	18.0	13.5	20.4
George Wimpey plc	7.1	5.0	4.8	8.4	6.32
Henry Boot and Sons	4.5	4.6	-11.2	-5.3	-1.85
A Monk Co Ltd	14.6	17.8	20.0	6.58	14.74
Newarthill plc	12.0	8.6	7.4	5.0	8.25
Rush & Tompkins	1.38	.28	1.8	-3.7	-0.06
Taylor Woodrow	6.3	8.3	15.8	12.8	10.8
Tarmac plc	20.4	11.2	19.8	19.7	17.7
Tilbury Group plc	10.5	-2.0	3.0	9.2	5.17
Turriff Corp plc	6.0	-2.3	6.9	16.7	6.8
Wilson Connolly	23.6	12.4	11.5	14.9	15.6
Averages:	11.34	9.0	9.10	8.59	9.6

TABLE 7.1: RESULTS OBTAINED FROM THE "NON-FAILED 20" GROUP

Failed Companies	Years Prior to Failure			Mean
	-3	-2	Last year	
Beech Wood Group plc	-1.07	-1.5	-9.8	-4.1
Cocksedge plc	-35	+2.3	-35.5	-22.6
David Charles Ltd	-18.7	-9.7	-25	-18.8
Crouch Group plc	-6.4	-9.5	-14.5	-10.13
James H Dennis plc	-6	-1	-19.4	-8.8
Mears Bros Ltd	-7.7	-6.8	-34	-16
Milbury plc	-17.7	-26	-11.4	-18.3
Modern Engineering Bristol	-11	-20	-33	-21.3
Moss Engineering Group	-11	-13	-30	-18
Southern Construction	+1	-12	-12.8	-7.66
S W Farmer	+7.3	-27	-14.6	-11.5
Averages:	-9.66	-11.5	-21.6	-14.3

TABLE 7.2: RESULTS OBTAINED FROM THE "FAILED 11" GROUP

FIGURE 7.1: HISTOGRAM OF THE "NON-FAILED 20" AND "FAILED 11" GROUPS

The results indicate that the model is discriminating between failed and non-failed well in spite of the high risk of the construction business.

Groups	Classified as		
	Failed	Vulnerable	"Non-failed"
"Failed 11" Group	11 (100)	-	-
"Non-failed 20" Group	-	2 (10)	18 (90)

TABLE 7.3: CLASSIFICATION OF THE "NON-FAILED 20" AND "FAILED 11" GROUPS
(Figures in brackets are percentages of total groups)

7.2.3 Prior Year Z-Score Analysis

Perhaps the most significant way in which to view the prior year's analysis is to plot the average-scores for the different groups for prior years. This plot can be seen in Figure 7.2.

We can see that although the "non-failed 20" group's mean Z-score varies from year to year, it is constantly above the 'grey area'. The "failed 11" group, on the other hand, is generally below the 'grey area'. This is a clear indication of the discriminating power of the model.

The trend in the mean Z-scores reflects economic changes in the construction industry from year to year with a downward trend during the period 1982-1986.

FIGURE 7.2: THE "NON-FAILED 20" AND "FAILED 11" COMPANIES PRIOR YEAR Z-SCORE MEANS OBTAINED FROM THE DISCRIMINANT MODEL [1]

FIGURE 7.3: THE "NON-FAILED 20" AND "FAILED 11" COMPANIES PRIOR YEAR Z-SCORE MEANS OBTAINED FROM THE MULTIPLE REGRESSION MODEL [2]

FIGURE 7.4: THE "NON-FAILED 20" AND "FAILED 11" COMPANIES PRIOR YEAR Z-SCORE OBTAINED FROM THE UPDATED MASON MODEL [3]

Table 7.4 shows the model classifies 75% of the "non-failed" group as "solvent" at year 4. Furthermore, taking 'grey area' limits (+2.94) improves the model classification by 15% and gives some indication of discriminating power of the model, although the "non-failed 20" group mean Z-score varies from year to year.

Table 7.4 shows prior years classification of the "non-failed 20" group (figures in brackets are percentages of total groups).

Years	1983	1984	1985	1986
Solvent	19 (95)	17 (85)	16 (80)	15 (75)
Vulnerable	1 (5)	3 (15)	2 (10)	3 (15)
Failed	-	-	2 (10)	2 (10)
Total:	20	20	20	20
Average Z-score:	11.34	9.0	9.1	8.59

TABLE 7.4

Table 7.5 shows prior years classification of the "failed 11" group.

Classification	Accounting year prior to company failure		
	-3	-2	Last year
Solvent	1 (9)	-	-
Vulnerable	2 (18)	3 (27)	-
Failed	8 (73)	8 (73)	11 (100)
Total:	11	11	11
Average Z-score	-9.66	-11.5	-21.6

TABLE 7.5

The Z-score fell below the cut-off level in the last year for two out of 20 companies. These companies were as follows:

1. Henry Boot and Sons.
2. Rush and Tomkins Group plc.

We can thus conclude that a single Z-score for a particular period may be insufficient to predict failure and a company's continuing dependence on its capability.

Table 7.5 shows how well the model behaved with data in the year prior to failure. It would be useful to consider how far in advance of failure a firm starts to resemble previous bankrupts.

The results appear good with the model classifying 73% of the group as failed up to three years prior to failure.

The Z-score trends during the period 1982-1986 for the "non-failed 20" firms and the last three years before failure of the "failed 11" firms appear in Appendix D.

7.3 RESULTS FROM THE "TAKEN-OVER 9" GROUP

The results obtained from the "taken-over 9" group are shown in Table 7.6 and prior years classification of the "taken over 9" group as shown in Table 7.7 below.

TAKEN-OVER COMPANIES	-4	-3	-2	Last Year
Braithwaite Group plc	16.6	13	11.67	-14
C Pearce and Sons plc	14.8	6.27	32	5.6
Fairclough Construction	13.6	17.9	14.7	22
Glossop plc	2.2	2.0	-2.7	2.4
Marchwiel plc	8	-23	-33	-7
Mitchell Construction	13.2	-7.2	10.7	7.5
Richard Construction	17	14.3	17.6	15
Roberts Adlard plc	17	12.9	17.6	16.9
Rowlinson Construction	3.8	6.9	4.1	0.7

TABLE 7.6: RESULTS OBTAINED FROM THE "TAKEN OVER 9" GROUP

Classified as	Accounting year prior to company take-over			
	-3	-2	-1	Last year
Solvent	8 (89)	7 (78)	7 (78)	5 (56)
Vulnerable	1 (11)	-	1 (11)	2 (22)
Failed	-	2 (22)	1 (11)	2 (22)
Total:	9	9	9	9
Average Z-score	11.8	6.7	8	5.45

TABLE 7.7: PRIOR YEARS CLASSIFICATION OF THE TAKE OVER 9" GROUP

(Figures in brackets are percentages of total groups)

The "taken-over" group have Z-scores ranging between "failed" and "non-failed", indicating that there were no financial features identifying the taken-over company. Also the results indicate that:

2 out of 9 companies were considered failed at last year

2 out of 9 companies were considered vulnerable.

The remaining five companies positively scored, but their Z-score deteriorated from year to year. Similarly the Z-score approach can be used to analyse merger activity (e.g. Taffler, 1985 [16]).

7.4 RESULTS OBTAINED FROM THE "NON-FAILED 20" AND "FAILED 11" GROUPS BY USING AN ALTERNATIVE REGRESSION MODEL

7.4.1 Introduction

The alternative model (see Section 5.5.2) was developed from the original Z model (see Section 6.2) using a regression technique and was tested with data used to form the model. The results are summarised below.

7.4.2 The Results of "Non-Failed 20" and "Failed 11" Groups

The results obtained from the "non-failed 20" and "failed 11" groups are given in Tables 7.8 and 7.9. By using the cut-off point $Z = 0$ as the classification boundary it can be seen that all 11 failed companies were correctly classified, and 17 out of 20 non-failed companies were correctly classified.

The model thus seems to be discriminating between solvent and insolvent groups well. For the "failed 11" group the result appears good with the model classifying 100% correctly. Table 7.10 shows the classification of the "non-failed 20" and "failed 11" groups using the multiple regression model.

	1983	1984	1985	1986	Mean
Aberdeen Const Ltd	2.96	2.39	2.3	1.44	2.272
Barratt Development	1.8	.77	-.5	1.118	0.797
Benlox Holdings plc	3.78	2.4	5.7	.36	3.06
Benbailly Const plc	11.7	-.82	-8.3	-5.8	-.800
C H Beazer Holds	1.433	4.5	.86	.386	1.794
BIOC plc	.67	.427	-5.22	+.685	-.83
Brown and Jackson	-.63	5.18	3.08	2.10	2.43
Bryan Holdings	1.68	1.237	2.02	.63	1.39
Boulton & Paul plc	2.98	2.53	2.24	2.84	2.64
M J Geeson Group	4.011	1.668	1.362	3.42	2.6
George Wimpey plc	.391	-.34	.967	.508	0.38
Henry Boot and Sons	1.22	2.92	3.33	-1.2	1.567
A Monk Co Ltd	2.68	1.548	-.41	.242	1.013
Newarthill plc	2.4	1.837	1.218	.71	1.54
Rush & Tompkins	-.296	-.165	-.18	-1.81	-.61
Taylor Woodrow	1.922	1.27	2.3	4.02	2.38
Tarmac plc	3.33	2.185	2.76	2.99	2.813
Tilbury Group plc	2.53	2.61	1.255	.8	1.79
Turriff Corp plc	.048	-.728	.0238	1.79	0.283
Wilson Connolly	4.77	2.42	2.26	3.66	3.27
Averages:	2.47	1.72	1.1	0.878	1.4969

TABLE 7.8: THE RESULTS OBTAINED FROM THE "NON-FAILED 20" GROUP BY USING AN ALTERNATIVE MULTIPLE REGRESSION MODEL

Year Prior to Failure			
Failed Companies	-2	-1	Last year
Beech Wood Group plc	-2.85	-1.27	-1.82
Cocksedge plc	-.94	-9.13	-3.17
David Charles Ltd	-1.7	-3.55	-5.18
Crouch Group plc	-2.15	-.62	.657
James H Dennis plc	-6.7	-1.1	-.76
Mears Bros Ltd	-4.11	.53	-5.3
Milbury plc	-6.7	-4.73	-2.16
Modern Engineering Bristol	-4.36	-3.68	-5.7
Moss Engineering Group	-.75	-.187	-.87
Southern Construction	+.83	-9.34	-6.4
S W Farmer	-2.816	-3.27	-4.012
Averages:	-2.93	-3.4	-3.155

TABLE 7.9: RESULTS OBTAINED FROM THE "FAILED 11" GROUP BY USING AN ALTERNATIVE MULTIPLE REGRESSION MODEL

Group	Classified as		
	Failed	Vulnerable	Non-failed
"Failed 11" Group	9 (82)	2 (18)	-
"Non-failed 20" Group	-	9 (45)	11 (55)

TABLE 7.10: CLASSIFICATION OF THE "NON-FAILED 20" AND "FAILED 11" BY USING MULTIPLE REGRESSION MODEL

By taking the grey-area between -1.60 to zero, 82% are correctly classified as failed, 55 are correctly classified as non-failed and 45% classified as vulnerable. The results do not appear as good as the 90% result of the "non-failed 20" group used to form the discriminant model.

For the "non-failed 20" group, three companies scored negatively in the last year and these were:

- 3 - Rush and Tomkins Group plc
- 1 - Benbailly Construction plc
- 2 - Henry Boot and Sons plc.

7.4.3 The "Grey" Area of the Multiple Regression Model

The previous section has set a cut-off point $Z = 0$ as the classification boundary, which divides the discriminant space into solvent and insolvent area.

This section attempts to develop the "grey-area" for the multiple regression model in order to use the model for operational classification purposes. This "area" is one within which an accurate classification of a company is not possible. An optimal line is chosen through trial and error on the demarcation line for failing, i.e. any firm below it being classified as a failed company. The results are then compared with actual data to find the percentage of incorrect prediction.

The ratio with the smallest percentage of misclassification is considered the best predictor of failure. In our case, it was found to be the (-1.6) threshold. Therefore, any company with a Z-score less than -1.6 was classified as failed whilst those firms with Z-scores between zero and -1.6 were considered as vulnerable, so any company having a Z-score within these limits cannot be confidently classified.

Finally, those firms with a Z-score greater than zero (i.e. positive scoring) may be assumed to lie in the solvent zone and can be confidently classified as "non-failed".

7.4.4 Prior Year Z-Score Analysis

Figure 7.3 shows that the mean Z-score of the "non-failed" group varies from year to year but is constantly above the cut-off limit i.e. the cut-off limit zero.

A comparison of the mean values of Z-scores for the "non-failed" group for both models during the period 1982-1986 reveals 11.34, 9, 9.10, 8.59 and 2.47, 1.72, 1.1, .876 respectively which again varies from year to year but were constantly higher than the cut-off limit. Applying both models for the last three years before failure produced -9.66, -11.5, -21.6 and -2.93, -3.4, -3.155 respectively.

The trend of Z-scores in both models appears similar, see Figure 7.3. Indeed for 10 out of 11 companies of the "failed 11" group their Z-scores in the three years prior to failure scored negatively. One company in particular, namely Southern Construction Ltd, had a Z-score in the three years prior to failure deteriorating from +0.83 to -6.4. Thus it was classified as failed in its second year prior to failure, although it was apparent from the rate of decrease of its Z-score that it was failing.

An exception was the Crouch Group plc, classified as failing in its last year prior to failure, in spite of increasing the rate of Z-score. However looking at reasons for failure reveals that in spite of the company's turnover increasing rapidly, severe losses had occurred since April 1983 due to poor trading on contracts obtained at tight margins during a period of recession (see case study in Appendix D). This is an occurrence which is impossible to forecast. Therefore it may be concluded that any company overtrading in its business may produce a misleading Z-score.

7.5 RESULTS OBTAINED FROM THE "NON-FAILED 20" AND "FAILED 11" GROUPS BY UPDATING MASON'S MODEL

7.5.1 Introduction

The updating of Mason's model (see Section 5.5.3) was developed from data collected during this research work combined with Z-scores from Mason's original model for 1976 and also that data obtained for the regression technique. The developed model (see Section 6.2) was tested using the same data used to form the model itself. The following summarises the results.

7.5.2 The Result

The results obtained from the "non-failed 20" and "failed 11" groups are given in Tables 7.11 and 7.12.

Ignoring the 'grey area' and using the cut-off as a classification boundary it can be seen that 16 out of 20 in the solvent area, 2 out of 11 of the "failed 11" group were also in the solvent area and only 9 of this group were correctly classified.

Figure 7.4 shows that the mean Z-score of both non-failed and failed groups varies from year to year. However for the non-failed group is constantly above the classification boundary (± 2.94), while for the failed group the mean Z-score at the second year before failure lies inside the classification boundary, but decreases dramatically at the year of failure.

	1983	1984	1985	1986	Mean
Aberdeen Const Ltd	3.85	2.47	1.72	2.04	2.52
Barratt Development	10.0	2.7	-6.0	5.17	2.96
Benlox Holdings plc	-7.1	1.65	-6.7	-6.6	-4.68
Benbailly Const plc	3.8	5.2	-5.4	-6.6	-2.55
C H Beazer Holdings	.72	9.7	8.7	6.27	6.3
BIOC plc	2.07	-0.9	2.62	3.47	2.017
Brown and Jackson	-.3	-5.3	1.14	-1.14	-1.4
Bryant Holdings	11.7	11.2	9.8	9.3	10.5
Boulton and Paul plc	5.3	14.5	6.9	7.4	8.52
M J Geeson Group	5.3	9.4	9.4	11.2	8.8
George Wimpey plc	-.3	-.33	-.2	4.14	.827
Henry Boot and Sons	1.73	.9	11.5	-4.2	2.48
A Monk Co Ltd	5.9	14.0	4.4	-.06	6.0
Newarthill plc	6.85	8.4	2.62	3.38	5.3
Rush and Tompkins Group plc	7.4	.86	.44	-2.8	1.47
Taylor Woodrow	8.5	8.4	10.7	10.26	9.47
Tarmac plc	4.57	12.6	7.0	8.15	8.08
Tilbury Group plc	5.12	8.4	1.98	1.37	4.2
Turriff Corp plc	7.0	-8.3	-9.9	.74	-2.6
Wilson Connolly Holdings	13.9	15.0	17.2	20.4	16.6
Averages:	4.8	5.56	3.4	3.6	

TABLE 7.11: RESULTS OBTAINED FROM THE "NON-FAILED 20" GROUP BY USING
AN UPDATED MASON MODEL

Failed Companies	Year Prior to Failure			
	-3	-2	Last year	Mean
Beech Wood Group plc	-7.2	-5.6	-4.1	-6.63
Cocksedge plc	2.9	14.3	-9.0	+2.73
David Charles plc	-0.57	-0.57	-3.45	-3.38
Crouch Group plc	-1.2	-7.2	-9.4	-5.93
James H Dennis plc	-11.6	-2.0	-4.26	-6.9
Mears Bros Ltd	-5.5	4.3	-4.6	-1.93
Milbury plc	-3.4	-4.1	-0.55	-3.68
Modern Engineering Bristol	-9.7	-0.4	+1.27	-2.94
Moss Engineering Group plc	-1.19	-4.2	-10.9	-4.93
Southern Construction Ltd	2.6	-22.0	-32.0	-17.1
S W Farmer plc	-6.1	1.8	-6.5	+0.73
Means:	-3.63	-2.33	-7.6	

TABLE 7.12: RESULTS OBTAINED FROM THE "FAILED 11" GROUP BY USING AN UPDATED MASON MODEL [3]

Table 7.13 shows the model classifying 70% of the "non-failed" as solvent up to four years prior to failure, but decreases to 55% in the last year. Taking the grey-area limit of ± 2.94 considered very high in this model 15% are misclassified i.e. 3 out of 20 companies are predicted as failed that do not fail.

Years	1983	1984	1985	1986
Solvent	14 (70)	11 (55)	9 (45)	11 (55)
Vulnerable	5 (25)	7 (35)	7 (35)	6 (30)
Failed	1 (5)	2 (10)	4 (20)	3 (15)
Total:	20	20	20	20
Average Z-scores:	4.8	5.56	3.4	3.6

TABLE 7.13: SHOWS PRIOR YEARS CLASSIFICATION OF THE "NON-FAILED" GROUP BY USING AN UPDATED MASON MODEL [3]

	-2	-1	— Last Year
Solvent	-	1 (9)	-
Vulnerable	5 (45)	4 (36)	2 (18)
Failed	6 (55)	5 (45)	9 (82)
Total:	11	11	11
Average Z-score	-3.63	-2.33	-7.6

TABLE 7.14: SHOWS PRIOR YEARS CLASSIFICATION OF THE "FAILED 11" GROUP BY USING AN UPDATED MASON MODEL [3]

7.6 TREND ANALYSIS

7.6.1 Introduction

This section attempts to show the trend analysis for discriminating variables for the three Z-models developed in this study. The attempts were made for non-failed and failed groups and 11 graphs were plotted to show the trend for two groups over four years.

7.6.2 Trend Analysis

The discriminating variables included in three Z-models are shown in Table 7.15 and a graphical representation of the trends of discriminating variables is made in Graphs 7.5 to 7.15.

Financial Ratios		Model 1	Model 2	Model 3
1	PAT/NCE	X	X	
2	EBIT/NCE			X
3	CA/NA	X	X	
4	CL/NA			X
5	TURN/NA	X	X	
6	STL/EBIT	X		
7	INT/EBIT		X	
8	DR/CL			X
9	TAX-TREND	X	X	
10	PAT-TREND	X		X
11	STL-TREND	X		

TABLE 7.15: SHOWS DISCRIMINATING VARIABLES INCLUSION IN THE THREE MODELS

The method of analysis required the arithmetic means of variables to be used in the calculation, these being the average of one year's data for all the companies in a group. It is obvious that when the data of many companies are grouped together to produce an aggregate, the results are in many respects an improvement on the financial data. The following is thus a brief description of non-failed and failed groups trend analysis.

Figure 7.5 profit after tax to net capital employed trend ratio. The trend for "non-failed" companies varies slightly from year to year, and shows a drop in the first year followed by a slight rise in the next year, then another slight drop in the last year. While for the failed group a drastic drop from year to year occurs, thereby reflecting the losses in profit over the period for failed companies which varies between +7% to -19%, while for "non-failed" companies the average ratio varies between 7.7% to 9.4%.

Figure 7.6 current assets to net assets trend ratio. The trend for "non-failed" companies varies slightly from year to year, and shows a drop in the first year followed by a slight rise for the last year of the study. While the graph of failed companies fluctuates widely reflecting instability of current assets in failed companies. Also the increase in current assets to net assets does not reflect the strength of the company since net assets decreasing continuously lead to an increase in this ratio. The average ratio in the "non-failed" companies varies between 1.23 to 1.14, while in the failed group varies between 1.24 to 2.10.

Figure 7.7 turnover to net assets trend ratio. The trend for "non-failed" companies varies slightly from year to year, and shows a rise in the first year followed by a slight drop, then a rise in the last year. The failed group indicates the dramatic rise in the ratio is not real since a drastic decrease in net assets should increase the ratio, i.e. some failed companies may be increasing turn-over by overtrading, a usual phenomenon in failed companies.

The average ratios in non-failed companies varies between 3.19 to 3.3, while in the failed group ^t increases drastically from 1.94 to 4.3 in the year of failure. The graph also shows there is no ordering of the groups.

Figure 7.8 short term loans to earning before tax ratio. The trend for the "non-failed" group varies from year to year for the first two years increase, followed by a drop, while for the failed group a sharp rising trend is evident, so reflecting the dependence of a failed company on short term loans. The ratio varies between 1.18 to 1.49 in solvent companies while in the failed group it varies between 4.08 to 5.62.

Figure 7.9 Tax trend. The graphs for both groups followed a very consistent pattern. Both graphs showed tax trends for solvent groups higher than the failed group, with the failed group sharply decreasing in trend, and varying between +1.2 to -.58.

Figure 7.10 Profit after tax trend. Although the trend for this "non-failed" group fell from year to year, it was positive, while the trend for the failed group was sharper and varied between +.25 to -.44. The "non-failed" companies varied between .538 to .148. The negative values reflect the losses made by the failed company.

Figure 7.11 Short term loan trend. The trend for the "non-failed" group varies from year to year for the first two years and then fell, followed by a rise. For the "failed" group the rise was constant to a crisis level. The trend varied for non-failed and failed groups from doubled every year in the failed group, reflecting high dependence of failed companies on short term loans. Also the two graphs differ from each other.

Figure 7.12 Earnings before tax and interest to net capital employed ratio. The trend for both failed and non-failed groups varies from year to year. The two graphs differ from each other, reflecting the rising profits and growth for the "non-failed" group. The ratio varies between .10 to .117, while for the failed group it varies between 0.077 to .069. In conclusion failed companies may make losses after paying interest and the costs of short term loans.

Figure 7.13 Debtors to current liability ratio. The trend for solvent companies showed a fall in the first year followed by a rise for the last two years, while for the failed group there was constant deterioration, reflecting an increase of current liabilities, when debtors reduced facilities to the failed company.

The two graphs differ from each other reflecting rising debtor facilities to solvent companies.

Figure 7.14 Current liability to net assets ratio. The trend for the "non-failed" group varied from year to year and fell in the first year, followed by a slight rise, while for failed companies the ratio rose constantly to crisis level 1.52. The non-failed group varied between 0.85 to 0.73; also the two graphs differ from each other.

Figure 7.15 Interest to earnings before tax and interest ratio. The trend for solvent companies showed a slight rise in the first year, followed by a decline for failed companies, with a slight drop followed by a sharp increase, thus reflecting the high interest paid by failed companies. Also the two graphs differ from each other.

FIGURE 7.5: THE TREND OF THE MEANS OF PROFIT AFTER TAX TO NET CAPITAL EMPLOYED RATIOS

FIGURE 7.6: THE TREND OF THE MEANS OF CURRENT ASSETS TO NET ASSETS RATIOS

FIGURE 7.7: THE TREND OF THE MEANS OF TURNOVER TO NET ASSETS RATIOS

FIGURE 7.8: THE TREND OF THE MEANS OF SHORT TERM LOANS TO EARNINGS BEFORE TAX AND INTEREST RATIOS

FIGURE 7.9: THE TAX TREND

FIGURE 7.10: THE PROFIT AFTER TAX TREND

FIGURE 7.11: THE SHORT TERM LOAN TREND

FIGURE 7.12: THE TREND OF THE MEANS OF EARNINGS BEFORE TAX AND INTEREST TO NET CAPITAL EMPLOYED RATIOS

FIGURE 7.13: THE TREND OF THE MEANS OF DEBTORS TO CURRENT LIABILITIES RATIOS

FIGURE 7.14: THE TREND OF THE MEANS OF CURRENT LIABILITIES TO NET ASSETS RATIOS

FIGURE 7.15: THE TREND OF THE MEANS OF PAYABLE INTEREST TO EARNINGS BEFORE TAX AND INTEREST RATIOS

Legend:

The trend of the "Failed 11" group

The trend of the "Non-failed 20" Group

7.6.3 Conclusions

The analysis of trends leads to the conclusions:

- The trend in profitability for solvent companies is always positive, while for the failed group it declines sharply and becomes negative in the year of failure. See Figures 7.5, 7.10 and 7.12.
- The trend in current assets for both groups is positive and rises, but the net assets in the failed groups always decline and fluctuate widely, thus reflecting instability of current assets in failed groups. See Figure 7.6.
- The trend in turn-over is not significant since failed companies may increase their turn-over by overtrading and which cannot be predicted by statistical tools. See Figure 7.7.
- The trend in gearing ratios is very significant for identifying the failed company when the trend in net assets gearing rises constantly to crisis level. In contrast solvent groups are generally stable. See Figure 7.14.
- The trend in income gearing for failed groups rises sharply to crisis level at the year of failure, while for the solvent group it is stable. See Figure 7.15.
- The short term loan trend for the failed group rises sharply, while for the solvent group it is stable. See Figure 7.11.

- The trend in liquidity for the failed companies always falls for the last four years before failure, reflecting that debtors decrease their facilities to the failed company when current liabilities are increasing constantly. Solvent companies are considered stable. See Figure 7.13.
- The trend in tax for solvent companies is always positive while for the failed group it declines sharply and becomes negative for the last two years before failure. See Figure 7.9.

7.7 FINANCIAL RATIOS AS A MEANS OF PREDICTING FAILURE

7.7.1 Introduction

Initially ratios measuring liquidity and gearing were considered for the following reasons:

1. Liquidity ratios predict failure better than non-liquidity assets ratios for the period of one or two years to failure, whereas the non-liquidity ratios perform better prediction in long periods prior to bankruptcy. Beaver [5] in a later study returned to a more detailed analysis of the liquidity ratios and their potential as forecasters of failure.
2. Gearing ratios show the extent to which a firm depends on borrowed funds. The greater the use of gearing, the greater the inability of the firm to withstand sudden changes in market conditions and so the higher the probability of its failure as in the construction companies. The data shows that prior to bankruptcy failed firms operate with a higher degree of gearing than the continuing companies.
3. Ratios predicting failure in long periods to bankruptcy such as profitability ratio are not included since its inclusion in the discriminant model.

In this section various ratios are calculated for samples of the "failed 11" and "non-failed 20" companies, and the mean values were compared for two groups.

The ratios of the failed firms were consistently lower than those of the "non-failed" companies. Furthermore in most cases the ratios declined several years prior to bankruptcy or failure. In particular three ratios were sensitive predictors of failure in the short term.

7.7.2 The Three Financial Ratios

The most discriminating financial ratios among 31 ratios tested were:

1. Current ratio: this current ratio indicates to what extent short term assets are adequate to settle short-term liabilities.

The study indicates that the current ratios of failed companies are consistently lower than those of continuing firms. The mean ratios for failed and non-failed groups were 1.16 and 1.66 respectively. A ratio lower than 1.5 is worrying on the grounds of liquidity. In the manufacturing industry the current ratio limit much favoured is about 2 to 1 (Argenti), while this study suggests that 1:1.5 is the more likely ultimate limit for construction firms.

Surprisingly the quick ratio was not significant, reflecting work in progress as being easily convertible to cash in the construction industry. Current ratios of discontinued firms were lower than those of the continuing firms and moreover declined three years prior to cessation of business.

2. Net assets to current liabilities ratio: Current liabilities include creditors, bills pay back, overdrafts, provisions and amounts such as corporation tax payable within one year. Net assets is the sum of fixed assets, intangible assets and total current assets less current liabilities.

Using the ratio of net worth to debt, i.e. net worth equals shareholders, funds less intangible assets, the mean of net assets/current liabilities ratio of continuing companies is 1.76 as compared to 0.81 in the failed firms.

The study revealed that 4 out of 20 of the continuing firms had a ratio less than unity, while 7 out of 11 of the failed firms current liabilities were greater than net assets over two years to failure, and eventually all the failed companies had a ratio of less than 1.0 in the last year of failure.

In 65% of the failed firms the ratio of net assets/current liabilities declined whilst in the continuing firms it remained fairly stable. The conclusion being that a ratio of less than 1.0 places the company in danger of failure. Similarly, by comparison in over 70% of the failed firms in Merwin's [2] sample, the ratio of net worth to debt declined, whilst in the continuing corporations it remained fairly stable.

The increasing reliance on borrowed funds over a relatively long period as substantiated by Beaver's study [3] is shown by the sharp increase in the mean of the debt/assets ratio of the failed companies over the five years prior to failure. During the same period the means of the ratio remained unchanged in the continuing firms.

3. Income gearing or "interest cover": This is the amount of interest the company is committed to pay on its long and short term loans as a ratio of its pre-tax profits. The mean of pre-tax profit/interest ratio of continuing companies is 4.7 as compared to 1.44 in the failed firms.

Nine out of 11 of the failed companies had a ratio of less than 2.0 in the last year of failure. The ratio is considered to be one of the most important single failure predictors in the year of failure. Therefore, we can conclude that a ratio less than 2.0 places the company in danger of failure.

7.7.3 Summary and Conclusions

Additional to discriminating variables in Z-models the following financial ratios are considered the important failure predictors.

- Current assets/current liabilities
- Net assets/current liabilities
- Pre-tax profit/interest

A comparison of the mean ratios for both the failed and non-failed groups concludes that the current ratio of failed companies is lower than the "non-failed" group. The mean ratios for the failed and "non-failed" groups were 1.16 and 1.66 respectively. Also the current ratio in the failed group deteriorates three years prior to failure. Also 10 out of 11 of the failed companies have ratios less than 1.5 in the last year of failure and the mean of the ratio when less than 1.5 and which has deteriorated over at least two years may be considered as a failure sign.

The mean ratios for both the failed and non-failed groups, indicates that the net assets/current liabilities ratio of the failed group is lower than the "non-failed" group. Seven out of 11 of the failed group had a ratio less than unity and the mean of the ratio is less than unity and deteriorating over at least three years may be considered as a failure sign.

A comparison of the mean ratios for both failed and non-failed groups shows that the pre-tax profit/interest paid of failed group is lower than 2.0 in 90% of cases, i.e. the mean of the ratio when below 2.0 in a single year may be a sign of failure.

A summary of results for the non-failed and failed groups is shown in Tables 7.16 and 7.17.

Ratios	CA/CL			NA/CL			EBIT/INT		
Non-failed Co	84	85	86	84	85	86	84	85	86
Aberdeen Const Ltd	0.98	1.1	1.05	1.05	2.1	1.8	4.5	2.1	1.58
Barratt Development	1.8	2.5	2.7	1.28	2.0	2.59	2.9	3.8	3.3
Benlox Holdings plc	1.17	1.2	1.8	1.4	1.33	1.1	9.4	6.8	5.37
Benbailly Const plc	1.6	1.6	1.6	1.02	0.77	0.99	3.0	0.71	0.58
C H Beazer Holds	2.3	2.8	1.88	1.7	2.2	1.55	4.7	5.6	3.3
BIOC plc	1.36	1.38	1.3	0.93	0.96	0.90	5.8	5.0	8.3
Brown and Jackson	2.5	2.3	3.1	2.0	1.8	2.8	3.8	5.1	3.7
Bryan Holdings	1.6	1.56	1.68	1.28	1.18	1.4	10.0	10.0	5.8
Boulton & Paul plc	2.7	2.5	2.5	2.7	2.2	2.5	26.0	25.0	25.0
M J Geeson Group	1.06	1.14	1.12	0.83	1.08	1.11	2.7	4.0	5.0
George Wimpey plc	1.66	1.8	1.66	1.42	1.5	1.5	2.2	2.3	3.2
Henry Boot and Sons	1.4	0.9	0.96	1.0	0.5	0.45	4.0	4.8	1.13
A Monk Co Ltd	1.6	1.6	1.6	1.02	0.9	1.0	2.0	1.8	2.1
Newarthill plc	1.6	1.33	1.5	2.3	1.7	1.58	6.2	5.0	3.4
Rush & Tompkins	1.4	1.16	1.8	1.88	1.42	0.8	1.09	1.17	0.88
Taylor Woodrow	1.5	1.4	1.22	2.1	2.2	2.1	7.3	10.0	11.9
Tarmac plc	1.17	1.4	1.5	1.25	1.56	1.56	6.4	5.7	7.5
Tilbury Group plc	1.3	1.44	1.58	1.3	1.23	1.03	33.0	33.0	33.0
Turriff Corp plc	1.25	1.16	1.12	0.6	0.56	0.7	3.3	3.8	11.0
Wilson Connolly	3.4	3.5	3.5	3.5	3.4	3.3	52.0	52.0	52.0
Means	1.66	1.68	1.72	1.57	1.54	1.52	4.6	4.5	4.5

TABLE 7.16: THE RESULTS OF THE DISCRIMINATOR RATIOS OBTAINED FROM THE "NON-FAILED 20" GROUP IN UNIVARIATE ANALYSIS

Ratios	CA/CL			NA/CL			EBIT/INT		
Years Failed Companies	-3	-2	-1	-3	-2	-1	-3	-2	-1
Beech Wood Group plc	1.6	1.56	1.25	1.59	1.49	0.93	1.07	0.55	1.08
Cocksedge plc	0.5	0.5	0.5	0.5	0.54	0.43	1.9	6.2	1.13
David Charles plc	1.77	1.9	1.5	1.12	1.3	0.98	0.2	3.7	1.03
Crouch Group plc	0.59	0.52	0.66	1.06	1.28	0.9	1.37	0.9	2.0
James H Dennis plc	1.2	0.88	0.95	1.7	0.8	0.56	1.8	0.25	0.5
Mears Bros Ltd	1.25	1.2	1.3	0.54	0.75	0.75	0.74	2.9	0.4
Milbury plc	1.3	1.49	1.25	0.6	0.64	0.7	0.58	0.4	1.16
Modern Eng Bristol plc	1.4	1.2	1.07	1.6	0.8	0.52	0.58	0	0
Moss Eng Group plc	1.47	1.28	1.1	1.05	0.73	0.6	4.4	1.3	0.75
Southern Construction Ltd	1.49	0.85	0.85	1.2	0.25	0.29	4.3	0	0
S W Farmer plc	1.4	1.44	1.25	0.5	0.55	0.33	2.5	3.2	0.9
Means:	1.26	1.16	1.06	0.99	0.83	0.63	1.79	1.78	0.76

TABLE 7.17: THE RESULTS OF PREDICTING RATIOS OBTAINED FROM THE "FAILED 11" GROUP IN UNIVARIATE ANALYSIS

Note The year indicates years before failure:

- CA/CL: Current assets/ current liabilities
- NA/CL: Net assets/current liabilities
- EBIT/INT: Earnings before interest and tax/interest

7.8 SUMMARY AND CONCLUSIONS

The results obtained from the "non-failed 20" and "failed 11" groups using the developed model (1), regression model (2), updated Mason model (3) and using the cut-off as a classification boundary and ignoring 'grey area' developed in section 6.6 are shown in Table 7.18:

Groups	Model 1		Model 2		Model 3	
	(-) Z	(+) Z	- Z	+ Z	(-) Z	+ Z
"Failed 11" Group	11(100)	-	11(100)	-	19(82)	2(18)
"Non-failed 20" Group	2 (10)	18(90)	3 (15)	17(85)	4(20)	16(80)

TABLE 7.18

Both models 1 and 2 100% correctly classified the failed group, while model 3 had a lower discriminating power i.e. 82%.

For the "non-failed" group both models 1 and 2 90% and 85% correctly classified, while model 3 had a lower discriminating power of 80%.

Models 1 and 2 discriminate better than model 3. However taking into account the 'grey area' limit (± 2.94) for model 1 and cut off point zero for model 2, because it has been developed by regression technique, it must be observed that all companies in the "failed 11" group were correctly classified, while 85% were correctly classified in the "non-failed" group with 15% classified as vulnerable. No misclassifications in both groups.

For the failed group the mean values of Z-score by applying both models for the last three years before failure were: -9.66, -11.25, -21.6 and -2.93, -3.40, -3.15 respectively. Ten out of 11 companies of the "failed 11" group scored negatively in the three years prior to failure reflecting the discriminating power of both models.

The following ratios are considered an ultimate test of a company's solvency if their values decrease to limits as calculated:

- Current assets/current liabilities ≥ 1.5
- Net assets/current liabilities ≥ 1.0
- Pre-tax profit/interest ≥ 2.0

Also the study suggests that while the traditional financial ratios are most useful tools, tried and tested, these cannot by themselves give a reliable overall picture of performance of a company and only pinpoint particular areas of concern, ratios cannot on their own predict failure, they only arouse anxiety. Z-scores also are not foolproof, and may be influenced by the economy (e.g. a rise in interest rates would cause a deterioration in all companies gearing).

Finally, Rush and Tompkins plc announced its failure in April 1990, therefore further investigations were made and it was found that the Z-scores for the period 1987-1989 were -1, -4, -16 respectively. Clearly the Z-score declined continuously and declined sharply at least one year before failure. Therefore it was concluded that the average length of time between the company registering an at risk Z-score on 31 March 1986 and the recent announcement was four years.

Additional to the Z-model prediction, the three financial ratios which are developed in Section 7.7 also successfully predicted the same. Table 7.16 shows that the current ratio, net assets/current liability ratio and pre-tax profit/interest ratio were lower than the solvency limits (1.5, 1.0 and 2.0 respectively). Furthermore these ratios deteriorated in 1986 when the company registered an at risk Z-score.

Thus it is essential to use at least two different methods of prediction before coming to a conclusion relating to a suspect company.

CHAPTER 8

VALIDATION OF THE Z-MODELS AND FINANCIAL RATIOS

AS A TOOL FOR PREDICTING FAILURE

- 8.1 Introduction
- 8.2 Validation of Developed Model
- 8.3 Validation of Multiple Regression Model
- 8.4 Validation of Financial Ratios as a Tool for Predicting Failure
- 8.5 Summary and Conclusion

CHAPTER 8
VALIDATION OF THE Z-MODELS AND FINANCIAL RATIOS AS A TOOL
FOR PREDICTING FAILURE

8.1 INTRODUCTION

This chapter presents the procedure taken to validate the developed model and regression model, however the Mason model was excluded due to the high percentage of misclassification errors. Results of the validation were obtained with independent data such as "Test failed 11" and "Test Continued 70" groups.

Section 8.2 includes validation of the developed discriminant analysis model.

Section 8.3 includes validation of an alternative regression technique model and also includes validation of the model in the London Borough of Camden.

Section 8.4 presents validation of the three financial ratios as tools for predicting failure.

The final section briefly discusses the validation of the model linked with critical financial ratios as a tool for predicting failure. A summary of the results is also included.

8.2 VALIDATION OF DEVELOPED MODEL

8.2.1 Introduction

This section deals with validation of the developed MDA model using independent data, being appropriate to check the model with data as follows:

- The "Test failed 11" group with a "failed 11" new group called the "All failed 22" group.
- A "Continued 70" group with the "non-failed 20" group used to develop the model itself, so forming a new group called the "All non-failed 90" group.

This procedure was adopted for two reasons: firstly, to analyse the prior year Z-score for both failed and non-failed groups. Secondly to determine the proportion of companies "at risk" in the population of continued companies. The combined population of "non-failed 20" and "continued 70" groups called the "All non-failed 90" group needs to be considered.

8.2.2 Results from the "Test Failed 11" and "Continued 70" Groups

The results obtained from the independent data for "Test failed 11" and "Continued 70" groups as shown in Tables 8.1 and 8.2 and taking into account the 'grey area' ± 2.94 produces results as shown in Table 8.3:

Companies	-3	-2	Last Year
1. A.C. & K. Builders Ltd	-41	-29	-42
2. Allied Construction Ltd	-28	-10	-18
3. Bowmate Construction Ltd	+7.0	-7.9	-14
4. Bright Brook Builders Ltd	+9.7	+13.5	-31
5. Comber Construction Ltd	-4	-13.6	-67
6. Pevland Construction Ltd	-	-	-20
7. Sphinx Building Const. Ltd	+20	-72	-19
8. Stevens & Sons Building Ltd	+19.6	-24	-19
9. Staines Construction Ltd	+37	-32	-35
10. Stottmills Build. Ltd	-1.6	-31	-132
11. Stream Star Const. Ltd	-2	-34	-35
Average Z-scores	-12	-24	-39

TABLE 8.1: RESULTS OBTAINED FROM THE "TEST FAILED 11" GROUP

Companies____	1984	1985	1986	1987
Amec plc	17.2	15.0	15.0	1.65
Amco Indus Hold plc	-1.0	17.0	-2.90	-
Babcock Cont Ltd	-14.0	-6.2	-8.0	-
Balfour Beatty Ltd	-2.5	-3.2	-6.7	2.135
Bellway Builders Ltd	-8.4	-24.0	-8.3	-
Peter Birse Hold	-36.0	-14.0	17.9	9.9
Bowmer & Kirkland Ltd	16.9	18.9	-3.0	15.0
Bryant Const Ltd	-38.0	-2.9	-9.5	-
Bovis Const Ltd	+80.0	69.0	-	38.3
A F Budge Cont Ltd	14.2	14.6	15.7	-
CBI Const Ltd	54.0	33.0	14.4	-23.0
Cementation Const Ltd	2.1	-12.4	5.5	-
Charles Davies	-	-	-17.0	-
Charles Gray Blds	-21.0	33.0	-	-
Charmwood Const Ltd	6.77	27.0	9.0	-
City of Aberdeen Ass	7.3	9.8	11.5	-
Conder Group plc	-	-29.0	47.0	-5.6
Consolidated Tern Inv	-	-6.4	-6.61	-
Costain Group plc	8.8	14.8	15.0	9.3
Croudace Hold Ltd	13.6	8.9	10.9	-
Dalton Const Ltd	-58	0.85	-	-
Danbury Const Ltd	12.0	4.45	-5.9	-
Davco Const Ltd	31.7	17.6	13.2	53.0
Dencora plc	-	5.4	.74	16.9
Dean & Bowes Group	-	51.0	41.7	-
Robert M Douglas plc	-2.0	1.06	-4.8	-2.0
Dunton Group plc	-	18.6	16.3	9.7
John Elliott plc	-	4.4	4.77	13.0
Eve Const plc	-	-	4.8	9.0
Exeter Bdg & Const	1.3	-	-	-
Galliford plc	9.4	12.0	7.7	33.0
Gargan Const Ltd	26.0	18.0	8.40	-
Gilbert House Invest	24.0	14.3	16.1	-
Haymills Holds Ltd	13.0	12.3	5.9	15.1
Higgs & Hill plc	3.24	5.1	13.9	22.4
Hollandsche Beton	-	-	-2.8	-
Johnston Group plc	2.6	14.8	15.6	16.37
John Laing plc	4.2	2.03	2.5	-.25
J M Jones & Sons	-	11.0	-43.0	-7.6
Kyle Stewart Ltd	-	-.05	12.4	34.0
Walter Lawrence plc	54.0	53.0	1.96	8.2
F J C Lilley plc	-4.4	1.77	7.2	2.09
London & Clyde Hold	10.7	3.3	-.37	-
James Longley & Co	-	-22.0	15.9	-
Y J Lovell Hold plc	-3.0	-4.9	6.3	62.8

Companies	1984	1985	1986	1987
Alfred McAlpine Con	-	1.4	-2.3	8.9
McLaughlin & Harvey	7.9	9.0	2.9	-
R J McLeod Cont	-	-3.0	-10.5	36.0
R Mansell Ltd	-	-25.0	15.0	17.6
May Gurney Holds Ltd	-	-	8.0	21.5
The Miller Group Ltd	-	-	3.4	4.3
John Mowlem & Co	64.0	61.0	74.0	15.9
Norwest Holst Ltd	-	-	5.6	.17
Ogilvie Holds Ltd	-	-	24.0	-
Reema Const Ltd	9.6	6.9	5.07	-
Andrew Scott (Civ)	-	50.0	19.7	-
Seddon Group Ltd	-	15.5	14.7	-
Shepherd Bldg Group	-5.9	-7.9	-7.0	12.7
Simons Const Ltd	11.9	11.9	5.7	-6.8
Sunley Hold plc	-	-	1.0	-
Tarmac Const Ltd	4.3	4.2	11.0	-
Tarmac Homes Midland	12.0	15.0	20.0	-
Tarroch Const Ltd	8.47	11.8	2.05	2.1
G Percy Tretham Ltd	-	15.4	-23.0	-
Trollope & Colls Const	-	5.5	-4.0	-9.0
Wates Const Ltd	-	-1.04	41.0	-
Whittaker Ellis Bdg	5.7	21.5	-9.4	-
Willett Ltd	-	-13.5	-1.05	-22.0
Willmott Dixon Holds	-	-	8.8	15.1
John E Wiltshire plc	4.6	-10.0	73.0	-
Average Z-score	8.96	8.56	9.4	11.56

TABLE 8.2: RESULTS OBTAINED FROM THE "TEST CONTINUED 70" GROUP

FIGURE 8.1: PRIOR YEARS Z-SCORE MEANS TREND OF THE "TEST CONTINUED 70" AND "TEST FAILED 11" GROUPS

Groups	Classified as		
	Failed	Vulnerable	"Non-failed"
"Test failed 11" Group	11 (100)	-	-
"Test Continued 70" Group	9 (13)	14 (20)	47 (67)

TABLE 8.3: CLASSIFICATION OF THE "TEST FAILED 11" AND "TEST CONTINUED 70" GROUPS

One hundred per cent are correctly classified as failed, 67% are correctly classified as non-failed and 20% classified as vulnerable. At first sight control does not appear as good as the 90% result of the "non-failed 20" group, see Table 7.3, used to form the model. Also 13% of "tested continued 70" classified as potential failures do not fail. These companies need further investigation, because of critical financial ratios before coming to a conclusion. In addition statistical evidence is necessary that such models predict better than chance or straight classification of all cases as non-failed.

8.2.3 Results from the "Test failed 11" and "All failed 22" Groups

The classification results for the year prior to failure for the "test failed 11" group are shown in Table 8.4:

Classified as		
Non-failed	Vulnerable	Failed
-	-	11 (100)
Total in Group: 11		

TABLE 8.4: CLASSIFICATION OF THE "TEST FAILED 11" GROUP

Taking into account the 'grey area', the model classified 100% of the "test failed 11" group correctly. This result is as good as the "failed 11 " group used to form the model. This is the real measure of the model's success as a classification device.

Furthermore inspection of the classification results in Table 8.5, indicates a very good result of the total failed sample, 100% are correctly classified as "failed".

Classified as		
Non-failed	Vulnerable	Failed
-	-	22 (100)
Total in Group: 22		

TABLE 8.5: CLASSIFICATION OF THE "ALL FAILED 22" GROUP

8.2.4 Prior Year Z-Score Analysis from "Test Failed 11" Group

Having seen how well the model works on data in the year prior to failure, it would be instructive to consider how far in advance of failure a firm starts to resemble previous bankruptcies.

The results for the "Test failed 11" group are shown in Table 8.6.

Classified as	Accounting year Prior to Company Failure		
	-3	-2	Last
"Non-failed"	4 (40)	1 (10)	-
Vulnerable	2 (20)	- (-)	-
Failed	4 (40)	9 (90)	11 (100)
Total:	10	10	11
Average Z-Scores	-12	-21	-39

TABLE 8.6: PRIOR YEAR CLASSIFICATION OF THE "TEST FAILED 11" GROUP
(Figures in brackets are percentages of total groups)

For the "test failed 11" group the results appear good with the model classifying 90% of the group as failed up to two years prior to failure, and 100% in the last year before failure.

8.2.5 Results from the "Test Continued 70" and "Non-failed 20" Groups
Comparison of the mean Z-scores for "test continued 70" and "non failed 20" groups for the last three years (1984, 1985 and 1986) gives 8.96, 8.56, 9.4 and 9.0, 9.10, 8.59 respectively i.e. both groups seem related to similar populations thereby indicating successful selection particularly of solvent companies.

Figure 8.1 shows the Z-scores of both "test continued 70" and "test failed 11" groups for those prior years. For "test continued 70" group they are constantly above the 'grey area', whereas the "test failed 11" group is generally below the 'grey area', i.e. a clear indication of the discriminating power of the model.

The change in the mean Z-scores is an indication of the changes in the construction industry from year to year, particularly in the case of the "continued" companies. It was not until 1985-86 that construction companies experienced a real improvement in demand while the years 1987, 1988 improvements were mainly in private housebuilding and private sectors (IOC report) [1].

8.2.6 Prior Year Z-Scores Analysis from "Continued 70" and "Non-failed 20" Groups

The classification results for the "continued 70" group are shown in Table 8.7.

Years	1984	1985	1986	1987
"Non-failed"	29 (62)	38 (62)	39 (60)	25 (66)
Vulnerable	7 (15)	8 (13)	14 (20)	7 (18)
Failed	11 (23)	15 (25)	14 (20)	6 (16)
Total:	47	61	67	38
Average Z-score	8.96	8.56	9.4	11.56

TABLE 8.7: PRIOR YEARS CLASSIFICATION OF "CONTINUED 70" GROUP
(Figures in brackets are percentage of total group)

A comparison of the classification results for both the "non-failed 20" and "continued 70" groups are shown in Tables 7.4 and 8.7. It may be seen that more companies are classified as "non-failed" in the "non-failed 20" group than in the "continued 70" group i.e. success was achieved in selecting particularly solvent companies in setting up the "non failed 20" group.

An attempt to determine the proportion of companies "at risk" in the population of continued companies requires consideration of the combined population of "non failed 20" and "Test continued 70" groups called the "All 90" group. The classification results for this group are shown in Table 8.8.

	1984	1985	1986	1987
Non-failed	46 (68)	55 (68)	54 (62)	25 (66)
Vulnerable	10 (15)	9 (11)	16 (18)	7 (18)
Failed	11 (17)	17 (21)	17 (20)	6 (16)
Total Co:	67	81	87	38
Average Z-score:	8.97	8.64	9.2	11.56

TABLE 8.8: PRIOR YEARS CLASSIFICATION OF THE "ALL 90" GROUP
(Figures in brackets are percentage of total group)

From these results it can be seen that on average approximately 18% of the continuing companies in the industry appear to have profiles similar to bankrupts and are therefore "at risk". Further to this on average another 16% of companies are in a "vulnerable" position.

The proportions of companies in danger, however, changes as the economic condition of the country changes and in classifying a company it is important to view the company in relation to the performance of the rest of the industry in the same year.

It can be seen in Figures 8.2 to 8.5 which show the results for the "All-90" group presented the population of construction companies for the years 1984-1987, that the histograms closely resemble the superimposed normal curves. This distribution can provide an indication of the performance of a specific company over the four year period by relating the particular Z-Score to the average of all companies in its sector of industry.

FIGURE 8.2: THE Z-SCORE DISTRIBUTION OF THE "ALL 90" GROUP FOR YEAR 1984 WITH SUPERIMPOSED NORMAL DISTRIBUTION

FIGURE 8.3: THE Z-SCORE DISTRIBUTION OF THE "ALL 90" GROUP FOR YEAR 1985 WITH SUPERIMPOSED NORMAL DISTRIBUTION

FIGURE 8.4: THE Z-SCORE DISTRIBUTION OF THE "ALL 90" GROUP FOR YEAR 1986 WITH SUPERIMPOSED NORMAL DISTRIBUTION

FIGURE 8.5: THE Z-SCORE DISTRIBUTION OF THE "ALL 90" GROUP FOR YEAR 1987 WITH SUPERIMPOSED NORMAL DISTRIBUTION

The company's Z-Score movement may be judged and its position identified at any specific time, for example Figure 8.4 gives a view of the results for the "All 90" group for a particular year, 1986. It can be seen that the histogram closely resembles the superimposed normal curve. The distribution may be used to give an indication of the performance of a particular company. If the company's Z-score for 1986 is less than the mean for 1986, then its performance is obviously less than average.

8.2.7 The Relationship Between Bankrupt and Z-Score Trend

Possession of a bankrupt profile is a necessary condition for failure but may be not sufficient if not also associated with a bankrupt trend for the whole industry, as illustrated in Figure (8.6) where the change in the mean Z-Scores provides an indication of movement from year to year.

Clearly for the period concerned it was not until 1985, that construction companies experienced a real improvement in demand as shown, the trend drop after 1985. The years 1986-1987 were it may be noticed best for the private house building and private sectors.

Overall bankrupt trend slightly rose over the years 1983, 1984 and 1985 followed by a fall in years 1986 and 1987. In contrast the mean Z-Scores of industry reduced during 1984 and 1985. Rising sharply thereafter reflecting the improvement in construction industries as shown in Figure 8.7.

FIGURE 8.6: THE INSOLVENCY TREND IN CONSTRUCTION INDUSTRY

FIGURE 8.7: THE Z-SCORE MEANS TREND IN CONSTRUCTION INDUSTRY REPRESENTED BY "ALL 90" GROUP

8.2.8 Prediction of Bankruptcy Using the Discriminant Model

A prediction of failure is based on the Z-score gained from the model and it is reasonable to assume that the lower the Z-score for a company and the more years the company is classed as "at risk" the more likely that the company is to fail.

Although a "bankrupt" profile is a necessary condition for failure, it is not a sufficient one. Unhealthy firms may be taken over as an alternative to bankruptcy, the government may bail them out, or they may simply be able to recover.

Finally, when a company is classed "at risk" the fate of the company depends on the actions of its debenture holders, bankers and creditors. Therefore, Z-score alone cannot predict failure but can only provide a financial indicator which gives a quantitative indication of the solvency of companies in the hands of the decision makers.

The model can only say that a certain company has a profile very similar to a failed company and therefore has a high probability of failure. Therefore, prediction of bankruptcy using the discriminant model is possible, if the probability of a company actually failing when it is classified "at risk" is calculated.

Some indication of risk can be determined statistically by using a Bayesian approach as follows:

$$P(F/C_f) = \frac{P(C_f/F)}{P(C_f/F) + p(C_f/NF)}$$

$P(F/C_f)$ = probability of a company failing given that it is classified as "failed"

$P(C_f/F)$ = probability of a company being classified as "failed" given that it will actually fail

$P(C_f/NF)$ = probability of a company being classified as "failed" given that it will not fail.

Table 6.5 shows insolvencies in the construction industry during 1986, approximately 3%. Tables 7.5 and 8.6 show that approximately 100% of failed companies were classified as "failed" in their last year.

From this information we can say that:

$$P(C_f/F) = 100\% \times .03 = .03$$

The denominator of equation

$$p(C_f/F) + p(C_f/NF)$$

can be approximated by taking the percentage of companies in the "all 90" group that are classified as "failed". From Table 8.8 we can see that it is 20% for 1986. Thus the probability of a company, classified "at risk" actually failing, can be calculated as:

$$P(F/C_f) = \frac{0.03}{0.20} = 15\%$$

Therefore, statistically there is a a high probability that about 15% of these firms, classified as "at risk" will actually fail in 1987.

A list of companies classified as "failed" in 1986 is as follows:

1. Bellway Builders Ltd
2. Bryant Construction Ltd
3. Danbury Construction ltd
4. R J McLeod Contractors.
5. Shepherd Building Group.
6. Whittaker Builders Ltd.
7. Robert M Douglas plc.
8. Babcock Construction Ltd.
9. Balfour Beatty Ltd.
10. Boomer and Kirkland Ltd.
11. J M Jones and Sons.
12. G Percy Tretham Ltd.
13. Trollope and Colls Construction Ltd.
14. Consolidated Tern Investments.
15. Henry Boot and Sons.
16. Rush and Tomkins Group plc.
17. Charles Davies Ltd.

We expected 15% of these companies to fail in 1987:

$$17 \times 0.15 = 2 \text{ companies}$$

The probabilities tell us that two companies will fail in 1987.

Our study successfully achieved its goal in which the following companies having been predicted as failed companies in 1986 actually failed the following year:

1. Charles Davies Ltd.

Liquidation Voluntary on 20 November 1987.

2. Whittaker Builders Ltd.

Dissolved on 1 September 1987.

Moreover, those "at risk" companies that do not fail in 1987 will not necessarily recover for example J M Jones and Sons Ltd and Rush and Tomkins plc failed in 1989 and 1990 respectively.

It has been shown that failing companies exhibit negative Z-scores for several years prior to failure, so a single year Z-score is not sufficient for prediction failure. Therefore, the individual Z-scores serve to rank the companies in terms of their solvency. The lower the Z-score the more likely a company is to fail.

Thus in conclusion a Z-score alone is insufficient evidence for failure prediction and further financial analysis for companies exhibiting "at risk" Z-scores will be necessary to reinforce the prediction.

8.3 VALIDATION OF AN ALTERNATIVE MULTIPLE REGRESSION MODEL

8.3.1 Introduction

This section includes validation of an alternative model using the independent data described in Section 8.2 and also including the previous groupings as follows:

- "Test failed 11" group
- "All failed 22" group
- "Test continued 70" group
- "All continued 90" group

Part of the validation process was undertaken in cooperation with the London Borough of Camden. The final section briefly summarises the validation of the alternative model.

8.3.2 Results from the "Test Failed 11" and "Continued 70" Groups

The results obtained from the independent data for "Test failed 11" and "Continued 70" groups as shown in Tables 8.9 and 8.10 and taking into account the 'grey area' limits -1.6, are shown in Table 8.11:

Companies	-3	-2	Last year
1 A.C. and K. Builders Ltd	-32.0	-32.0	-35.0
2 Allied Construction Ltd	-8.5	-5.7	-4.7
3 Bowmate Construction Ltd	+8.0	-2.4	-2.6
4 Bright Brook Builders Ltd	-15.0	-11.5	-6.4
5 Comber Construction Ltd	+6.7	-0.22	-6.38
6 Pevland Construction Ltd	-	-	-3.85
7 Sphinx Building Const Ltd	-14.8	-7.36	-7.8
8 Staines Construction Ltd	-13.6	-9.3	-10.2
9 Stevens & Sons Build Ltd	+4.8	0.2	-2.85
10 Stott Mills Build Ltd	-38.0	-62.0	-46.0
11 Stream Star Const Ltd	+4.3	+4.64	-32.0
Averages:	-9.8	-12.6	-14.0

TABLE 8.9: RESULTS OBTAINED FROM THE "TEST FAILED 11" GROUP BY USING MULTIPLE REGRESSION MODEL

Companies	1984	1985	1986	1987
Charles Davis Ltd	-	-	-4.7	-
Bellway Builders Ltd	-2.29	-3.4	-6.6	-4.66
Bryant Const Ltd	-5.8	-7.8	-2.43	-2.35
Bovis Const Ltd	11.8	9.65	18.0	4.56
Charnwood Const Ltd	-10.0	-11.9	2.8	5.7
Dalton Const Ltd	-18.7	9.9	-7.0	-
Danbury Const Ltd	-2.5	3.78	1.75	-2.8
Davco Const Ltd	-	5.57	1.08	-1.0
Gargan Const Ltd	-	4.64	1.0	3.94
Tarmac Homes Midland	-4.9	-1.76	-2.74	-1.87
Tarrook Const Ltd	-	0.055	0.47	+0.38
Tarmac Const Ltd	0.35	1.41	1.58	3.02
CBI Const Ltd	5.6	-1.8	-3.3	19.8
Charles Gray Blds	-0.19	-3.76	2.45	-
Haymills Holds Ltd	-	2.02	2.03	2.34
Ogilvie Holds Ltd	-7.1	-8.7	-	3.8
Eve Const plc	-	-	-	+0.28
Alfred McAlpine Con	-	5.92	-0.36	+0.92
R J McLeod Cont	-	1.16	-0.5	+0.34
Shepherd Bldg Group	-	0.79	0.43	-1.5
Reema Const Ltd	3.2	0.71	1.18	1.17
Andrew Scott (Civ)	4.7	-3.9	12.4	-5.5
Simons Const Ltd	2.75	0.7	4.2	-2.3
Whittaker Builders Ltd	1.7	-0.76	3.4	-1.67
Amec plc	-	1.65	1.54	2.08
Anco Indus Hold plc	-0.42	3.4	-3.7	-
Rush & Tompkins plc	-	-2.12	-1.25	0.14
Costain Group plc	-2.97	2.4	2.57	1.87
Robert M Douglas plc	-	-0.4	0.42	1.14
Galliford plc	2.4	1.85	1.36	5.10
Higgs & Hill plc	1.27	1.56	2.15	3.9
Johnston Group plc	2.7	2.68	3.3	3.01
John Laing plc	0.02	0.137	-0.02	-0.147
Walter Lawrence plc	2.8	8.4	-0.30	1.14
F J C Lilley plc	-	0.37	0.8	5.5
Y J Lovell Hold plc	4.18	-0.13	0.9	10.6
John Mowlem & Co	3.9	9.07	1.13	3.06
Sunley Hold plc	-11.0	-16.0	0.14	-
John E Wiltshire plc	1.3	-4.8	7.3	-
Babcock Cont Ltd	-1.0	-1.7	-1.0	-
Balfour Beatty Ltd	-1.28	-2.3	-1.9	-1.5
Peter Birse Hold	-0.37	1.87	3.13	2.1
Bowmer & Kirkland Ltd	2.06	-3.8	2.75	-0.014
A F Budge Cont Ltd	2.75	2.45	3.4	-
Cementation Const Ltd	-0.9	-3.5	-0.75	-

To be continued

Companies	1984	1985	1986	1987
Croudace Hold Ltd	2.5	1.6	2.23	-
Hollandsche Beton	-8.5	-	-4.7	-
J M Jones & Sons	-	0.9	-5.9	-7.2
Kyle Stewart Ltd	1.6	-0.27	-0.467	4.2
James Longley & Co				
R Mansell Ltd	-0.86	1.79	2.09	1.844
May Gurney Holds Ltd	-	1.77	-0.57	3.45
The Miller Group Ltd	-0.54	-0.96	-0.25	-0.26
Norwest Holst Ltd	-	-2.48	-1.25	-0.81
Seddon Group Ltd	4.16	1.082	3.36	-
G Percy Tretham Ltd	0.95	0.538	0.096	-
Trollope & Colls Const	-1.02	-0.104	-2.32	-1.84
Wates Const Ltd	-3.3	-2.05	-1.53	-
Willetts Ltd	-0.46	-4.4	-0.34	-1.0
Willmott Dixon Holds	-	-0.6	-1.67	-0.864
City of Aberdeen Ltd	-0.144	0.57	0.616	-
Conder Group plc	-6.11	-8.87	-1.867	-2.4
Consolidated Term Inv Ltd	2.34	-4.25	-15.8	-
Dencora plc	1.4	-4.8	-1.02	1.47
Dean & Bowes Group	-	8.9	7.23	-
Dunton Group plc	4.0	3.27	1.928	3.4
Exeter Bdg & Const Ltd	-2.2	-	-	-
London & Clyde Hold Ltd	1.924	-0.47	-0.346	-
McLaughlin & Harvey Ltd	1.15	0.60	0.28	-
Gilbert House Invest	-2.27	1.44	-6.5	-
John Elliott plc	-	-0.553	0.58	0.54

TABLE 8.10: RESULTS OBTAINED FROM THE "CONTINUED 70" GROUP BY USING MULTIPLE REGRESSION MODEL (2)

Groups	Classified as		
	Failed	Vulnerable	Non-failed
"Test Failed 11" Group	11 (100)	-	-
"Test Continued 70" Group	14 (20)	16 (23)	40 (57)

TABLE 8.11: CLASSIFICATION OF THE "TEST FAILED 11" GROUP AND "TEST CONTINUED 70" GROUPS

It can be seen that 100% of firms are correctly classified as failed with 57% classified as non-failed and 23% classified as vulnerable. These results are clearly not as accurate as the model described previously.

Twenty per cent of the "Test continued 70" group are classified as failed compared to 13% in the previous model, reflecting the sensitivity of the model which classified 23% of "Tests continued 70" group as vulnerable. In other words these results reflect the inherent risk of the construction industry.

8.3.3 Result from the "Test Failed 11" and "All failed 22" Groups

The classification results for the year prior to failure for the "Test failed 11" and "All failed 22" groups are shown in Tables 8.12 and 8.13.

Classified as		
Non-failed	Vulnerable	Failed
-	-	11 (100)
Total in Group = 11		

TABLE 8.12: CLASSIFICATION OF THE "TEST FAILED 11" GROUP

Classified as		
Non-failed	Vulnerable	Failed
-	-	22 (100)
Total in Group = 22		

TABLE 8.13: CLASSIFICATION OF THE "ALL FAILED 22" GROUP

The model classified 100% of both "Test failed 11" and "All failed 22" groups as failed for the year prior to failure, i.e. as good as previously indicating that both models classified the failed companies correctly in spite of differences of sensitivity.

8.3.4 Prior Year Z-Score Analysis from "Test Failed 11" Group

The results for the "Test failed 11" group are shown in Table 8.14.

Classified as	Accounting year prior to company failure		
	-3	-2	Last year
"Non-failed"	4 (36)	2 (18)	-
Vulnerable	-	-	-
Failed	7 (64)	8 (72)	11 (100)

TABLE 8.14: PRIOR YEAR CLASSIFICATION OF THE "TEST FAILED 11" GROUP

The model classified 64% of the group as failed up to three years prior to failure, and 72% up to two years, i.e. as good as the results of the previous model.

8.3.5 Results from the "Test Continued 70" and "Non-Failed 20" Groups

By comparing the results of Z-scores for companies classified as failed between the discriminant model and the regression model using the same data of "Test continued 70" and "Non-failed 20" groups, both models appear to classify similarly, i.e. 17 companies are classified as failed by the discriminant model, while the regression model classified 10 out of 17 as failed with the remaining 7 companies classified as vulnerable in 1986 as shown in Table 8.8. Clearly this test is useful in that both models are measuring the same aspect but at a different scale.

The following companies were classified as failed in 1986 in both models:

- Bellway Builders Ltd
- Bryant Construction Ltd
- Danbury Construction Ltd
- Whittaker Builders Ltd
- Balfour Beatty Ltd
- J M Jones and Sons Ltd
- Trollope and Colls Construction Ltd
- Consolidated Tern Investments Ltd
- Henry Boot and Sons plc
- Rush and Tomkins Groups plc

8.3.6 Prior Year Z-score Analysis from "Continued 70" and "Non-failed 20" Groups by the Multiple Regression Model

The classification results for the "Continued 70" and "Non-failed 20" groups both called the "All 90" group are shown in Table 8.15:

Classified as	1984	1985	1986	1987
Non-failed	47 (66)	54 (63)	55 (64)	26 (53)
Vulnerable	10 (14)	10 (12)	15 (17)	13 (27)
Failed	14 (20)	22 (25)	16 (19)	10 (20)
Total Co:	71	86	86	49

TABLE 8.15: PRIOR YEARS CLASSIFICATION OF THE "ALL 90" GROUP BY USING MULTIPLE REGRESSION MODEL

From these results we can conclude that the average of the continued companies in the industry which have profiles similar to bankrupts in both models, are approximately the same as 18% for the last four years, see Table 8.8.

This is a real test of both models. They classify similarly the failed companies but they differ in classifying the non-failed and vulnerable companies. Also we can conclude that the regression model classified companies as vulnerable substantially larger than the developed model, therefore it has less discriminating power than the developed model in spite of its classification of the failed company, better than the developed model.

8.3.7 Validation of Multiple Regression Model at London Borough of Camden

It was decided to test the multiple regression second version model the London Borough of Camden for three reasons:

- Firstly the true predictability of the model is in practice
- Secondly, the model is simple and contains five discriminating variables measuring five different aspects of company structure.
- Thirdly the model classified the failed companies (privately owned companies) better than the developed model. The model classified 64% of the failed companies as failed up to three years before failure, while the developed model classified 40% for the same period.

The discriminant model was originally developed for medium size to large companies, while the multiple regression second version was presumed better for private companies because of its emphasis on the income gearing ratio, which is indeed an indicator of financial weakness in small companies.

Practically, the practitioner needs to know who is at risk. The model has been applied on 200 construction companies dealing with the London Borough of Camden. By taking the classification boundary -1.6 as threshold, the results showed that the discriminating power of the model was better than Altman's model which was mainly developed for manufacturing companies.

Although the model is the second model developed in Britain after Mason's model for the construction industry during the past decade, it proves its operational use as a tool in vetting construction companies on tender lists. Whatever the success the model has achieved, the model should however never be used as the sole decision tool. The experts are aware of the potential dangers of relying exclusively upon the results of a single test (see letter from London Borough of Camden in Appendix D). The aims of this report have been matched to the experts approach of company failure by using different tools to approaching failure.

8.4 VALIDATION OF FINANCIAL RATIOS AS A TOOL FOR PREDICTING FAILURE

8.4.1 Introduction

This section includes validation of the following financial ratios as a tool to predict company failure which are researched in Section 7.6:

- Current assets/current liabilities ratio
- Net assets/current liabilities ratio
- Pre-tax profit/interest ratio.

Also this section includes a validation link between the Z-score and these financial ratios as a tool for predicting failure, by dividing the "All quoted 90" group into two groups:

Group 1 includes 73 companies which are classified as none failed in 1986 by both Z-score models.

Group 2 includes 17 companies which are classified as failed and vulnerable in 1986 by the same Z-score models. A comparison of the financial ratios in both groups provides us with a link between Z-score and these ratios, to enhance the predictability for both Z-modes and these ratios.

8.4.2 Results from the "Test Failed 11" Group

The results obtained from the "Test failed 11" group for the last three years before failure are shown in Table 8.16.

Test Failed Companies	CA/CL		NA/CL		EBIT/INT	
	-2	-1	-2	-1	-2	-1
1 A.C. & K. Builders Ltd	.51	0.01	-.15	1.0	2.2	1.06
2 Allied Construction Ltd	1.38	3.05	0.41	2.03	1.7	0
3 Bowmate Constructio Ltd	1.08	1.015	0.33	0.17	0	0
4 Bright Brook Build. Ltd	1.0	0.93	1.0	1.0	0.28	0.37
5 Comber Construction Ltd	0.63	0.81	0.207	0.23	0.5	1.06
6 Pevland Construction Ltd	-	0.84	-	0.028	-	1.36
7 Sphinx Builders Ltd	0.66	0.11	0.15	0.77	0	0
8 Staines Construction Ltd	0.66	0.73	0.33	0.65	0	0
9 Steven & Sons Build Ltd	3.1	3.5	2.2	2.59	0	0
10 Stott Mills Build Ltd	0.6	0.45	0.02	0.29	0	0
11 Stream Star Constr Ltd	1.48	0.68	1.04	0.04	0	0

TABLE 8.16: THE RESULTS OF DISCRIMINATING RATIOS OBTAINED FROM THE "TEST FAILED 11" GROUP IN UNIVARIATE ANALYSIS

Note: The year indicates years before failure:
CA/CL - current assets/current liabilities
NA/CL - net assets/current liabilities
EBIT/INT - earnings before interest and tax/interest

The results show that the current ratio i.e. the ratio of current assets to current liabilities for the "Test failed 11" companies are worse than those in the "Failed 11" companies in Section 7.7, where 8 out of 11 group has a current ratio < 1.0 , while the "failed 11" group, 4 out of 11 group has a ratio less than 1.0. Relatively the ratio is less than 1.5 which is worrying on the grounds of liquidity, and therefore it was decided to reduce the value of this ratio to 1.0 as an ultimate test of company solvency.

Also the results show that the ratios of net assets to current liabilities for the "Test failed 11" group are worse than those in the "Failed 11" group in Section 7.7. Eight out of 11 have a ratio of < 1.0 for the last three years before failure, while 7 out of 11 of the "Failed 11" group have a ratio less than unity.

Also closer scrutiny of the results of the "Test failed 11" group with the "Failed 11" group in Section 7.7 reveals that the "Test failed 11" group had a gearing ratio worse than those in the "Failed 11" group, whereas all the "Test failed 11" companies the ratio was less than 2.0. In the "Failed 11" group 9 out of 11 had a ratio of less than 2.0. Thus suggesting that any company resembling failure probably has at least two ratios below a specific limit, for example, Bright Brock Builders Ltd has a ratio net asset/current liabilities > 1 , but its current assets/current liabilities < 1 and pre-tax profit/interest < 2 .

Similarly Bowmate Construction Ltd has current assets/current liabilities > 1.0 , but its net assets/current liabilities < 1 and pre-tax profits/interest < 2 .

The remaining companies in the "Test failed 11" group had the three critical ratios below the specific limit in this study. The "Test failed 11" group with "Failed 11" group are now combined to form a new group called the "All failed 22" group, with results as follows:

The current ratio for the "All failed 22" group shows that 17 out of 22 of the group is less than unity. Also the net assets to current liability ratio for the "All failed 22" group in 15 out of 22 of the group is less than unity, i.e. percentages of misclassification are 23% and 32% respectively in this group.

Furthermore the pre-tax to interest ratio for the "All failed 22" group in 20 out of 22 of the group is less than 2.0, i.e. percentage of misclassification is 9%. Indeed 2 out of 22 of the group had two ratios above the specific limits while the remaining group had all the three ratios below the specific limit.

By comparing the above results with results obtained from the "non-failed 20" group (see Section 7.4), they show that one out of 20 of the group is less than unity. Also the net assets to current liability ratios for the "non-failed 20" group, 5 out of 20 of the group, is less than unity, i.e. percentages of misclassification are 5% and 25% respectively. Furthermore, the pretax profit to interest ratio for the "non-failed 20" group, 4 out of 20 of the group is less than 2.0, i.e. percentage of misclassification is 20%. Nevertheless 3 out of 20 of the group had two ratios below the specific limits. The ratio with the smallest error of misclassification and therefore the best single predictor was current assets/current liabilities followed by income gearing ratio and net assets/current liabilities ratio. This was done mainly on the basis of the dichotomous classification technique [see Beaver (3)].

The dichotomous classification technique predicts the likelihood of bankruptcy through the use of a given financial ratio only.

The firms are arbitrarily divided into two groups and arranged (for each ratio) in ascending order. An optimal cut-off point is chosen through trial and error as the demarcation line for failing i.e. any firm below it being categorised as a failed firm. The results are then compared with actual data to find the percentage of incorrect predictions. Often many trial times are repeated before the optimal cut-off point is reached.

8.4.3 Validation of the Z-Score Linked with Discriminating Financial Ratios as Predictors

It was decided to validate the discriminating financial ratios linked with the Z-score for two reasons. Firstly, there may be a company that does not respond to Z-score models and gives freak results. Secondly, the experts warn of relying exclusively upon the results of a single test.

The results of critical financial ratios for companies classified as non-failed by both Z-models group (1), and companies classified as failed or vulnerable by both Z-models group (2) are shown in Tables 8.17 and 8.18.

Companies	CA/CL		NA/CL		EBIT/INT	
	-2	-1	-2	-1	-2	-1
1 Babcock Const Ltd	0.83	0.83	0.27	0.3	3.6	10.0
2 Balfour Beatty Ltd	1.8	1.1	0.3	0.3	10.0	8.0
3 Benbailly Const Ltd	1.6	1.6	0.97	0.99	0.71	0.58
4 Bowmer & Kirkland Ltd	1.2	1.1	0.7	0.45	27.0	6.0
5 Bryant Const Ltd	0.72	0.63	0.43	0.67	3.17	2.7
6 Consolidated Tern Inv	0.97	0.78	0.38	0.08	0.3	0.4
7 Danbury Constr Ltd	0.96	0.81	0.83	0.82	2.0	2.0
8 J.M. Jones & Sons Ltd	0.7	0.96	0.28	0.22	5.6	3.7
9 Henry Boot & Sons Ltd	0.9	0.95	0.46	0.42	5.0	1.12
10 G. Percy Tretham Ltd	1.14	1.1	0.89	0.69	2.3	2.8
11 R.G. McLeod Cont Ltd	1.4	1.33	1.0	0.98	11.0	10.0
12 Rush & Tomkins plc	1.16	1.01	1.48	0.81	1.17	0.88
13 Robert M. Douglas plc	1.04	0.99	0.66	0.73	3.0	6.4
14 Shepherd Build Group	1.8	1.8	1.7	1.8	8.4	13.0
15 Trollope & Colls Con	1.9	1.7	0.91	0.73	2.0	2.0
16 Whittaker Build Ltd	1.33	1.35	0.6	0.52	15.0	16.0
17 Bellway Const Ltd	0.52	0.5	0.54	0.71	1.8	1.16

TABLE 8.17: THE RESULTS OF DISCRIMINATING RATIOS OBTAINED FROM THE "CLASSIFIED FAILED 17" GROUP

Companies	CA/CL		NA/CL		EBIT/INT	
	-2	-1	-2	-1	-2	-1
Bovis Const Ltd	1.6	1.6	0.55	0.53	62.0	62.0
Charnwood Const Ltd	0.21	0.37	1.53	6.2	1.6	0.58
Dalton Const Ltd	1.35	1.25	0.5	0.33	25.0	2.0
Davco Const Ltd	1.23	1.58	0.81	1.3	2.0	2.0
Gargan Const Ltd	0.9	1.0	2.9	1.5	0.9	2.5
Tarmac Homes Midland	1.8	1.47	0.9	0.72	13.0	1.0
Tarrook Const Ltd	1.25	1.33	0.5	0.55	2.0	0.55
Tarmac Const Ltd	1.0	0.96	0.17	0.17	2.0	2.0
CBI Const Ltd	1.4	1.35	0.58	0.43	0.77	1.7
Charles Gray Blds	1.28	1.1	0.5	0.4	1.1	2.2
Haymills Holds Ltd	2.0	2.0	1.8	2.1	2.0	2.0
Ogilvie Holds Ltd	0.66	1.1	0.1	0.8	7.0	2.6
Eve Const plc	1.5	1.5	1.05	1.0	22.0	22.0
Alfred McAlpine Con	1.29	1.28	0.5	0.5	10.0	10.0
Reema Const Ltd	1.6	1.66	0.94	1.05	10.0	10.0
Andrew Scott (Civ)	1.92	2.2	1.35	1.63	5.0	10.0
Simons Const Ltd	1.4	1.4	1.8	1.5	1.47	0.63
Amec plc	1.13	1.08	0.58	0.52	14.0	18.0
Amec Indus Hold plc	1.0	1.0	0.6	0.6	3.0	0.8
Costain Group plc	0.77	0.66	1.72	1.85	6.0	5.0
Galliford plc	1.16	1.1	0.62	0.55	12.0	12.0
Higgs & Hill plc	1.5	1.66	1.13	1.25	8.0	17.0
Johnston Group plc	1.8	1.66	1.7	1.85	14.0	14.0
John Laing plc	1.28	1.28	0.52	0.5	10.0	11.0
Walter Lawrence plc	1.4	1.56	0.61	0.73	2.1	3.7
F J C Lilley plc	1.4	0.9	1.07	0.25	3.0	11.0
Y J Lovell Hold plc	1.58	1.56	1.01	0.85	5.5	7.0
John Mowlem & Co	1.01	1.2	0.68	0.9	5.5	7.8
Sunley Hold plc	2.3	2.0	1.9	2.5	2.6	1.6
John E Wiltshire plc	1.1	1.1	0.25	0.25	2.17	1.08
Peter Birse Hold	1.38	2.6	0.87	0.68	8.0	13.0
A F Budge Cont Ltd	1.33	1.1	1.88	2.3	3.8	5.5
Cementation Const Ltd	1.2	1.4	0.33	0.57	10.0	10.0
Croudace Hold Ltd	1.4	1.66	1.7	1.73	1.6	2.3
Hollandsche Beton	0.76	0.9	0.04	0.2	4.0	1.4
Kyle Stewart Ltd	0.9	0.96	0.5	0.5	2.6	2.5
James Longley & Co	1.7	0.96	0.5	0.5	2.6	2.5
R Mansell Ltd	1.01	1.03	0.44	0.45	10.0	10.0
May Gurney Holds Ltd	0.67	0.67	1.09	1.17	5.0	1.1
The Miller Group Ltd	0.72	0.66	0.7	0.83	1.92	2.4
Norwest Holst Ltd	1.25	1.4	0.5	0.73	6.5	2.6
Seddon Group Ltd	4.0	4.0	4.6	5.0	10.0	10.0
Wates Const Ltd	1.53	2.1	0.53	1.18	2.0	2.0
Willett Ltd	1.9	1.9	0.92	0.94	1.2	6.4

To be continued

Companies	CA/CL		NA/CL		EBIT/INT	
	-2	-1	-2	-1	-2	-1
Willmott Dixon Holds	1.1	1.1	0.5	0.58	1.0	0.9
City of Aberdeen Ltd	2.1	2.9	1.14	2.09	4.6	4.3
Conder Group plc	1.0	1.1	0.35	0.31	0.4	1.4
Dencora plc	1.29	1.12	4.0	2.8	0.3	0.54
Dean & Bowes Group	1.24	1.52	0.95	1.31	20.0	20.0
Dunton Group plc	1.4	1.85	1.62	3.5	2.8	3.0
Exeter Bdg & Const Ltd	1.32	1.18	0.91	0.65	2.0	0.79
London & Clyde Hold Ltd	1.7	1.76	1.03	1.12	3.0	2.6
McLaughlin & Harvey Ltd	1.4	1.35	1.04	1.1	5.2	4.47
Gilbert House Invest	0.84	0.43	5.9	3.3	0.72	0.22
John Elliott plc	1.1	0.97	0.31	0.176	3.4	32.0
Aberdeen Construction plc	1.1	1.05	2.1	1.8	2.1	1.58
Barratt Development	2.5	2.7	2.0	2.59	3.8	3.3
Benlox Holdings plc	1.2	1.8	1.33	1.10	6.8	5.33
C H Beazer Holdings	2.8	2.88	2.2	1.55	5.6	3.3
BIOC plc	1.38	1.30	0.96	0.90	5.0	8.3
Brown and Jackson	2.3	3.1	1.8	2.8	5.1	3.7
Bryant Holdings	1.56	1.88	1.18	1.4	10.0	5.8
Boulton and Paul plc	2.5	2.5	2.2	2.25	25.0	25.0
M J Geeson Group	1.14	1.12	1.08	1.11	4.0	5.0
George Wimpey plc	1.8	1.66	1.5	1.5	2.3	3.2
A Monk Company plc	1.6	1.6	0.9	1.0	1.8	2.1
Newarthill plc	1.33	1.5	1.7	1.58	5.0	3.4
Taylor Woodrow	1.4	1.22	2.2	2.1	10.0	11.9
Tarmac plc	1.4	1.5	1.56	1.56	5.7	7.5
Tilbury Group plc	1.44	1.58	1.23	1.03	33.0	33.0
Turriff Corporation plc	1.15	1.12	0.56	0.7	3.8	11.0
Wilson Connolly Holdings	3.5	3.5	3.9	3.3	52.0	52.0

TABLE 8.18: THE RESULTS OF DISCRIMINATING RATIOS OBTAINED FROM THE CLASSIFIED AS "NON-FAILED 73" GROUP

The results obtained from groups 1 and 2 for 1986 Z-scores indicate that 6 out of 73 of group (1) have current asset ratios less than unity, while for 8 out of 17 of group (2), the ratio is less than unity. Also, 30 out of 73 of group (1) have net assets/current liabilities ratio less than unity compared to 15 out of 17 of group (2). In addition 14 out of 73 of group (1) have pre-tax to current liabilities ratio less than 2.0, compared to 4 out of 17 of group (2).

Furthermore 12 out of 73 of group (1) have two critical ratios less than the specified limits in contrast to group (2). Seven out of 17 have two critical ratios less than the specified limits.

These tests indicate that companies in group (2) classified as failed using Z-models, have critical ratios less than those classified as non-failed.

Clearly the Z-scores linked with the critical ratios are good predictors of failure. Indeed, there were a few companies classified as non-failed using only Z-models but had two critical ratios below the specified limits indicating that some companies do not fully respond to the Z-model and need further analysis like financial ratios.

8.5 SUMMARY AND CONCLUSIONS

Although the results of validation of both Z-models were convincing and performed well on the data used in this study for quoted and unquoted companies, application of the model at the London Borough of Camden proved a very rewarding real experience in vetting companies for tender lists in particular, and generally the smaller unquoted companies.

However, in conclusion unfortunately not all companies responded to the Z-model and other extra indicators such as traditional ratios tried and tested by time, are invaluable support evidence, particularly the critical ratios which have shown deterioration over several years.

This study was especially successful in using the Z-model with critical ratios in identifying a short list of companies at risk with confidence. However too much reliance on this aspect should be avoided in that a certain company may only have a profile very similar to a failed company indicating a high probability of failure, but the fate of the company always depends on personal judgement of debenture holders, bankers and creditors etc.

Nevertheless it is reasonable to expect that the lower the Z-score, and deteriorating ratios for a company, and the more years the company is classified at risk, the more likely that company is to fail. However, unhealthy firms may be taken over as an alternative to bankruptcy, government assistance may be at hand, or they may simply be able to recover.

CHAPTER 9

MANAGERIAL FACTORS RELATING TO COMPANY FAILURE

- 9.1 Introduction
- 9.2 Particular Factors of Failure by a Case Study Approach
- 9.3 Management Defects and Management Mistakes
- 9.4 Survey Related to Managerial Defects and Mistakes
- 9.5 Summary and Conclusions

CHAPTER 9
MANAGERIAL FACTORS RELATED TO COMPANY FAILURE

9.1 INTRODUCTION

The previous sections continued to treat Z-scores and financial ratios with considerable respect as both these finance-based tools suffer from two potential defects; firstly, creative accounting, and secondly management mistakes which cannot be predicted statistically.

Companies generally fail because of inadequate management, the simple expedient of applying accounting ratios to all companies will not necessarily give a true reason for the reasons of failure. Furthermore some companies identified as certain failures by any accounting method, can survive because experienced managers adequately deal with the adverse situation.

Generally two indicators may be observed as a company moves towards collapse, namely financial, as has already been seen in Z-scores and traditional financial ratios. Unfortunately an indication appears only towards the end of the long process of failure, probably only in the last two years and sometimes even later.

Secondly, long before financial distress becomes visible, many non-financial signs are often apparent such as management mistakes. Indeed many financial experts stress that balance sheet information alone is not enough to predict catastrophic factors such as bad management, economic down turn, overtrading, acquisition of a failed company, excessive inventories, too much paper work and so on should

not be overlooked. Thus some form of non-finance based analysis is also needed to classify a company at risk of failure.

Section 9.2 identifies particular factors in failure by a case study approach.

Section 9.3 briefly explains the management defects and management mistakes as evidenced in other investigations and a case study.

Section 9.4 describes a survey conducted into management defects and management mistakes.

The final section briefly discusses the managerial factors related to company failure and provides a summary of the survey results.

9.2 PARTICULAR FACTORS OF FAILURE BY A CASE STUDY APPROACH

9.2.1 Introduction

It is essential to identify the factors behind failure before coming to a conclusion relating to a suspect company. A case study is a very sensible approach to identify particular factors in failure. Indeed a substantial amount of work has already been carried out into the reasons for particular failures via case studies, particularly Cork Gully, see Appendix D for example. The following companies were declared bankrupt with Cork Gully appointed as liquidator:

1. Southern Construction Ltd
2. Crouch Construction Ltd and Crouch Group plc.
3. Mears Bros Holdings Ltd.

9.2.2 Case Study (1)

Southern Construction Ltd entered into receivership as a result of a fall in turnover over several years, with the major reason for this deterioration being related to acquiring the Caffin Division of Ernest Ireland Group, including its offices at Rickmansworth and various employees, plus an assignment of several contracts. Ultimately the acquisition decision proved disastrous due to the fact that the new firm's activities did not fit in well with the existing business [see Appendix D].

9.2.3 Case Study (2)

Crouch Construction Ltd became a wholly owned subsidiary of Crouch Group plc in April 1978 and embarked upon a rapid expansion in contract work, particularly local authority housing.

The company then suffered severe losses beginning around April 1983 culminating in the holding company changing the board of directors of this company. The report stated that the trading position of Crouch Construction Ltd during 1983/84 suffered as a result of poor trading on contracts taken on at tight margins during a period of recession. Further problems had also arisen from the numerous changes in directors and senior staff.

Furthermore the company suffered from a continuing shortage of working capital caused by tied up funds in the stock of land for private house building purposes. With continued losses on contracts, Crouch Construction Ltd went into liquidation. The Group Board then found it impossible to continue trading without additional bank support. The Bank was unable to agree to provide an increased facility in excess of the existing borrowing. Legal advice was taken, and the Directors considered they had no alternative other than to request the Bank to appoint Receivers [see Appendix D].

9.2.4 Case Study (3)

Mears Bros Holdings Ltd was the parent company of a group of building, civil engineering and contracting companies.

In the mid 1970's the Group decided to expand its activities overseas. As part of this effort Mears Construction formed Mears International to act as civil engineering contractors in the Middle East. During this period Mears Construction also expanded its UK operations, the bulk of which consisted of civil engineering work such as roads, reservoirs, sea defences, public building work and public housing.

After 1978 the trading position had deteriorated considerably. It was reported that the failure of the Group was attributed by the Directors of Mears Holdings to the following factors:

1. Certain major contract loss-making due to adverse weather conditions and the tight price of contracts.
2. The delay by clients in the settlement of certain substantial claims on contracts.
3. The demands made upon the Group banking facility due to losses incurred by other companies within the Group.
4. The financial drain caused by attempts to establish a contracting trading base overseas.
5. The short term cash effects of the move to Swindon.

9.2.5 Conclusions

In reviewing the reasons for failure for these examples of failed companies, failure might be displayed in non-financial signs of deterioration as well as financial ones.

The failure of Southern Construction was caused by a deteriorating turnover observed in balance sheet information as well as managerial acts such as acquiring a disastrous company such as Caffin Division of Ernest Ireland.

The failure of Crouch Construction Ltd and Crouch Group plc were due to deteriorating profits, also as shown in balance sheet information, as well as managerial acts like too many changes of directors and senior staff.

Also, the failure of Mears Bros Holdings Ltd was due to deteriorating liquidity also to be seen in balance sheet information as well as managerial acts such as the delay in claim settlements and losses on overseas contracts.

The following managerial acts could be included as leading to company failure:

1. Acquisition of a failing firm.
2. Overtrading.
3. Losses in contract claims.
4. Losses in overseas contacts.
5. Inexperienced staff
6. Passive board of directors.
7. High leverage trading.
8. Weak response to market change.

9.3 MANAGEMENT DEFECTS AND MANAGEMENT MISTAKES

9.3.1 Introduction

The purpose of this section is to describe a number of specific defects observed to be existing in company management. For decades managers, receivers, academics have made lists of these defects, as published in financial journals and previous studies. In particular John Argenti [7] describes some in his latest research work in the UK. Such deficiencies lead management into mistakes.

9.3.2 Management Defects

The following are considered the major deficiencies in a company's management:

1. Autocratic Chief Executive:

The autocrat may be distinguished from the team leader by the way he dominates the company, especially indicated by preservation of a position of sole authority.

2. The same person as both chief executive and chairman:

A most important task of the company chairman is to be able to dismiss an inadequate chief executive; someone who is both is unlikely to do this.

3. The company board comprises too many non-contributing directors or persons not working in the company.

4. Lack of engineering skills.

5. Lack of a strong finance director:

It is not enough for finance directors to exercise financial skills, they must also be able to make financial decisions. An indication of a weak finance director is shared responsibility for financial decision making.

6. Defective managerial skills:

Companies may fail from defective finance or poor human relations, or inadequate marketing or legal skills as much as from poor engineering experience.

7. Incomplete accountancy system:

a) Inadequate cash flow plan. The financial department either has no cash flow plan, or one that is not updated or reviewed periodically.

b) Poor budgetary control system. The company either has no budgets prepared at all, or the budgets are prepared but are not reviewed periodically.

8. Defective bidding system:

When senior management are insufficiently experienced in bidding or bidding decisions are taken without cross-referring with other senior management.

9. Poor marketing skills:

A main task of the board is to review the perspective of the market. Indeed there is almost complete agreement among specialists in this field that companies that fail are those which have either not noticed a change in their business market, or have not responded to it.

Typically many construction companies have invested heavily in land and property during boom periods, subsequently when prices slowed down and interest rates increased, substantial or occasionally critical losses have been incurred.

9.3.3 Management Mistakes

Management sometimes make a mistake which leads to failure many years after the first critical decision was taken. Typical examples include:

1. Too much reliance on short term loans. Companies sometimes issue debentures with a fixed interest rate in order to raise investment funds. Failing companies often appeared to allow leverage of these loans to rise to a level at which its future was placed in jeopardy. In a previous study Argenti has illustrated that companies run by ambitious autocrats, not constrained by strong finance directors, are particularly liable to make such errors.
2. Overtrading. Companies often try to expand business to a point which will not cause overtrading typically a company expanding faster than its funding. For example, Mears Bros Holdings Ltd [see Appendix D] expanded its UK and overseas operations quickly leading to shortages in cash flow before failure. In preference an expanding company should try to increase its equity base instead of relying on loans.
3. Losses in projects. Companies that fail are often those that have undertaken large projects, involving an excessive inventory building or high technical industrial construction.

Similar effects can result from guaranteeing the loan of a subsidiary company. The obligation may not be able to be met if matters deteriorate particularly:

a) Contract claims:

Administration should ensure that these are given the proper attention, carefully analysed and documented, to be equitably resolved as soon as possible. Once a claim has been resolved, a charge order should be issued to cover the resolution. Unresolved claims cause shortage in liquidity and therefore could lead to failure.

One of the main reasons behind the failure of Mears Bros Holdings Ltd seemed to be improper handling of substantial claims on contracts.

b) Overseas Contracting:

Work abroad seemed to be a good option for large firms suffering declines in their home market. However, some companies suffered huge losses due to lack of managerial control in an unfamiliar environment. Indeed, Mears Bros Holdings Ltd suffered a critical financial drain attempting to establish a contracting trading base overseas.

4. Acquisition of a Potentially Failing Firm. A company may unfortunately take over a firm and later find a hidden difficult financial situation resulting in disaster if the acquired firm fails. Indeed Southern Construction Ltd failed primarily due to acquiring the Caffin Division of the Ernest Ireland Group.

Sometimes unhealthy firms are taken over as an alternative to bankruptcy, eventually causing the take over company also to fail. Indeed results obtained from the "Taken over 9" group show that 2 out of 9 were classified as failed two years before take over, with a further 2 out of 9 classified as vulnerable in the last year before take over. The remaining 5 companies were classified as non-failed but their Z-scores deteriorated from year to year.

9.3.4 Summary and Conclusions

From case studies and previous studies [see Appendix D] the main defects in a company's management appear to be:

1. Autocratic chief executive.
2. The same person acting as both chief executive and chairman.
3. The board of directors comprises non-contributing and executive directors.
4. Lack of engineering experience.
5. Lack of a strong finance director.
6. Inadequate managerial skills.
7. Defective accountancy system.
8. Defective bidding system.
9. Inadequate marketing skills.

Other important factors leading to failure are:

1. Too much reliance on a short term loan.
2. Overtrading
3. Losses in projects.
4. Taking over failed firms.

9.4 SURVEY RELATED TO MANAGERIAL DEFECTS AND MISTAKES

9.4.1 Introduction

Previous sections diagnosed the major managerial defects and mistakes leading to failure. A questionnaire was thus designed to identify these defects and mistakes and to try and discover which corrective actions companies had taken to help survive. The survey included two groups as follows:

Group 1: Companies classified as potential failures but not failing i.e. those scoring negatively by both Z-models, i.e. "failed" or "vulnerable".

Group 2: Comprised companies scoring positively by both Z-models, i.e. those classified as "non-failed" by both models.

By comparing the two groups, some of the reasons for revival were ascertained as well as determining the reasons for financial distress. Both groups were selected non-randomly in which criteria of selection was based on those medium size companies operating in construction and civil engineering which have limited liabilities and are classified in two groups according to their Z-scores for the last three years. Since there are significant differences in Z-scores in both groups there could be a difference in managerial system.

9.4.2 The Survey

Ninety companies were contacted and 28 responded. Unfortunately ultimately only seven provided enough information for each group as shown in Tables 9.1 and 9.2:

Company	Model 1 (Origin)			Model 2 (Regression)		
	84	85	86	85	86	87
1 Babcock Ltd	-14.0	-6.2	-8.0	-1.0	-1.7	1.0
2 Consolidated Ltd	2.0	-6.4	-6.6	2.3	-4.25	-15.8
3 Cementation Ltd	2.1	-12.4	5.5	-0.9	-3.5	-0.75
4 Henry Boot & Sons	4.6	-11.2	-5.3	2.9	3.3	-1.2
5 J M Jones Ltd	11.0	-43.0	-7.6	0.9	-5.9	-7.2
6 Trollope & Colls Ltd	5.0	-4.0	-9.0	-1.02	-1.04	-2.3
7 Willet Ltd	-13.5	-1.05	-22.5	-0.46	-4.9	-0.34

TABLE 9.1: SHOWS Z-SCORE FOR GROUP (1) BY USING BOTH Z-MODELS

Company	Model 1			Model 2		
	84	85	86	85	86	87
1 A F Budge Cont Ltd	14.2	14.6	15.7	2.75	2.45	3.5
2 Petbirs Hold Ltd	14.0	17.9	9.9	1.87	3.13	2.1
3 Tarmac Cont Ltd	4.3	4.2	11.0	1.48	1.58	3.02
4 Haymills Hold Ltd	12.3	5.9	15.2	2.03	2.34	2.48
5 Kyle Stewart Ltd	0	12.4	34.0	-0.27	-0.467	4.2
6 Croudace Hold Ltd	13.6	8.96	10.9	2.5	1.6	2.23
7 R Mansell Ltd	-25.0	15.0	17.6	1.79	2.09	1.84

TABLE 9.2: SHOWS Z-SCORE FOR GROUP (2) BY USING BOTH Z-MODELS

9.4.3 Results from the Survey

— The existence of managerial factors related to failure was investigated in the questionnaire using the multiple choice method, (see Appendix D). The questionnaires included 17 questions related to failure for both groups and produced the following observations:

- i) The chief executive of the company has sole authority in 6 out of 7 companies in group (1), while in group (2), only 3 out of 7 has this condition, i.e. the chief executive in group (1) had sole authority more than group (2) i.e. 86% in group (1) and 43% in group (2). The results reinforce the opinion that companies in group (1) experienced more difficulties than those companies with an assistant or deputy with authority.
- ii) The chief executive and chairman are the same person. One out of 7 in group (1) had a combined chief executive and chairman post, while in group (2) 5 out of 7 demonstrated this characteristic. Thus as long as a company is run by a team of managers with authority, a better chance of survival seems most likely.
- iii) The board of the company comprises persons not working in the company. Two out of 7 of group (1) and 3 out of 7 of group (2) company board comprised persons not working in the company. While strong conclusions are not possible, companies may be more successful if outside persons are involved at least in authoritative decision making at the highest level as indicated by companies in group (1) classified as vulnerable.

- iv) Engineering experience. Over 70% of both groups employed engineers with less than ten years experience and little can be deduced.
- v) Lack of a strong finance director. Information supplied by companies particularly identified this problem. Indeed finance directors should be clearly responsible for their company's financial decision making. In all the companies of group (1) the financial director had shared authority, while 4 out of 7 of group (2) had similar responsibility. Since group (1) had more financial difficulties than group (2), the presence of a weak financial director may be a main factor behind the financial difficulties.
- vi) Lack of overall management skills observed. Only 1 out of 7 of group (1) had managers with average experience less than ten years, while none of group (2) had this deficiency. This defect in both groups seems minor, therefore any observer should not place too much emphasis on this point as in both groups managers were generally well experienced.
- vii) Defects in accountancy system. In the failing companies the finance department either had no cash flow plan or one that was not regularly updated. Borrowing requirements for the next month, quarter, or a year ahead were generally poorly evaluated. All companies in group (1) produced cash flow plans reviewed periodically, while 1 out of 7 in group (2) had not produced a cash flow plan. The survey however revealed that all companies in both groups (1) and (2) had budgetary control systems. Also, generally all construction companies had a good accountancy system, but some companies had a weak finance director.

viii) Bidding methods. In 2 out of 7 of group (1), middle managers and specialists in bidding did not in all cases contribute, in contrast group (2) middle managers always were involved in the bidding process.

ix) Lack of response to market change. Four out of 7 in group (1) had insufficiently responded to market changes, while 2 out of 7 of group (2) indicated a slow response to market change. Against the competition and with rapid change in the construction market, companies need to be strongly placed in the market. Gork Gully [Chartered Accountants] believes that most companies suffer financial distress when attitudes to market changes are weak. Furthermore, almost complete agreement exists among specialists in that failing companies are those which have either not noticed a change in their business environment or have not responded to it (John Argenti [7]).

Typically construction companies that have invested heavily in land and property during a boom period, in a subsequent slow down accompanied by increasing interest rates, often incurred losses that may lead to failure.

Some particular factors in failure raised in the survey include:

i) Debentures: Normally companies issue debentures with a fixed interest rate in order to raise investment funds. Failing companies often then allow leverage to rise to a level where its future is placed in jeopardy.

No company in group (1) had issued debentures, but 1 out of 7 in group (2) had done so. Thus debentures could be viewed as a helpful means of stemming financial difficulties compared to other loan forms.

- ii) Overtrading: Companies often try to expand to a limit which will not lead to overtrading. In group (1) 2 out of 7 firms appeared to do this, while no company in group (2) had done so. Clearly group (1) companies had taken such risks e.g. J.M. Jones Ltd but small compared to the size of the company. Overtrading generally results when a company expands faster than its capital. This gives an indication of overtrading when the ratio of turnover to capital employed becomes very high. In our case $\times 7.27$ and 4.4 , respectively, i.e. excessive for the size of business.
- iii) Losses in projects: A company may undertake loss making projects, perhaps resulting in disaster in the largest cases. Six out of 7 of group (1) and 2 out of 7 of group (2) had made such commitments. Although group (1) firms incurred losses more than group (2), some companies in the survey considered the resulting losses small compared to size of business, e.g. Tarmac Construction Ltd. Misjudgements of this kind were not significant in big firms, while for small firms the results could mean bankruptcy.
- iv) Taking over a failing firm: A company may take over another firm and later find a hidden difficulty. The financial situation may then deteriorate if the acquired firm fails. Indeed Southern Construction Ltd failed due to acquiring the Caffin Division of

the Ernest Ireland Group. In our case, 1 out of 7 of each group incurred such losses. However the size of losses depends upon _____ the size of company. For example, Taylor Woodrow plc who are not included in both groups, describes such losses as minimal in the context of company size. Furthermore, in boom periods mergers often intensify to facilitate expansion of resources and so allow more ambitious undertakings, while in a recession mergers are more likely for diversification reasons to temper fluctuations or because of an opportunity to acquire cheaply.

- v) Diversification: An attempt to take corrective action by diversifying business in order to secure a reasonable existence in another sector or even in the same line of business to smooth out the fluctuations in demand can be achieved by diversification. The survey indicates no company had diversified business into other sectors.
- vi) Contract claims: In the survey 4 out of 7 of group (1) and 2 out of 7 of group (2) had undertaken projects involving contract claims resulting in significant losses. Clearly, unresolved claims are potential causes of failure, however large companies like Henry Boot Ltd and Tarmac Construction Ltd were able to sustain significant losses from contract claims, but the effects could be more severe with small firms. As seen from the previous section, Mears Bros Holdings Ltd in particular appeared to have failed because of the delay by clients in the settlement of certain substantial claims on contracts. R D Gilbreath [38] recommends the elimination or reduction of the incidence of claim provoking conditions and claims themselves. When claims have to be presented the contract administrator should ensure

that they are given the proper management visibility within the owner's organisation, carefully analysed and documented and equitably resolved as soon as possible.

- vii) Overseas projects: In the survey, work abroad seemed to be a favoured option for large firms, suffering decline in their home market. Two out of 7 of group (1) and 1 out of 7 of group (2) involved in overseas projects reported significant losses. As seen in the previous section, Mears Bros Holdings Ltd which failed had suffered a critical financial drain when attempting to establish a contracting trading base overseas. Generally losses on overseas projects could be due to lack of managerial control or restrictive regulations in these countries.

9.4.4 Conclusions

Comparison of the effects of managerial factors related to failure in both groups produced the following survey findings:

- The existence of managerial factors in group (1) is obviously more than in group (2).
- The effects of these factors depends upon the size of company i.e. managerial factors related to failure were not significant in large firms, while for the smaller type the deficiencies could cause bankruptcy.
- The majority of companies negatively Z-scoring in group (1) were dominated by an ambitious chief executive with sole authority as seen in 6 out of 7 of group (1) and not constrained by strong finance directors as demonstrated in all companies in group (1) where the financial director had shared authority.

- The majority of companies which are negatively Z-scoring in group (1), were incurring losses in projects, whereas 6 out of 7 of group (1) had been incurring big losses additional to losses in contract claims.
- The majority of companies negatively Z-scored had high leverage i.e. total liability to equity > 3 also the mean ratio of group of total liability/net assets > 2.

9.5 SUMMARY AND CONCLUSIONS

Managerial factors related to failure in order of importance appear to be as follows:

- Weak finance director
- Chief executive sole authority without assistant.
- Average experience of engineers less than 10 years.
- No quick response to market changes.
- Non contributory persons on company's board.
- Senior management staff not involved in bidding process.
- Average experience for management staff less than ten years.
- Chief executive and chairman same person.

Particular defects in order of importance were as follows:

- Losses in projects.
- Losses in contract claims.
- Losses from overseas projects.
- Overtrading.
- Taking over a failing firm.

CHAPTER 10

THE A-SCORE

- 10.1 Introduction
- 10.2 Formation of Data Group
- 10.3 The Developed A-Score Model
- 10.4 Validation of Results from the "Test 14" Group
- 10.5 Relationship Between A-Score and Z-Score
- 10.6 Summary and Conclusions

CHAPTER 10

A-SCORES

10.1 INTRODUCTION

The concept behind the A-score is based on the belief that if a company is in financial difficulty the reasons generally relate to inadequate management ability and errors perpetrated earlier.

This section is an attempt to rank the factors related to failure in order of importance and to produce a weighted result. The factors were previously described in Chapter 9.

The A-score is designed to introduce a measure of quantification of failure prediction. However, an A-score is dependent upon personal judgement normally insufficient to draw firm conclusions, in contrast company ratios analysis and Z-score evaluates are generally much more objective.

Practically, the A-score should be used only for a suspect company when:

- accounts are not available or are late
- accounts suffer from "creative accounting"
- Z-scores or ratios give freak results.

Section 10.2 reviews previous studies.

Section 10.3 includes formation of data groups.

Section 10.4 describes briefly the developed A-score model.

Section 10.5 includes results obtained from the "solvent 7" and "at risk 7" groups.

Section 10.6 includes validation of the Z-score model.

Section 10.7 describes the relationship between A-score and Z-score models.

The final section briefly discusses the results and summarises the results with conclusions.

10.2 FORMATION OF DATA GROUP

There was a general problem in obtaining the required information for a large number of companies, mainly due to the policy restrictions. Furthermore the data should include failed firms but difficulties were encountered in persuading such firms to answer the questions.

An alternative approach was to investigate continuing firms with similar financial profiles to failing firms. In response 28 out of 90 continuing firms were prepared to provide information from which 7 out of 28 were classified as vulnerable and placed in an "at risk 7" group i.e. those scoring negatively by the Z-score model. Of the 21 remaining firms 7 were placed in the "solvent 7" group, i.e. those scoring positively by the Z-score model. The remaining 14 firms were placed in a "test 14" group. A list of companies in the "at risk 7" and "solvent 7" groups are as follows:

A list of companies "at risk 7":

1. Babcock Contractors Ltd
2. Cementation Construction Ltd
3. Consolidation Tern Investments Ltd
4. Henry Boot and Sons
5. J.M. Jones Ltd
6. Trollope and Colls Ltd
7. Willet Construction Ltd

A list of companies classified as "solvent 7" group:

1. A.F. Budge Ltd
2. Peter Birse Holdings Ltd
3. Tarmac Construction Ltd
4. Haymill Contractors Ltd
5. Kyle and Stewart Cosntruction Ltd
6. Croudace Construction Ltd
7. R. Mansel Contractors Ltd

The two groups were analysed statistically and significant differences between groups were found to exist, (see Appendix E).

10.3 THE DEVELOPED A-SCORE MODEL

As was seen in the previous section the "solvent 7" and "at risk 7" groups were used successfully for comparison of the effects of managerial factors related to failure and therefore were selected in developing the A-model.

Managerial factors related to failure described in the previous Chapter in order of importance were as follows:

1. Weak finance director
2. Chief executive sole authority without authorised assistants.
3. Average experience in years for engineers, less than ten years.
4. Slow response to market changes.
5. Non-executive persons on the company board.
6. Senior management staff do not participate in bidding.
7. Average years of experience of management staff less than ten years.
8. Chief executive and chairman, same person.

Also, the identified managerial errors related to failure in order of importance were as follows:

1. Making losses on projects.
2. Making losses in contract claims.
3. Making losses in overseas contracts.
4. High leverage.
5. Taking over failing firms.

Having identified the relevant factors they are now weighted for the survey sample of "solvent 7" and "at risk 7" groups.

The A-score for a company is then obtained by adding the weight of all factors together. Tables 10.1 and 10.2 show the A-score results obtained from the "at risk 7" and "solvent 7" groups.

- The least A-score in group (1) considered to indicate vulnerability is 50. All companies in group (1) scored above 50, a reasonable cut off value between vulnerable and solvent companies.

- In sample group (1) virtually all the companies were clearly in danger in contrast to the strong group (2).
- All companies of group (2) scored less than 50 with a mean value group score of 37.7. The mean value of group (1) was 65.85.

"At risk 7" Group Companies	A-Score
1 Babcock Contractors Ltd	62
2 Cementation Construction Ltd	72
3 Consolidation Term Investments Ltd	62
4 Henry Boot Ltd	96
5 J M Jones Ltd	50
6 Trollop and Colls Ltd	69
7 Willet Construction Ltd	50

TABLE 10.1: SHOWS RESULTS OBTAINED FROM "AT RISK 7" GROUP (1)

"Solvent 7" Group Companies	A-Score
1 A F Budge Ltd	31
2 Peter Birse Holdings Ltd	45
3 Croudace Construction Ltd	41
4 Hymill Contractors Ltd	29
5 Kyle and Stewart Construction Ltd	47
6 R. Mansell Ltd	28
7 Tarmac Construction Ltd	43

TABLE 10.2: SHOWS RESULTS OBTAINED FROM "SOLVENT 7" GROUP (2)

10.3.1 Weighted Results

The items related to failure weighted in accordance with their importance produced the following list:

	<u>Managerial Factors Related to Failure</u>	<u>Weighting</u>
1.	Weak finance director	17
2.	Autocratic chief executive	14
3.	Lack of engineering skills	12
4.	Poor response to market change	10
5.	Senior management staff not experienced in bidding	5
6.	Company board comprised persons not working in the company	5
7.	Chief executive and chairman, same person	2
8.	Lack of managerial skills	<u>2</u>
Total:		67

	<u>Managerial Errors Related to Failure</u>	<u>Weighting</u>
1.	Making losses in projects	14
2.	Making losses caused by contract claims	7
3.	High leverage	5
4.	Making losses caused by overseas contracts	5
5.	Making losses caused by taking over failing firms	<u>2</u>
Total:		33

10.3.2 Method of Scoring

1. The scores are given only if the observer is confident that the factors and errors are clearly evident in the suspect company, otherwise nils are recorded.

2. The score should be full values or zero. Intermediate scores are not permitted.
3. The overall critical mark is 50. A company scoring above that level is considered vulnerable, clearly a score of this level when accompanied by a negative Z-score should signify a crisis.

10.3.3 Statistical Analysis

The two groups were analysed statistically and significant differences between groups were found to exist (see Appendix E).

10.4 VALIDATION OF RESULTS FROM THE "TEST 14" GROUP

Although the results in the previous section indicate that the A-score model is discriminating between "solvent" and "at risk" companies well the true test of the model's accuracy requires validation of independent data. The results obtained from data for 14 companies are shown in Table 10.3.

Companies	A-Scores
1. Alfred McAlpine Construction Ltd	74
2. Balfour Beatty Construction Ltd	39
3. Ben Baily plc	48
4. C H Beazer plc	24
5. Costain Construction Ltd	76
6. Dunton plc	24
7. Higgs plc	48
8. F J Lilly plc	81
9. John Laing Construction	50
10. Miller Group plc	46
11. Mowlem Group plc	50
12. Taylor Woodrow plc	50
13. Walter Lawrence plc	41
14. Willmot Dixon Construction Ltd	50

TABLE 10.3: THE A-SCORE FOR "TEST 14" GROUP

Three out of 14 of the "test 14" group are classified at risk, even when scoring above 50. These were very large companies, namely: ____

1. Alfred McAlpine Ltd
2. Costain Construction Ltd
3. F J Lilly plc.

Thus some caution should be exercised when dealing with large companies and A-scores need to be viewed with more tolerance than small companies. Furthermore, by examining the Z-scores of these companies, all scored positively. Of the total "test 14" group 78% are correctly classified as solvent, when scoring less than 50 with their Z-score also positive.

Thus at first sight the results do not appear as good as the 100% correctly classified in both the "solvent 7" and "at risk 7" groups. Thus it must be concluded that an A-score alone is an insufficient tool for prediction failure. However the results are quite valuable when placed alongside the Z-score and financial ratios methods.

10.5 RELATIONSHIP BETWEEN A-SCORE AND Z-SCORE

The results obtained from "at risk 7" and "solvent 7" groups indicate that there may be a relationship between A-score and Z-score, which would be useful if proven statistically, (see Appendix E).

Unfortunately the results obtained from statistical analysis show that the inter-correlations between A-score and Z-score are only 67.7% i.e. not very strong. However, the Z-score value of zero also corresponds to an A-score of about 50 i.e. the values considered critical in both models. Nevertheless, these results may still be misleading because of the small number of companies in the survey.

The results also indicate that when the Z-score falls below zero, the corresponding A-score increases above 50 i.e. the value considered to be a cut-off between "at risk" and "solvent" companies.

10.6 SUMMARY AND CONCLUSIONS

The A-score was developed to systematise failure prediction by quantification measures based on non-financial features and then linked with Z-scores.

It could be concluded that there is a link between Z-score and A-score. As was seen from the results of "at risk 7" and "solvent 7" groups, those companies scoring negatively in the Z-model also have A-scores above 50 in 100% of the "at risk" group.

Furthermore the results of the "test 14" group show that 3 out of 14 companies scoring positively in the Z-model had A-scores above 50, these being large firms whose strength and reputation can stave off insolvency for some considerable time.

Another point of interest is the possibility the A-score concept might be a suitable measure for those firms engaged in rescues. Put simply when a company moves down the path to failure its A-score rises above 50 and to return to a healthy situation the items that contribute to A-scores have to be corrected, for example, replacing a weak finance director or reducing leverage etc.

Other alternatives might be:

- a merger
- diversification
- issuing debentures.

Finally, the above described analysis does not by itself deal with the actions required to return a failing company to health, but only to improve predictive ability by highlighting the factors and errors which may lead to failure.

CHAPTER 11

DISCUSSION AND CONCLUSIONS

- 11.1 Introduction
- 11.2 The Z-Score
- 11.3 The Traditional Ratios
- 11.4 The A-Scores
- 11.5 Research Findings
- 11.6 Recommendations for Implementing the Research Findings for
Vetting Construction Companies on Tender Lists
- 11.7 Contribution of Thesis to Construction Industry
- 11.8 Further Research Work

CHAPTER 11

DISCUSSION AND CONCLUSIONS

11.1 INTRODUCTION

Construction is a high risk business, clearly therefore advantages accrue if potential failures can be recognised at the earliest possible stage and thereby minimise costs of liquidation to all concerned. Some method is apparently needed which will give a quantitative indication of the solvency.

This chapter discusses some of the other methods available to predict company failure, also considers linkages between them. The three methods developed in this research were namely the Z-scores (see Section 11.2), the traditional ratios (Section 11.3), and the A-score technique (Section 11.4). This latter method of failure identification however operates on different principles to either the Z-scores or the traditional ratios.

Section 11.5 brings all the research findings together and attempts to conclude how well the methods developed meet the research objectives.

Section 11.6 makes recommendations for implementing the research findings in practice.

Finally the chapter presents the conclusions of the thesis and recommendations for future studies.

11.2 THE Z-SCORES

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This research is first detailed attempt to develop a Z-scores model for construction companies in the UK following Mason's earlier work in the late 1970s and covers development of three new Z-models and reexamination of Mason's model.

Two of the models failed to meet completely all the underlying statistical criteria required in the discriminant approach because of the small number of company accounts in the survey, restrictive policies of construction firms in providing sensitive information, and also "creative accounting" of some suspect companies.

Nevertheless, both these models were able to distinguish between "failed" and "solvent" companies well and could identify a short list of "at risk" i.e. the profiles are very similar to failed companies and that they are likely to experience financial distress which may cause failure.

Indeed the results obtained from the "all-90" group continuing companies in the industry indicate that over the last four years 17% and 20% respectively have profiles similar to those bankruptcies in both models. See Tables 8.8 and 8.15. This is a real test of both models.

Furthermore the regression model classified companies as vulnerable substantially better than the original model particularly with respect to sensitivity to failed company data, although the model had less discriminating power than the original model. It also classified the geared up company better than the original model i.e. those companies

relying on borrowed funds over a long period. In practice industry prioritise those firms typified to be at risk and for this reason a decision was made to evaluate the regression model further with the London Borough of Camden with over 200 firms involved with this local authority. By taking the classification boundary at the -1.6 threshold, the discriminating power of the model was shown to be good.

Further verification of the quality of both models can be seen in their composition with similar discriminating variables. The main difference being that the regression model includes five variables, indeed 3 out of 7 of the discriminating variables in the original model were removed and replaced by better representatives, namely income gearing ratio, i.e. the ratio of interest to profit before tax and interest.

Figure 7.15 shows the trend in income gearing for the failed group rising sharply to crisis level at the year of failure while for the solvent group its value is stable indicating the discriminating power of this variable.

The updated results of Mason's model are shown in Section 7.5 which indicates the model has less discriminating power than those developed in this research and thus needs further testing to provide its validity.

Finally when applying Z-scores in vetting construction companies on tender lists, the user should consider the following:

- not to rely on single Z-score values for a single period. At least three years or maybe a longer period may be needed because some companies continue in the business depending on their capabilities.
- individual Z-scores serve to rank companies in terms of their solvency, the lower the Z-score or the more companies exhibit negative Z-scores for several years indicate more likelihood of failure.
- the study introduced a distribution to give the user an indication of the performance of a particular company, i.e. if the company Z-score for 1986 is less than the mean for the industry in 1986 then its performance is obviously less than average (see Figure 8.4).
- Z-scores alone cannot predict failure but only provide a financial indicator to give a quantitative indication of the solvency of a company, or a simple rule for gauging financial health.

11.3 THE TRADITIONAL RATIOS

Among 31 financial ratios analysed in this study, only three ratios were considered to be reliable failure prediction tools i.e. those critical ratios reflecting financial difficulties in a company (see Sections 7.7, 8.4).

The results obtained from the "All failed 22" group produced the following values:

- the current ratio in 17 out of 22 of the group is less than unity
- the net assets to current liabilities ratio in 15 out of 22 of the group is less than unity

- the pretax profit to interest ratio in 20 out of 22 of the group is less than 2.0
-

Furthermore, the study suggests that the above ratios can help to identify failing companies when deterioration has continued over several years. Also the study showed that a company with a low Z-score and deteriorating ratios is likely to fail.

Finally, the study managed to combine Z-scores with critical ratios i.e. companies classified as failed by Z-scores analysis when the critical ratios were also less than the specified limit for these ratios.

11.4 THE A-SCORES

The A-score was developed to systematically predict failure with a quantification measure based on non-financial features linked to Z-scores.

The A-score alone was by itself an insufficient tool for predicting failure, but provides a valuable indicator when placed alongside Z-scores and financial ratios.

It was apparent from the results that Z-scores below zero and A-scores above 50, are values considered to be cut-offs between at risk and solvent companies, the exception being large firms which need to be viewed more tolerantly because of strength and reputation. Usually, small companies suffer first in a recession period and therefore become more vulnerable than large firms [interview with Addy of Cork Gulley].

Finally the A-score concept might be very suitable for those engaged in rescues, put simply when a company moves down the path to failure its A-score rises above 50. To return to a healthy situation the items that contribute to A-scores have to be corrected, for example replace a weak finance director or reduce leverage etc.

11.5 RESEARCH FINDINGS

The ultimate findings of this work are:

1. There are likely to be two features of company failure; firstly financial as has been seen Z-scores and traditional ratios are indicators of approaching failure, which generally appear in the last three years before collapse. Secondly, non-financial features as observed through A-scores.
2. Z-scores alone cannot predict failure; similarly a combination of traditional ratios and Z-scores.
3. There will be companies that do not respond to Z-scores analysis and give freak results. Similarly traditional ratios cannot always provide a reliable overall picture of performance but can pinpoint particular areas of concern. Some large firms do not always respond to A-scores and need to be examined by other tools.
4. Z-scores and traditional ratios are liable to be influenced by changes in the economy i.e. a rise in interest rates which may cause a deterioration in all gearing for all companies.

5. Traditional ratios and Z-scores should be ranked with those for its own sector of industry.
6. Z-score models need redevelopment when they become "old and tired" as "bankruptcy prediction models are fundamentally non-stationary" (see Mensah, 1984 [18], pp391) also the test of Mason's model after 10 years in Section 2.3.6 .
7. Prediction of bankruptcy using Z-scores is likely when the probability using a Bayesian approach (see Section 8.2.8) of a company actually failing is classified as at risk can be calculated approximately.
8. The results obtained from the "All 90" group, suggest that 18% of continuing companies in the industry might have profiles similar to the bankruptcy profile in both Z-models i.e. approximately 18% to be over the last four years (see Tables 8.8 and 8.15).
9. Failure signs can be seen in financial ratios and indicate an increasing reliance on borrowed funds over at least a three year period. In particular net assets to current liabilities ratios of failed companies decrease, while the ratio remains stable in the continuing firms.
10. The current ratio in failed companies deteriorates at least two years prior to failure, while in continuing firms it remains stable. Pretax profit to interest ratio of failed companies is lower than 2.0.

11. The following ratios are considered to be an ultimate test of company solvency, if their values decrease to specific limits as calculated from the means of "All failed 22" and "Non-failed 20" groups (see Section 8.4.2):
 - current assets/current liabilities < 1.0
 - net assets/current liabilities < 1.0
 - pretax profit/interest < 2.0
12. The results obtained from 73 continuing companies with positive Z-scores had the above three ratios as follows:
 - i) 6 out of 73 of the group had a current ratio less than unity (see Section 8.4.3)
 - ii) 30 out of 73 of the group had a net assets to current liabilities ratio less than unity thus reflecting that over 40% of construction companies rely on having borrowed funds, considered to be unusual in other industries.
 - iii) 14 out of 73 of the group had a pretax profits to payable interest ratio less than 2.0.
13. Twelve companies out of 73 of the group had two ratios mentioned above less than the specified limits of the "failed 22" group i.e. about 16% of continuing companies have profiles similar to failed companies.
14. The lower the Z-score and deteriorating ratios for a company and the more years the company is classified at risk the more likely that company is to fail.

15. The evaluation of the managerial factors related to failure in order of importance were as follows:
- weak finance director
 - chief executive sole authority without authorised assistants
 - lack of engineering skills
 - poor response to market change
 - non-contributing persons on company board
 - senior management staff not involved in bidding process
 - lack of managerial skills
 - chief executive and chairman, same person.
16. The evaluation of management errors in order of importance were:
- making losses in projects
 - making losses in contract claims
 - making losses in overseas contracts
 - high leverage
 - taking over failing firms
17. The results obtained from case studies showed that the following factors and errors can lead to failure:
- poor trading on contracts taken on at tight margins
 - delays in settlement of substantial claims
 - losses incurred by other companies within the group such as guaranteeing loans of a subsidiary company
 - acquiring failing firms with activities not fitting in well with the parent business
 - financial drain caused by expansion of home or overseas work.

18. The analysis of trends of failed and non-failed companies was as follows: ____

- profitability ratios for solvent companies is always positive, while for failed firms declines sharply and becomes negative (see Figures 7.5, 7.10, 7.12)
- current assets to net assets ratio for failed firms rises due to increased reliance on borrowed funds, net assets decrease sharply, current assets remains stable in continuing firms (see Figure 7.6)
- turnover to net assets ratios for failed companies rises due to overtrading, while for continuing companies remains stable (see Figure 7.7)
- current liabilities to net asset ratios for failed companies rises due to increased reliance on borrowed funds with sharp decreases in net assets, but for continuing companies remains stable (see Figure 7.14).

11.6 RECOMMENDATIONS FOR IMPLEMENTING THE RESEARCH FINDINGS IN VETTING CONSTRUCTION COMPANIES ON TENDER LISTS

To obtain reliable results in vetting construction companies on tender lists, application of the developed models of this study as classification devices required the following to be implemented:

- Financial ratios and Z-scores should be ranked with those in its own sector of industry. It is important to view the company in relation to the performance of the rest of the industry.

- Produce a distribution of Z-scores for the industry each year, and compare the performance of a particular company with the mean of Z-scores for that year.
- There is potential danger in relying upon the results of single tests, at least two methods should be adopted in vetting construction companies on tender lists.
- At least two financial ratios out of the three critical ratios are needed to give results less than the specified limits and to exhibit negative Z-scores for at least three years before coming to the conclusion that a company is "at risk".
- A-scores should only be used for companies exhibiting failure Z-scores and/or critical ratios methods.
- A-scores should be viewed more tolerantly for large compared to small firms because of their strength and reputation in the market.

For a systematic appraisal of contractors, the procedure is as shown in Figure 11.1 and is designed to facilitate the vetting of construction companies on a tender list. However, the developed models should only be used as part of an overall assessment of company stability. Any predictions should be interpreted with caution as the models require further testing on a broader range of companies. It is also important to appreciate that the use of such models to exclude companies from tender lists could accelerate or even cause failure.

FIGURE 11.1: SHOWS A SYSTEMATIC APPRAISAL OF CONTRACTORS IN THE CONSTRUCTION INDUSTRY

Model (1)

$$Z_1 = 14.6 + 82 V_1 - 14.5 V_2 + 2.5 V_3 - 1.2 V_4 + 3.55 V_5 - 3.55 V_6 - 3 V_7$$

V₁ : As a ratio of earnings after tax and interest to net capital employed -

V₂ : A a ratio of current assets to net asset

V₃ : A a ratio of turnover to net asset

V₄ : A a ratio of short term loan to earnings before tax and interest

V₅ : As a tax trend

$$V_6 : \text{Earnings after tax trend} : \frac{E_n + E(n-1) - E(n-2)}{2} \\ \frac{\quad}{E(n-2)}$$

$$V_7 : \text{Short term loan trend} : \frac{L_n + L(n-1) - L(n-2)}{2} \\ \frac{\quad}{L(n-2)}$$

Model (2)

$$Z = 2.81 - 2.84 X_1 + 15.3 X_2 - 2.08 X_3 + 0.581 X_4 + 0.282 X_5$$

X₁ : As a ratio of current assets to net asset

X₂ : As a ratio of earning after tax and interest to net capital employed

X₃ : As a ratio of interest to earning before tax and interest.

$$X_4 : \text{Tax trend} \frac{T_n + T(n-1) - T(n-2)}{2} \\ \frac{\quad}{T(n-2)}$$

X₅ : As a ratio of turnover to net asset

Note ;

- The denominator is taken as the absolute value
- The trend ratios are calculated for year n.

FIGURE 11.2: KEY TO FIGURE 11.1

11.7 CONTRIBUTION OF THESIS TO THE CONSTRUCTION INDUSTRY

This research provides an insight into the methodology of predicting company failure in the construction industry and offers an opportunity to link several methods together in order to systematically appraise contractors on tender lists. Until now other construction based systems in the UK have been unavailable.

The research provides several models which provide quantitative indications of the solvency of companies.

Finally, the research highlighted managerial factors contributing to failure and provides the A-score test suitable for those engaged in rescues.

11.8 FURTHER RESEARCH WORK

1. Development of an expert system package to help in vetting construction companies on tender lists, perhaps using the models indicated in this research.
2. Produce an alternative remedy to bankruptcy for companies classified at risk in the construction industry.
3. Development of quantitative measures to return a failing company to health in the construction industry, perhaps using the models indicated in this research.
4. Multivariate Discriminant Analysis approach for analysing merger activity in the construction industry.

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APPENDICES

- A. Manual for Use with the Fortran Program "ADNAN-FOR" for the Computation of Financial Ratios
- B. A Manual for Use with the "SPSS-X" Statistical Package for the Social Sciences Sub-program "Discriminant" an output
- C. A Manual for Use with the Minitab Statistical Package and its Output
- D. Correspondence, diagrams, case studies and questionnaire
- E. Statistical Tests

* * * * *

APPENDIX A

MANUAL FOR USE WITH THE FORTRAN PROGRAM "ADNAN-FOR" FOR THE COMPUTATION OF FINANCIAL RATIOS

1.1 INTRODUCTION

The Fortran program, ADNAN.FOR developed to perform the financial ratio calculations and data manipulation including:

- the User Manual
- the Program Documentation

1.2 USER MANUAL

1.2.1 Introduction

The computer program ADNAN.FOR has been written and developed for specific use in the calculations required in this project and could be used in financial institutions. The User Manual sets out how the program may be used to perform the calculations and the program documentation section allows the program to be understood.

The program calculates, from 18 pieces of financial information obtained from company financial reports, a series of financial ratios and measures 46 in all relevant to this study.

The program is in two parts:

- the 18 pieces of financial information are read by the computer and printed out for checking

- the program calculates the 46 financial ratios and measure of performance for the six years as maximum period, and the program asks the user the required number of years, and name of file for output.

The program also calculates the means of financial ratios for the required period, and the program prints the trend and growth ratios for the 18 pieces of financial data and also the means of the results.

1.2.2 Input Data

This section describes the financial information extracted by the user from the company financial reports to the computer. The following information is required for input for six years as maximum period.

Financial Data No	Description	Units
1	Annual turnover	$\times 10^6$
2	Profit after tax	
3	Profit before tax	
4	Net assets	
5	Cash	
6	Current assets	
7	Current liabilities	
8	Fixed assets	
9	Stock and work in progress	
10	Debtors	
11	Debit over one year	
12	Total interest charged	
13	Short term loan and overdraft	
14	Depreciation	
15	Retained profit	
16	Equity	
17	Employees remuneration	
18	Total tax	

Note: The maximum number which could be used in this program is 6 characters without decimals, three places if decimals are available for all data. Each number must have a decimal point, and may be written anywhere in the 10 allocated columns.

Figure A1 shows the method of inputting data, and Figure A2 shows a sample printout.

Year	1	2		6
Line 1	123456.000	56.000		6.000
Line 2	.123	1.234		12.345
Line 19	123456.123	.123		6.123

col. 1-10 col. 11-20 col. 51-60

FIGURE A1

1.2.3 Output

The output is tabular in form, the printout includes:

1. the financial data for each company.
2. the financial measurements of performance for each company including financial ratios for six years with mean, trends and growth ratios.

To indicate what the user should expect from the program, Figures A3 and A4 show some output resulting from running the program.

A concise flowchart of the four parts is as follows:

The data should be inputted as follows:

1. For each of the 30 companies, 19 lines of recording must be completed.
2. On line 1 the company number is written i.e. 1-30 which should for clarity not contain a decimal point and should be in the first 10 columns. This enables the company data to be easily identified.
3. Lines 2-19 the financial data, 1-18 above is entered.

1.3 PROGRAM DOCUMENTATION

1.3.1 Introduction

ADNAN.FOR is a computer program written in the programming language FORTRAN 77 for use on the PC-IBM.

Core space required 141186 bytes.

Input data is stored in a three-dimensional array, and all calculations are performed using three-dimensional arrays.

1.3.2 Variables

The following variables are used:

- 1 V: a three-dimensional array 30,18,6
containing the 18 pieces of input financial data for 6 years and for 30 companies.
- 2 R: a three-dimensional array 30,46,10
containing the 46 calculated financial ratios for 6 years, and for 30 companies. Further the means of the data are held in R.
- 3 A file name for output
- 4 N the number of the company
- 5 ny the number of years
- 6 Ii, i=1, , , 18 the subscripted variables used as a counter in the DO loops.

PROGRAMME LISTING

```
common      V(30,18,6)
real*8 R(30,46,10)
character*32 fname
```

```
write(*, '( " Enter data filename" ) )' )
read(*, '(a)' ) fname
open(file=fname, access='sequential', unit=7, status='old')
```

```
write(*, '( " Enter number of years " ) )' )
read(*, *) ny
```

```
write(*, '( " Enter filename for output" ) )' )
read(*, '(a)' ) fname
open(file=fname, status='new', access='sequential', unit=8)
```

```
WRITE(8,999)
```

```
999 FORMAT(1H,//////////)
      il=1
```

```
1 continue
```

C

C

```
READ COMPANY NUMBER
```

C

```
READ(7,10,end=300,err=300) N
```

```
10 FORMAT(I3).
```

```
DO 50 I2=1,18
```

C

C

```
READ I'TH COMPANY DATA
```

C

```
READ(7,*,end=300,err=300) (V(I1,I2,I3), I3=1,ny)
```

```
50 CONTINUE
```

C

C

```
PRINT I'TH COMPANY DATA
```

C

```
WRITE(8,55)
```

```
55 FORMAT(1H1)
```

```
WRITE(8,160)
```

```
WRITE(8,60) n
```

```
60 FORMAT(1H ,/,10X, '*****INPUT FOR COMPANY', I4, ' *****', /)
```

```
WRITE(8,160)
```

```
WRITE(8,70)
```

```
70 FORMAT(1H , 'DATA', 7X, ' 1', 7X, ' 2', 10X, ' 3', 10X, ' 4', 10X,
```

```
1 ' 5', 10X, ' 6', /)
```

```
WRITE(8,160)
```

```
DO 90 I4=1,18
```

```
WRITE(8,80) I4, (V(I1,I4,I5), I5=1,ny)
```

```
80 FORMAT(I3, 6F14.3)
```

```
90 CONTINUE
```

CALCULATE FINANCIAL RATIOS FOR YITH COMPANY

```

DO 100 I6=1,ny
EBIT/NA

$$R(I1,1,I6)=V(I1,3,I6)/V(I1,4,I6)$$

EBIT/EQ

$$R(I1,2,I6)=V(I1,3,I6)/V(I1,16,I6)$$

EBIT/CL

$$R(I1,3,I6)=V(I1,3,I6)/V(I1,7,I6)$$

EBIT/NCE

$$R(I1,4,I6)=V(I1,3,I6)/(V(I1,4,I6)+V(I1,13,I6))$$

EBIT/TURNOVER

$$R(I1,5,I6)=V(I1,3,I6)/V(I1,1,I6)$$

PAT/NCE

$$R(I1,6,I6)=V(I1,2,I6)/(V(I1,4,I6)+V(I1,13,I6))$$

PAT/EQ

$$R(I1,7,I6)=V(I1,2,I6)/V(I1,16,I6)$$

FA/EQ

$$R(I1,8,I6)=V(I1,8,I6)/V(I1,16,I6)$$

LA/CL

$$R(I1,9,I6)=(V(I1,6,I6)-V(I1,9,I6))/V(I1,7,I6)$$

WC/NCE

$$R(I1,10,I6)=(V(I1,6,I6)-V(I1,7,I6))/(V(I1,4,I6)+V(I1,13,I6))$$

DR/CL

$$R(I1,11,I6)=V(I1,10,I6)/V(I1,7,I6)$$

INT/EBIT
IF (V(I1,3,I6).EQ.0.0) THEN
R(I1,12,I6)=0.0
ELSE

$$R(I1,12,I6)=V(I1,12,I6)/V(I1,3,I6)$$

END IF
CL/NA

$$R(I1,13,I6)=V(I1,7,I6)/V(I1,4,I6)$$

CL/NCE

$$R(I1,14,I6)=V(I1,7,I6)/(V(I1,4,I6)+V(I1,13,I6))$$

DEBIT/NCE

$$R(I1,15,I6)=V(I1,11,I6)/(V(I1,4,I6)+V(I1,13,I6))$$

CA/CL

$$R(I1,16,I6)=V(I1,6,I6)/V(I1,7,I6)$$

CA/NA

$$R(I1,17,I6)=V(I1,6,I6)/V(I1,4,I6)$$

CA/EQ

$$R(I1,18,I6)=V(I1,6,I6)/V(I1,16,I6)$$

CA/NCE

$$R(I1,19,I6)=V(I1,6,I6)/(V(I1,4,I6)+V(I1,13,I6))$$

LA/NA
20 
$$R(I1,20,I6)=(V(I1,6,I6)-V(I1,9,I6))/V(I1,4,I6)$$


```



```

C    LA/EQ
R(I1,21,I6)=(V(I1,8,I6)-V(I1,9,I6))/V(I1,16,I6)
C    TURNOV/NA
R(I1,22,I6)=V(I1,1,I6)/V(I1,4,I6)
C    STL/EBIT
IF(V(I1,3,I6).EQ.0.0) THEN
R(I1,23,I6)=0.0
ELSE
R(I1,23,I6)=V(I1,13,I6)/V(I1,3,I6)
END IF
C    NCF/CL
R(I1,24,I6)=(V(I1,14,I6)+V(I1,15,I6))/V(I1,7,I6)
C    CASH FLOW/CL
R(I1,25,I6)=(V(I1,2,I6)+V(I1,14,I6))/V(I1,7,I6)
C    NON-BANK CREDIT TO TURNOVER
R(I1,26,I6)=(V(I1,7,I6)-V(I1,13,I6))/V(I1,1,I6)
C    WC/TURNOVER
R(I1,27,I6)=(V(I1,6,I6)-V(I1,7,I6))/V(I1,1,I6)
C    WC/NA
R(I1,28,I6)=(V(I1,6,I6)-V(I1,7,I6))/V(I1,4,I6)
C    WC/CA
R(I1,29,I6)=(V(I1,6,I6)-V(I1,7,I6))/V(I1,6,I6)
C    CASH/TURNOVER
R(I1,30,I6)=V(I1,5,I6)/V(I1,1,I6)
C    CASH/CL
R(I1,31,I6)=V(I1,5,I6)/V(I1,7,I6)
C    CASH/CA
R(I1,32,I6)=V(I1,5,I6)/V(I1,6,I6)
C    CASH/NA
R(I1,33,I6)=V(I1,5,I6)/V(I1,4,I6)
C    CASH/NON-BANK CREDIT
R(I1,34,I6)=V(I1,5,I6)/(V(I1,7,I6)-V(I1,13,I6))
C    RETAINED EARNING/NA
R(I1,35,I6)=V(I1,15,I6)/V(I1,4,I6)
C    STOCK/CI
R(I1,36,I6)=V(I1,9,I6)/V(I1,7,I6)
C    STOCK/TURNOVER
R(I1,37,I6)=V(I1,9,I6)/V(I1,1,I6)
C    TURNOVER/EQUITY
R(I1,38,I6)=V(I1,1,I6)/V(I1,16,I6)
C    TURNOVER/FA
R(I1,39,I6)=V(I1,1,I6)/V(I1,8,I6)
C    EMPLOYEE REMUNERATION/TURNOVER
R(I1,40,I6)=V(I1,17,I6)/V(I1,1,I6)
C    EMPLOYEE REMUNERATION / EBIT
IF(V(I1,3,I6).EQ.0.0) THEN
R(I1,41,I6)=0.0

```

```

ELSE
  R(I1,41,I6)=V(I1,17,I6)/V(I1,3,I6)
END IF
C INTEREST COVER RATIO
IF(V(I1,12,I6).EQ.0.0) THEN
  R(I1,42,I6)=0.0
ELSE
  R(I1,42,I6)=(V(I1,3,I6)+V(I1,12,I6))/V(I1,12,I6)
END IF
C DEGREE OF CAPITAL GEARING RATIO
IF(V(I1,3,I6).EQ.0.0) THEN
  R(I1,43,I6)=0.0
ELSE
  R(I1,43,I6)=(V(I1,3,I6)+V(I1,12,I6))/V(I1,3,I6)
END IF
C PRE-TAX RETURN ON LONG TERM FUND EMPLOYED
R(I1,44,I6)=(V(I1,3,I6)+V(I1,12,I6))/(V(I1,16,I6)+V(I1,11,I6))
C PRE-TAX RETURN ON TOTAL FUND EMPLOYED
R(I1,45,I6)=(V(I1,3,I6)+V(I1,12,I6))/(V(I1,16,I6)+
+ V(I1,7,I6)+V(I1,11,I6))
C DEBTOR/TURNOVER
R(I1,46,I6)=(V(I1,10,I6)*365.0)/V(I1,1,I6)
100 CONTINUE
C
C CALCULATE RATIO MEANS
C
DO 120 I7=1,46
  r(i1,i7,7)=0.0
DO 110 I8=1,ny
  R(I1,I7,7)=R(I1,I7,7)+R(I1,I7,I8)
110 CONTINUE
  R(I1,I7,7)=R(I1,I7,7)/float(ny)
120 CONTINUE
C
C
  write(8,160)
160 format(' =====')
+ ' =====')
  write(8,170)i1
170 format(1h,9x,'***** financial ratios ****',i4,'***',/)
  write(8,160)
  write(8,180)
180 format(1h,'ratio ',5x,' 1',10x,' 2',10x,' 3',10x,
c ' 4',10x,' 5',10x,' 6',10x,'mean',/)
  write(8,160)
  do 200 i12=1,46
  write(8,190)i12,(r(i1,i12,i13),i13=1,7)

```

```

190 format(13,8f14.3)
200 continue

      write(8,160)
      write(8,160)
      write(8,('' TRENDS''))
      write(8,(''Input'',24x, ''2'',13x, ''3'',13x, ''4'',13x, ''5'',
+          13x, ''6'',13x, ''mean''))

      write(8, '/')
      DO 777 I=1,18
      call trend(I,ny,i1)
777 CONTINUE

      write(8,160)
      write(8,('' GROWTH RATIO''))
      write(8,(''Input'',24x, ''2'',13x, ''3'',13x, ''4'',13x, ''5'',
+          13x, ''6'',13x, ''mean''))
      write(8, '/')
      DO 778 I=1,18
      call growth(I,ny,i1)
778 CONTINUE

      write(8,160)
      write(8,160)
      i1=i1+1
      goto 1
300 continue
step
end

      subroutine trend(n,ny,ic)
      common v(30,18,6)
      dimension x(6)

      x(6)=0.0
      do 10 i=1,(ny-1)
      if(v(ic,n,i).eq.0.0) then
        x(i)=0.0
      else
        x(i)=(v(ic,n,(i+1))-v(ic,n,i))/v(ic,n,i)
      endif
      x(6)=x(6)+x(i)
10 continue
      x(6)=x(6)/(ny-1)

```

```
write(8,'(i3,14x,7f14.3)')n,(x(i),i=1,6)
```

```
return  
end
```

```
subroutine growth(n,ny,ic)  
common v(30,18,6)  
dimension x(6)
```

```
x(6)=0.0  
do 10 i=1,(ny-1)  
if(v(ic,n,i).eq.0.0) then  
x(i)=0.0  
else  
x(i)=v(ic,n,(i+1))/v(ic,n,i)  
endif  
x(6)=x(6)+x(i)  
10 continue  
x(6)=x(6)/(ny-1)
```

```
write(8,'(i3,14x,7f14.3)')n,(x(i),i=1,6)
```

```
return  
end
```

```

1
17268 25711 21489
535 1834 1184
551 2009 1280
8015 17508 12761
6154 5811 5982
18819 30769 24794
12665 24958 18811
1861 11697 6779
16897 23973 20435
780 2420 1600
450 5119 2784
1390 1739 1564
8409 17007 12704
177 203 190
258 1603 930
7565 12389 9977
799 1047 923
46 16 16
2
2384 3526 2955
-145 -738 -441
-734 -145 -439
984 850 917
880 994 937
932 1034 983
1812 2028 1920
1864 1844 1854
234 176 205
693 855 774
33 43 38
117 128 122
1120 865 992
425 471 448
-746 -145 -445
951 807 879
1269 1064 1166
4 4 0
3
4566 4105 4586
95 -592 -2
40 112 -584
2910 1886 1429
460 272 120
2183 2040 2420
1723 2312 2540
2378 2086 1450
851 509 644
1324 1529 1374
925 643 496
157 219 209
517 1113 1214
71 175 274
56 -596 -6
2910 1886 1429

17 8 2
4
16240 21049 18644
487 1905 1196
578 1905 1241
13546 8796 11171
9733 5020 7376
20333 14751 17542
10000 7751 10165
3813 3776 3794
13405 10905 12155
5698 2095 3896
5801 4890 5345
639 656 647
6654 4624 5639
132 115 123
294 -1905 -805
7745 3906 5825
2415 2672 2543
271 91 0
5

```

FIGURE A.2: THE INPUT FINANCIAL DATA

	1	2	3	4	5	6	mean
1	17268.000	23711.000	21489.000				
2	533.000	1834.000	1184.000				
3	8511.000	2009.000	1280.000				
4	8013.000	17308.000	12741.000				
5	6184.000	5811.000	5982.000				
6	18919.000	30749.000	24794.000				
7	12685.000	24958.000	18811.000				
8	1841.000	11487.000	4779.000				
9	18897.000	23973.000	20435.000				
10	780.000	2420.000	1400.000				
11	4851.000	8119.000	2784.000				
12	1390.000	1339.000	1364.000				
13	8409.000	1007.000	12704.000				
14	177.000		190.000				
15	8581.000	1403.000	930.000				
16	7543.000	12389.000	3927.000				
17	998.000	1047.000	923.000				
18	44.000	14.000	14.000				
===== Financial Ratios =====							
1	0.69	1.15	1.00	.000	.000	.000	.092
2	0.073	1.162	1.128	.000	.000	.000	.121
3	0.44	.080	.068	.000	.000	.000	.084
4	1.034	1.058	1.050	.000	.000	.000	.047
5	0.32	.078	.060	.000	.000	.000	.057
6	1.033	1.033	1.046	.000	.000	.000	.044
7	0.71	.115	.115	.000	.000	.000	.112
8	1.241	1.444	1.479	.000	.000	.000	.622
9	.182	.272	.232	.000	.000	.000	.219
10	1.375	1.168	.235	.000	.000	.000	.259
11	.062	.097	.085	.000	.000	.000	.081
12	2.823	1.846	1.222	.000	.000	.000	1.537
13	1.380	1.474	1.474	.000	.000	.000	1.497
14	1.771	1.723	1.739	.000	.000	.000	.744
15	.077	.148	.109	.000	.000	.000	.095
16	1.146	1.123	1.318	.000	.000	.000	1.344
17	2.348	1.737	1.943	.000	.000	.000	2.016
18	2.148	2.484	2.148	.000	.000	.000	2.484
19	1.144	.891	.974	.000	.000	.000	1.004
20	1.240	1.388	1.342	.000	.000	.000	.377
21	.294	.549	.537	.000	.000	.000	.417
22	1.2184	1.1449	1.684	.000	.000	.000	1.749
23	15.261	8.563	9.923	.000	.000	.000	11.217
24	1.034	.072	.060	.000	.000	.000	.084
25	.094	.082	.073	.000	.000	.000	.070
26	1.286	1.309	1.284	.000	.000	.000	.289
27	.37	.278	.278	.000	.000	.000	.287
28	1.748	1.332	.469	.000	.000	.000	.507
29	.327	.189	.241	.000	.000	.000	.241
30	.354	.224	.278	.000	.000	.000	.278
31	.484	.233	.318	.000	.000	.000	.245
32	.327	.189	.241	.000	.000	.000	.252
33	.748	.332	.469	.000	.000	.000	.527
34	1.144	.731	.980	.000	.000	.000	1.055
35	.032	.072	.073	.000	.000	.000	.066
36	1.1334	.961	1.086	.000	.000	.000	1.127
37	.879	.932	.951	.000	.000	.000	.954
38	2.283	2.075	2.194	.000	.000	.000	2.171
39	9.279	2.198	3.170	.000	.000	.000	4.882
40	1.046	.041	.043	.000	.000	.000	.043
41	1.450	.321	.721	.000	.000	.000	.897
42	1.396	2.155	1.818	.000	.000	.000	1.740
43	1.373	.864	2.222	.000	.000	.000	2.537
44	.084	.214	.223	.000	.000	.000	.226
45	1.084	.098	.090	.000	.000	.000	.091
46	1.1487	34.355	27.177	.000	.000	.000	26.004
===== TREND =====							
Input	1	2	3	4	5	6	mean
1	489	144	.000	.000	.000	.000	1.62
2	2.428	1.354	.000	.000	.000	.000	1.037
3	2.444	.363	.000	.000	.000	.000	1.142
4	1.7184	-.273	.000	.000	.000	.000	.497
5	-.054	.029	.000	.000	.000	.000	-.017
6	1.635	-.184	.000	.000	.000	.000	.220
7	.971	-.244	.000	.000	.000	.000	.362
8	5.285	-.420	.000	.000	.000	.000	2.432
9	.419	-.148	.000	.000	.000	.000	1.136
10	2.100	-.339	.000	.000	.000	.000	.882
11	10.374	-.454	.000	.000	.000	.000	4.940
12	.283	-.109	.000	.000	.000	.000	.075
13	1.022	-.253	.000	.000	.000	.000	.385
14	1.147	-.064	.000	.000	.000	.000	.041
15	3.213	-.420	.000	.000	.000	.000	2.397
16	.438	-.195	.000	.000	.000	.000	.221
17	.310	-.118	.000	.000	.000	.000	.094
18	1.632	.000	.000	.000	.000	.000	1.326
===== GROWTH-RATIO =====							
Input	1	2	3	4	5	6	mean
1	1.489	1.354	.000	.000	.000	.000	1.162
2	3.428	.444	.000	.000	.000	.000	2.037
3	3.444	.372	.000	.000	.000	.000	2.142
4	2.184	.729	.000	.000	.000	.000	1.437
5	1.964	1.029	.000	.000	.000	.000	1.982
6	1.635	.804	.000	.000	.000	.000	1.320
7	1.877	.744	.000	.000	.000	.000	1.352
8	4.285	.580	.000	.000	.000	.000	3.432
9	1.419	.852	.000	.000	.000	.000	1.134
10	3.103	.661	.000	.000	.000	.000	1.882
11	1.077	.548	.000	.000	.000	.000	1.368
12	1.251	.899	.000	.000	.000	.000	1.075
13	2.022	.747	.000	.000	.000	.000	1.385
14	1.147	.936	.000	.000	.000	.000	1.041
15	3.213	.880	.000	.000	.000	.000	3.337
16	1.438	.805	.000	.000	.000	.000	1.221
17	1.310	.892	.000	.000	.000	.000	1.094
18	3.48	1.000	.000	.000	.000	.000	6.74

FIGURE A.3: THE CALCULATED FINANCIAL RATIOS FOR COMPANY 1

APPENDIX B

A MANUAL FOR USE OF THE "SPSS-X" STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES SUBPROGRAM "DISCRIMINANT" AND ITS OUTPUT

1. INTRODUCTION

The statistical package described here is used through the Computer Centre of Loughborough University of Technology, see SPSS (Version X) Manual, McGraw-Hill and SPSSX Handbook by M J Hunt.

2. THE STANDARD PROGRAM

A listing of a standard program to call up the DISCRIMINANT program, is shown on page 264 using the Multics command SPSSX followed by the name of the file, the SPSSX command (called the control file).

To run SPSS-X requires constructing a file giving two different types of information:

1. Definition command, which describes the data
2. SPSS-X procedures, which perform the analysis.

The data itself should be held on a separate file.

All lines must begin with a command name, unless the line is a continuation of a command given on a previous line. Continuation lines must begin with at least one blank character. The command name is usually followed by further information. For example, the first

command title is followed by the actual legend of desired companies in quotation marks:

Title "Comparison of profitable and insolvent companies"

often requires more lengthy information and is often broken up by the slash character '/' with key words followed by the = character, for example

file handle account/at d=" file-adnan.data"

in which the name of the file to be handled, in our case "adnan.data" which includes 31 financial ratios for both "solvent and insolvent companies".

The file handle command simply tells SPSS-X where to find the data i.e. the name of the data file.

The next command needed is the data list. This command tells SPSS-X whereabouts in the data file to find each item of data.

The variable labels command is simply used to give meaning to the blunt variable names in the data list command. The two labelling commands are:

Variable labels V32 "status"

Value labels V32 1 "Solvent" 2 "Insolvent".

Both label commands are not essential but enable us to remember what we are doing and interpret printout, and will help future researchers to use the same work.

3. SUBCOMMANDS

The subcommands which are used in this program are as follows:

3.1 The "GROUPS" Subcommand

The GROUP subcommand defines the groups. Each case used in the computation of discriminations is assigned to a group based on its value on grouping variables for example:

$$\text{DISCRIMINANT GROUPS} = V_{32} (1,2)$$

In our case two groups are defined by the variable V_{32} .

3.2 The VARIABLES Subcommand

The VARIABLES subcommand names the variables to be used as discriminating variables during the analysis phase, for example

$$\text{VARIABLES} = V_1 \text{ to } V_{31}$$

specifies that variables V_1 through to V_{31} are to be used during the analysis phase.

3.3 The ANALYSIS Subcommand

Several discriminant analyses can be done with one DISCRIMINANT command. The user should be named all the variables to be used in the various analyses on the VARIABLES subcommand and then use the ANALYSIS subcommand to specify subsets of variables for individual analysis. For example:

$$\text{ANALYSIS} = V_4 V_9 V_1 V_{13} \text{ etc}$$

3.4 The METHOD Subcommand

Different stepwise methods in the METHOD subcommand are available. These methods enter and remove variables one at a time, selecting them on the basis of specific criteria. Different criteria are used for different stepwise methods.

The METHOD subcommand follows the ANALYSIS subcommand and the method applied in this research was Wilks, in which the variables that minimise the overall Wilks' Lambda are selected. The other methods are described in the Manual, McGraw Hill.

3.5 The STATISTIC Command

Several optional statistics are available in this program, see (SPSS-X) Manual by McGraw-Hill.

4. OUTPUT FROM THE DISCRIMINANT PROGRAM

The following is some output resulting from the program listing on page 264. The liable card results in the printout as shown in Figure 1, the number of cases by group, in our case in two groups, solvent group 20 cases and insolvent group 11 cases.

Prior to each subanalysis the information shown in Figure 2 is printed out, the information includes the tolerance level "Maximum number of steps" that are allowed for the analysis, minimum "F-value" of variables for inclusion into the function, and the "F-value" for deletion from the function, statement of the method to be used in the analysis and value of the prior probabilities of group membership are included.

In stepwise method the program automatically prints out standard step by step information, as shown in Figure 3, also the information includes at each step, a value for "Wilks Lambda", for which an approximate "F-test" of significance is given. These are followed by information about each of the discriminating variables. The variables which have been entered into the analysis are listed, and the value of the "Entry criterion" at the time the variable was selected is given along with the current "F to remove".

At step 9, seven discriminant variables have resulted as shown in Figure 4. The program also results in the "Statistic 11" unstandardised canonical discriminant functions. These coefficients are multiplied by the raw input data to arrive at discriminant scores. Coefficients and canonical discriminant functions are evaluated at group means (group centroids) as shown in Figure 5, and the "Statistic 14" discriminant scores as shown in Figure 6.

The "actual" group for each case and also the group for which it has the highest probability of membership under $P(G/X)$ is printed as the probability of membership on which the classification was based.

The second highest group probability $P(G/X)$, is also printed if it exceeds .0005. These are then followed by the "Discriminant Scores".

Assuming the statistics table as shown in Figure 7 includes eigenvalues, percentage of variance, cumulative percentage of variance, canonical correlation, Wilks Lambda, chi-square, degree of freedom, and significance of chi-square are reported for the functions.

5. OUTPUT FROM THE PROGRAM BY USING THREE GROUPS

An attempt was made to discriminate between three groups of companies used in this analysis and these groups are namely:

1. "Continued 20" group.
2. "Failed 11" group.
3. "Taken-over 9" group.

Because of the complexity of functions which are included, 19 discriminating variables, the discriminating model has not been developed for the following reasons:

- time restriction
- has not strictly adhered to failure prediction
- requires further research beyond the scope of this thesis

The following is output resulting from the program listing on page 272.

The program resulting from the "Statistic 11" unstandardised canonical discriminant function coefficients for functions 1 and 2 are shown in Figure 8.

The "Statistic 10" territorial map as shown in Figure 9 shows the all-group scatter plot and the "Statistic 14" discriminant scores are as shown in Figure 10.

The "Statistic 13" classification results are shown in Figure 11 and include a portion of cases classified correctly. The overall classification rate is 97.5%.

The "Statistic 16" separate-groups plots, in our case three scatter plots, are produced as shown in Figure 12 including all the groups scatter-plots.

To compare the territorial map as shown in Figure 9 with the all-group plot, we can identify the misclassified cases, those are the cases not falling within the outline boundaries on the territorial map. Assuming statistics as shown in Figure 13, eigenvalue, percentage of variance, cumulative percentage of variance, canonical correlation, Wilks Lambda, chi-square, degree of freedom and significance of chi-square are included.

PROGRAM LISTING FOR TWO GROUPS

20 MAY 88 SPSS-X RELEASE 1.0 A Honeywell/Multics
Loughborough University Honeywell 68/80 Multics

SPSS INC LICENSE NUMBER: 906

```
1 0      title 'Comparison of Profitable and Insolvent Companies'
2 0      file handle accounts /atd="vfile_adnan.data"
3 0      data list file=accounts free/ v1 to v32
4 0      variable labels v32 'Status'
5 0      value labels v32 1 'Solvent' 2 'Insolvent'
6 0      /*breakdown tables=v1 to v31 by v32
7 0      discriminant groups=v32(1,2)/
8 0      variables = v1 to v31/
9 0      /*analysis = v4 v9 v11 v13 v16 v18 v20 v22 v26/
10 0     method = wilks/
11 0     statistics 11,14
```

THERE ARE 997480 BYTES OF MEMORY AVAILABLE.
THE LARGEST CONTIGUOUS AREA HAS 997480 BYTES.

SINCE ANALYSIS= WAS OMITTED FOR THE FIRST ANALYSIS ALL VARIABLES
ON THE VARIABLES= LIST WILL BE ENTERED AT LEVEL 1.

THIS DISCRIMINANT ANALYSIS REQUIRES 23544 (23.0K) BYTES OF WORKING SPACE

----- D I S C R I M I N A N T A
 ON GROUPS DEFINED BY V32 Status

31 (UNWEIGHTED) CASES WERE PROCESSED.
 0 OF THESE WERE EXCLUDED FROM THE ANALYSIS.
 31 (UNWEIGHTED) CASES WILL BE USED IN THE ANALYSIS.

NUMBER OF CASES BY GROUP

V32	NUMBER OF CASES UNWEIGHTED	WEIGHTED	LABEL
1	20	20.0	Solvent
2	11	11.0	Insolvent
TOTAL	31	31.0	

FIGURE 1: NUMBER OF CASES BY GROUP

MAY 88 Comparison of Profitable and Insolvent Companies
) Loughborough University Honeywell 68/80 Multics

----- D I S C R I M I N A N T A I
 I GROUPS DEFINED BY V32 Status

ANALYSIS NUMBER 1

STEPWISE VARIABLE SELECTION

SELECTION RULE: MINIMIZE WILKS' LAMBDA
 MAXIMUM NUMBER OF STEPS..... 62
 MINIMUM TOLERANCE LEVEL..... 0.00100
 MINIMUM F TO ENTER..... 1.0000
 MAXIMUM F TO REMOVE..... 1.0000

NONICAL DISCRIMINANT FUNCTIONS

MAXIMUM NUMBER OF FUNCTIONS..... 1
 MINIMUM CUMULATIVE PERCENT OF VARIANCE... 100.00
 MAXIMUM SIGNIFICANCE OF WILKS' LAMBDA.... 1.0000

RIOR PROBABILITY FOR EACH GROUP IS 0.50000

FIGURE 2: STEPWISE VARIABLE SELECTION

AT STEP 1, V17 WAS INCLUDED IN THE ANALYSIS.

		DEGREES OF FREEDOM	SIGNIF.	BE
WILKS' LAMBDA	0.66258	1 1	29.0	
EQUIVALENT F	14.7684	1	29.0	0.0006

----- VARIABLES IN THE ANALYSIS AFTER STEP 1 -----

VARIABLE	TOLERANCE	F TO REMOVE	WILKS' LAMBDA
V17	1.0000000	14.768	

----- VARIABLES NOT IN THE ANALYSIS AFTER STEP 1 -----

VARIABLE	TOLERANCE	MINIMUM TOLERANCE	F TO ENTER	WILKS' LAMBDA
V1	0.9990450	0.9990450	4.6439	0.56832
V2	0.9681785	0.9681785	1.4144	0.63072
V3	0.9983150	0.9983150	5.9521	0.54642
V4	0.9985298	0.9985298	.81888	0.64375
V5	0.9993747	0.9993747	6.0529	0.54481
V6	0.9917448	0.9917448	11.193	0.47336
V7	0.9653664	0.9653664	3.1499	0.59558
V8	0.9909484	0.9909484	2.3178	0.61192
V9	0.9992914	0.9992914	.24032	0.65694
V10	0.9406767	0.9406767	.74155	0.64548
V11	0.9751889	0.9751889	.36107	0.65414
V12	0.9803528	0.9803528	9.8783	0.48978
V13	0.8935987	0.8935987	2.0991	0.61637
V14	0.7227410	0.7227410	0.19159E-01	0.66213
V15	0.7893639	0.7893639	0.74505E-02	0.66240
V16	0.9426998	0.9426998	5.9474	0.54650
V18	0.7477856	0.7477856	.23070	0.65716
V19	0.4454334	0.4454334	8.8747	0.50311
V20	0.9758882	0.9758882	0.63005E-01	0.66109
V21	0.8782115	0.8782115	.23516	0.65706
V22	0.9897215	0.9897215	3.7502	0.58432
V23	0.6022425	0.6022425	3.4224	0.59041
V24	0.9926706	0.9926706	7.0123	0.52988
V25	0.9194308	0.9194308	3.0076	0.59831
V26	0.9960822	0.9960822	.47371	0.65156
V27	0.9910142	0.9910142	0.44931E-01	0.66152
V28	0.9126132	0.9126132	.62446	0.64812
V29	0.9709617	0.9709617	.89549	0.64204
V30	0.9519061	0.9519061	.11358	0.65990
V31	0.9770676	0.9770676	.23636	0.65703

FIGURE 3: VARIABLES IN THE ANALYSIS AT STEP 1

AT STEP 9, V12 WAS REMOVED FROM THE ANALYSIS.

		DEGREES OF FREEDOM	SIGNIF.	BETWEEN
WILKS' LAMBDA	0.13517	7 1	29.0	
EQUIVALENT F	21.0224	7	23.0	0.0000

----- VARIABLES IN THE ANALYSIS AFTER STEP 9 -----

VARIABLE	TOLERANCE	F TO REMOVE	WILKS' LAMBDA
V1	0.5602124	29.295	0.30734
V17	0.3447527	29.648	0.30941
V23	0.2829541	16.182	0.23027
V24	0.6434045	13.928	0.21703
V25	0.5113777	19.161	0.24778
V26	0.5479918	8.5112	0.18519
V30	0.6915605	6.8454	0.17540

----- VARIABLES NOT IN THE ANALYSIS AFTER STEP 9 -----

VARIABLE	TOLERANCE	MINIMUM TOLERANCE	F TO ENTER	WILKS' LAMBDA
V1	0.1546806	0.1546806	.46462	0.13237
V2	0.2803695	0.2306829	0.32042E-03	0.13517
V3	0.3626145	0.2643240	.80408	0.13040
V4	0.8003164	0.2795612	.45011	0.13246
V5	0.2270301	0.1956506	.50261	0.13215
V7	0.1747145	0.1747145	.13911	0.13432
V8	0.8036324	0.2810149	0.49684E-01	0.13486
V9	0.5767617	0.2801188	.69035	0.13106
V10	0.8359510	0.2828644	0.85863E-01	0.13464
V11	0.8100130	0.2795873	.28084	0.13347
V12	0.1695183	0.1491418	0.23381E-01	0.13503
V13	0.4297389	0.2194048	.49203	0.13221
V14	0.4924572	0.2365650	0.95672E-02	0.13511
V15	0.5726225	0.2715193	0.51554E-04	0.13517
V16	0.3735249	0.2652799	.17501	0.13410
V18	0.5415379	0.2417479	.11248	0.13448
V19	0.3171498	0.2593306	0.45041E-01	0.13489
V20	0.7387956	0.2726227	.12648	0.13440
V21	0.7220602	0.2716766	.11060	0.13449
V22	0.8627341	0.2793084	.68119	0.13111
V27	0.9404892	0.2826655	0.69288E-02	0.13513
V28	0.7182636	0.2748877	0.13368E-01	0.13509
V29	0.8042650	0.2795671	.44794	0.13247
V31	0.9175061	0.2792637	0.67571E-01	0.13476

FIGURE 4: VARIABLES IN ANALYSIS AT STEP 9

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UNSTANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS

	FUNC 1
V6	-16.06449
V17	2.848277
V23	-.4894365
V24	.2345166
V25	-.6957342
V26	.6957439
V30	.5972381
(CONSTANT)	-2.854138

CANONICAL DISCRIMINANT FUNCTIONS EVALUATED AT GROUP MEANS (GROUP CENTROIDS)

GROUP	FUNC 1
1	-1.81437
2	3.29885

FIGURE 5: UNSTANDARDISED CANONICAL DISCRIMINANT COEFFICIENTS

AY 88 Comparison of Profitable and Insolvent Companies
Loughborough University Honeywell 68/80 Multics

E UM	MIS VAL	SEL	ACTUAL GROUP	HIGHEST PROBABILITY GROUP P(D/G) P(G/D)	2ND HIGHEST GROUP P(G/D)	DISCRIMI SCORES.
1			1	1 0.7082 1.0000	2 0.0000	-1.4401
2			1	1 0.1939 1.0000	2 0.0000	-3.1135
3			1	1 0.6821 1.0000	2 0.0000	-2.2240
4			1	1 0.0371 0.9179	2 0.0821	0.2700
5			1	1 0.1307 0.9952	2 0.0048	-0.3030
6			1	1 0.8858 1.0000	2 0.0000	-1.9579
7			1	1 0.8725 1.0000	2 0.0000	-1.9749
8			1	1 0.2105 1.0000	2 0.0000	-3.0666
9			1	1 0.8708 1.0000	2 0.0000	-1.6517
10			1	1 0.1115 0.9929	2 0.0071	-0.2229
11			1	1 0.8525 1.0000	2 0.0000	-1.6284
12			1	1 0.8702 1.0000	2 0.0000	-1.9778
13			1	1 0.1149 1.0000	2 0.0000	-3.3910
14			1	1 0.3247 1.0000	2 0.0000	-2.7992
15			1	1 0.3745 1.0000	2 0.0000	-2.7024
16			1	1 0.2483 0.9992	2 0.0008	-0.6598
17			1	1 0.4542 0.9999	2 0.0001	-1.0660
18			1	1 0.4069 1.0000	2 0.0000	-2.6437
19			1	1 0.9687 1.0000	2 0.0000	-1.7752
20			1	1 0.8847 1.0000	2 0.0000	-1.9594
21			2	2 0.4483 1.0000	1 0.0000	4.0570
22			2	2 0.8445 1.0000	1 0.0000	3.4950
23			2	2 0.4115 0.9999	1 0.0001	2.4775
24			2	2 0.0309 0.8843	1 0.1157	1.1400
25			2	2 0.2252 1.0000	1 0.0000	4.5116
26			2	2 0.4628 1.0000	1 0.0000	4.0330
27			2	2 0.4354 0.9999	1 0.0001	2.5189
28			2	2 0.8504 1.0000	1 0.0000	3.1102
29			2	2 0.9364 1.0000	1 0.0000	3.3787
30			2	2 0.8766 1.0000	1 0.0000	3.4541
31			2	2 0.4166 1.0000	1 0.0000	4.1112

DISCRIMINATION PROCESSING SUMMARY

31 CASES WERE PROCESSED.
0 CASES WERE EXCLUDED FOR MISSING OR OUT-OF-RANGE GROUP CODES.
0 CASES HAD AT LEAST ONE MISSING DISCRIMINATING VARIABLE.
31 CASES WERE USED FOR PRINTED OUTPUT.

FIGURE 6: THE DISCRIMINANT SCORES

SUMMARY TABLE

STEP	ACTION ENTERED REMOVED	VAR IN	WILKS' LAMBDA	SIG.	LABEL
1	V17	1	.66258	.0006	
2	V6	2	.47336	.0000	
3	V12	3	.35081	.0000	
4	V25	4	.25383	.0000	
5	V23	5	.21584	.0000	
6	V26	6	.17535	.0000	
7	V30	7	.15087	.0000	
8	V24	8	.13503	.0000	
9	V12	7	.13517	.0000	

CANONICAL DISCRIMINANT 1

FUNCTION	EIGENVALUE	PERCENT OF VARIANCE	CUMULATIVE PERCENT	CANONICAL : CORRELATION : FUNCT	AFT
1*	6.39813	100.00	100.00	0.9299627	:

* MARKS THE 1 CANONICAL DISCRIMINANT FUNCTIONS REMAINING IN

STANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS

FUNC 1	
V6	-1.07529
V17	1.37431
V23	-1.29912
V24	0.82331
V25	-1.01372
V26	0.75494
V30	0.61927

FIGURE 7: EIGENVALUE, PERCENTAGE OF VARIANCE CANONICAL
 CORRELATION

PROGRAMME LISTING FOR THREE GROUPS

Loughborough University Honeywell 68/80 Multics

SPSS INC LICENSE NUMBER: 18950

```
0      title 'Comparison of Profitable and Insolvent Companies'
0      file handle accounts /atd="vfile_set2.data"
0      data list file=accounts free/ v1 to v32
0      variable labels v32 'Status'
0      value labels v32 1 'Solvent' 2 'Insolvent' 3 'Take over'
0      breakdown tables=v1 to v31 by v32
```

ARE 995960 BYTES OF MEMORY AVAILABLE.

LARGEST CONTIGUOUS AREA HAS 995960 BYTES.

* GIVEN WORKSPACE ALLOWS FOR 6224 CELLS WITH 1 DIMENSIONS FOR BREAKDOWN

UNSTANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS

	FUNC 1	FUNC 2
V3	-7.530362	1.555425
V4	-11.09368	3.951185
V5	64.82103	1.338344
V6	-14.13432	-11.70164
V10	5.210845	.4421673
V14	-4.581054	6.395205
V15	12.51857	-3.634966
V16	7.550571	-3.971655
V17	5.817900	-4.192620
V18	-3.333902	1.732463
V19	1.657647	-6.357691
V20	-3.879387	3.190735
V21	5.320921	-2.586156
V22	-1.993904	1.962062
V24	0.2681234E-01	.2481200
V25	.2507642	-.6466737
V28	4.792134	-.2785467
V29	-.7492963	-.3938435
V31	-4.632241	1.080963
(CONSTANT)	-6.554657	-.6737030

CANONICAL DISCRIMINANT FUNCTIONS EVALUATED AT GROUP MEANS (GROUP CENTROID)

GROUP	FUNC 1	FUNC 2
1	1.23286	-1.66466
2	1.24474	3.02013
3	-4.26105	0.00798

FIGURE 8: UNSTANDARDISED CANONICAL DISCRIMINANT
FUNCTION COEFFICIENTS

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Comparison of Profitable and Insolvent Companies
Loughborough University

Honeywell 68/80 Multics

FIGURE 9: ALL GROUP SCATTER PLOT

SEL	ACTUAL GROUP	HIGHEST PROBABILITY GROUP P(D/G) P(G/D)	2ND HIGHEST GROUP P(G/D)	DISCRIMINANT SCORES...
	1	1 0.3455 0.9998	3 0.0002	-0.2170 -1.818
	1	1 0.1219 0.9981	3 0.0019	-0.7692 -2.113
	1	1 0.6842 0.9997	2 0.0003	1.8265 -1.027
	1 **	2 0.0888 0.6602	1 0.3398	1.2419 0.819
	1	1 0.6722 1.0000	2 0.0000	2.0786 -1.945
	1	1 0.9117 1.0000	2 0.0000	1.6285 -1.832
	1	1 0.5361 1.0000	2 0.0000	2.3392 -1.815
	1	1 0.8313 1.0000	2 0.0000	0.7803 -2.070
	1	1 0.6013 1.0000	2 0.0000	0.8660 -2.604
	1	1 0.3358 0.9989	2 0.0009	0.0172 -0.825
	1	1 0.3376 0.9997	2 0.0003	2.5809 -1.069
	1	1 0.0479 1.0000	2 0.0000	2.7958 -3.571
	1	1 0.5896 1.0000	2 0.0000	1.7352 -2.561
	1	1 0.5604 1.0000	3 0.0000	0.5037 -2.456
	1	1 0.6620 1.0000	2 0.0000	0.6022 -2.318
	1	1 0.0187 0.6143	2 0.3629	-0.4891 0.569
	1	1 0.2816 1.0000	2 0.0000	2.8097 -1.883
	1	1 0.8308 0.9997	2 0.0003	1.3317 -1.063
	1	1 0.9861 1.0000	2 0.0000	1.2814 -1.504
	1	1 0.7716 1.0000	2 0.0000	1.7138 -2.200
	2	2 0.5154 1.0000	1 0.0000	1.4757 4.148
	2	2 0.8053 1.0000	1 0.0000	1.3984 3.660
	2	2 0.3936 0.9984	1 0.0016	2.2024 2.046
	2	2 0.6872 0.9995	1 0.0005	0.7314 2.322
	2	2 0.9001 0.9999	1 0.0001	1.2885 2.563
	2	2 0.3922 1.0000	1 0.0000	2.3258 3.858
	2	2 0.0243 0.5795	1 0.4143	-0.2694 0.753
	2	2 0.9779 1.0000	1 0.0000	1.0663 3.133
	2	2 0.5703 1.0000	1 0.0000	0.2054 3.227
	2	2 0.8733 1.0000	1 0.0000	1.5330 3.453
	2	2 0.5196 1.0000	1 0.0000	1.7348 4.054
	3	3 0.5163 1.0000	2 0.0000	-3.3885 0.756
	3	3 0.2075 1.0000	1 0.0000	-6.0067 0.321
	3	3 0.9845 1.0000	1 0.0000	-4.3479 -0.146
	3	3 0.6434 1.0000	1 0.0000	-4.9349 0.662
	3	3 0.7336 1.0000	1 0.0000	-4.7603 0.616
	3	3 0.2357 0.9988	1 0.0012	-2.6532 -0.544
	3	3 0.0687 1.0000	1 0.0000	-5.2786 -2.070
	3	3 0.7521 1.0000	1 0.0000	-3.5086 0.068
	3	3 0.6755 1.0000	1 0.0000	-3.4707 0.408

FIGURE 10: THE DISCRIMINANT SCORES

ASSIFICATION RESULTS -

ACTUAL GROUP		NO. OF CASES	PREDICTED GROUP MEMBERSHIP		
-----			1	2	3
		-----	-----	-----	-----
OUP	1	20	19	1	0
lvent			95.0%	5.0%	0.0%
OUP	2	11	0	11	0
solvent			0.0%	100.0%	0.0%
OUP	3	9	0	0	9
e over			0.0%	0.0%	100.0%

PERCENT OF "GROUPED" CASES CORRECTLY CLASSIFIED: 97.50%

ASSIFICATION PROCESSING SUMMARY

40 CASES WERE PROCESSED.
 0 CASES WERE EXCLUDED FOR MISSING OR OUT-OF-RANGE GROUP CODES.
 0 CASES HAD AT LEAST ONE MISSING DISCRIMINATING VARIABLE.
 40 CASES WERE USED FOR PRINTED OUTPUT.

FIGURE 11: CLASSIFICATION RESULTS

CANONICAL DISCRIMINANT FUNCTION 1

CANONICAL DISCRIMINANT FUNCTIONS

FUNCTION	EIGENVALUE	PERCENT OF VARIANCE	CUMULATIVE PERCENT	CANONICAL CORRELATION :	AFTER FUNCTION :	WILK
1*	5.69868	57.51	57.51	0.9223431	0	0-
2*	4.20961	42.49	100.00	0.8989143	1	0-

* MARKS THE 2 CANONICAL DISCRIMINANT FUNCTIONS REMAINING IN THE ANALY

STANDARDIZED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS

	FUNC 1	FUNC 2
13	-1.22079	0.25216
14	-1.10525	0.39365
15	3.01058	0.06216
16	-0.88397	-0.73183
110	0.98088	0.08323
114	-1.58097	2.20706
115	1.14318	-0.33194
116	1.87153	-0.98444
117	2.97854	-0.21465
118	-7.41498	3.85319
119	0.64408	-2.47027
120	-1.31478	1.08138
121	6.60072	-3.20818
122	-0.81020	0.79726
124	0.10640	0.98461
125	0.33065	-0.85268
128	1.57714	-0.09167
129	-0.85922	-0.45162
131	-2.10811	0.49194

FIGURE 13: EIGENVALUE CANONICAL CORRELATION AND STANDARDISED CANONICAL DISCRIMINANT FUNCTION COEFFICIENTS

APPENDIX C

A MANUAL FOR USE OF THE MINITAB STATISTICAL PACKAGE AND ITS OUTPUT

1. INTRODUCTION

Minitab is an interactive statistics package written and distributed by Minitab Inc, Pennsylvania.

Minitab stores the data being analysed in a worksheet which is arranged in a structure of rows and columns. The values of each different variable are stored in a separate column of the worksheet within Minitab. These columns are designated $C_1, C_2 \dots C_{20}$.

The package offers various statistical analyses as follows:

- simple descriptive statistics
- graph and histogram plots
- correlation and significance testing
- regression analysis (including stepwise)
- probabilities
- variance analysis.

2. MINITAB COMMANDS

There are over 100 Minitab commands of which any one user will probably analyse a few of them. The following commands are used in this thesis.

2.1 The "Set" Command

To input data from the terminal in prime systems, it needs to use the "set" command which inputs data one column at a time. The values of 31 financial ratios were inputted in separate columns of the worksheet.

2.2 The "End" Command

The input is terminated by the "end" command. The following columns were inputted onto the worksheet.

C₁-C₃₁: represents 31 financial ratios.

C₃₂: represents Z-values calculated from the Mason model.

C₃₄: represents the value of discriminant scores obtained from MDA, see Figure 5.5.

2.3 The "Save" Command

To store the data on file, the "save" command is used, followed by "filename". For example, save "Adnan".

2.4 The "Stop" Command

To leave the Minitab, the "stop" command is used which stops the program.

2.5 The "Retrieve" Command

To retrieve the data, it is necessary to use the "retrieve" command, followed by the filename. For example, retrieve "Adnan".

2.6 The "Help" Command

The Minitab program is itself able to supply information on its own command and method of use.

To use the "help" command, type "help" followed by the command, e.g. help regress or help correlation.

3. STATISTICAL COMMANDS

The package offers various statistical commands and can be used for data manipulation. Several optional statistics are available in this program. The commands which are used in this program are as follows.

3.1 The "Describe" Command

This is used to deliver descriptive statistics about continuous type data variables. In particular, "describe" gives the mean standard deviation etc.

To use "describe" simply give the command followed by any number of columns. For example, describe C₁-C₃₁.

3.2 The "Histogram" Command

This is used to plot histograms. To use "histogram" simply give the command, followed by any number of columns, e.g. Hist C₁.

3.3 The "Regression" Command

To use "regress" simply give the command "regress" followed by number of independent variables which are included in the analysis. For example, regress C₃₂ 5 C₆ C₁₂ C₁₇ C₂₃ C₂₅.

4.0 OUTPUT FROM THE MINITAB PROGRAM

The following is some output resulting from the program listing on pages 282 to 301.

MTB > print c1-c32

ROW	C1	C2	C3	C4	C5	C6	C7	C8
1	0.0755	0.1000	0.1100	0.067	0.0330	0.0570	0.0620	0.6900
2	0.1560	0.1620	0.1470	0.155	0.0630	0.0960	0.1000	0.7150
3	0.0800	0.1000	0.1500	0.068	0.0450	0.0600	0.0700	1.1500
4	0.0460	0.0700	0.0630	0.035	0.0250	0.0260	0.0520	1.3200
5	0.0970	0.1270	0.1760	0.084	0.0680	0.0860	0.0860	0.4000
6	0.1500	0.1600	0.1560	0.150	0.0270	0.1030	0.1150	0.4400
7	0.1540	0.1850	0.1870	0.140	0.0490	0.0900	0.1200	0.7700
8	0.2200	0.2780	0.7500	0.210	0.1700	0.1260	0.1670	0.3600
9	0.0830	0.1070	0.1500	0.070	0.0600	0.0430	0.1800	1.1500
10	0.1150	0.1300	0.0750	0.100	0.0160	0.0900	0.1100	0.7300
11	0.1580	0.1760	0.0940	0.118	0.1120	0.1130	0.1720	1.0000
12	0.0960	0.1250	0.2040	0.095	0.0685	0.0640	0.0840	1.0580
13	0.2300	0.3300	0.3070	0.218	0.0877	0.1460	0.2250	1.1360
14	0.2130	0.2360	0.5120	0.207	0.1220	0.1250	0.1420	0.4260
15	0.0960	0.1060	0.1000	0.083	0.0300	0.0770	0.0990	0.7900
16	0.1720	0.2250	0.1600	0.210	0.0470	0.0440	0.1300	0.8100
17	0.0900	0.1000	0.1070	0.061	0.0360	0.0480	0.0770	0.3870
18	0.0570	0.0550	0.0740	0.055	0.0060	0.0430	0.0500	0.3000
19	0.1620	0.1890	0.2100	0.568	0.0900	0.0930	0.1230	0.5800
20	0.1270	0.1790	0.2060	0.117	0.0800	0.0760	0.1200	0.3800
21	0.0913	0.1170	0.0619	0.046	0.0549	0.0430	0.1000	0.5950
Continue?								
22	-0.4570	-0.4750	-0.5590	0.216	-0.1740	-0.2490	-0.5330	2.1200
23	-0.0800	-0.0800	-0.0200	0.081	-0.0027	-0.0450	-0.0030	0.9680
24	0.1293	0.2810	0.1240	0.085	0.0625	0.0830	0.2750	0.7315
25	0.0400	0.1570	0.0440	0.028	0.0177	0.0248	0.0347	0.4580
26	-0.1710	-0.1710	-0.0600	0.085	-0.0277	-0.0980	-0.1920	0.4530
27	0.1160	0.1160	0.1110	0.100	0.0500	0.0890	0.1040	0.4470
28	-0.5900	-0.5900	-0.1270	0.274	-0.0380	-0.1310	-0.3200	1.2200
29	0.2440	0.0690	0.0480	0.056	0.0099	0.0220	0.0280	0.5960
30	0.1315	0.8230	0.1065	0.070	0.0500	0.0707	0.3710	0.9850
31	0.2030	0.6620	0.1050	0.085	0.0420	0.0510	0.4000	0.9190

ROW	C9	C10	C11	C12	C13	C14	C15	C16
1	0.480	0.4220	0.320	0.3600	0.670	0.6000	0.2100	0.5900
2	0.420	0.0990	0.105	0.3150	1.100	1.1000	0.0400	0.9100
3	0.320	0.0330	0.270	0.3600	0.530	0.4400	0.1400	0.9400
4	0.340	0.1400	0.250	0.9500	0.760	0.5800	0.2500	0.8300
5	0.560	0.6000	0.290	0.2600	0.550	0.4700	0.1880	0.4400
6	0.980	0.5800	0.400	0.4700	0.970	0.9900	0.0830	0.6100
7	0.560	0.3100	0.500	0.0300	0.820	0.7400	0.3700	0.7000
8	1.460	0.6800	0.160	0.0197	0.300	0.2770	0.1930	0.2900
9	0.780	0.1330	0.135	0.1900	0.430	0.3770	0.2050	0.6000
10	0.820	0.3300	0.367	0.2300	1.580	1.4100	0.1300	0.8000
Continue?								
11	0.455	0.1440	0.323	0.3540	1.660	1.2700	0.0820	0.9580
12	0.500	0.1780	0.020	0.1140	0.470	0.4670	0.2260	0.7270
13	0.634	0.2070	0.037	0.1390	0.763	0.9320	0.2940	0.7680
14	0.940	0.6000	0.570	0.0400	0.420	0.3100	0.0950	0.4050
15	0.980	0.2700	0.610	0.1580	0.880	0.7600	0.0910	0.7800
16	0.770	0.3370	0.517	0.1640	1.070	0.9500	0.0480	0.7360
17	0.430	0.4000	0.380	1.4200	0.930	0.5700	0.0430	0.5850
18	1.560	0.7100	0.490	0.1920	0.960	0.9300	0.0900	0.4800
19	0.080	0.4300	0.042	0.1000	0.600	0.6700	0.1220	0.6100
20	0.800	0.6740	0.270	0.2380	0.630	0.5700	0.2650	0.4600
21	0.400	0.3580	0.079	1.6900	1.500	0.7530	0.0880	0.7415
22	0.404	0.4980	0.400	0.5200	2.110	1.0200	0.0203	1.9500
23	0.710	0.0930	0.623	1.5100	1.190	0.7560	0.1950	0.9940
24	0.522	0.4270	0.376	0.7250	0.944	0.6250	0.3240	0.5900
25	1.228	0.2730	0.326	0.9360	0.790	0.8160	0.2500	0.6800
26	0.586	0.2970	0.580	0.2590	0.723	0.9260	0.0001	0.7990
27	0.734	0.3615	0.730	0.6260	1.170	0.9680	0.0001	0.7220
28	0.230	0.2720	0.210	0.0920	2.760	1.3170	0.0025	1.0000
29	0.278	0.3080	0.268	1.3750	1.490	1.1580	0.0001	0.7860
30	0.989	0.7320	0.255	0.6160	0.890	0.9735	0.0001	0.5640
31	0.525	0.2940	0.520	0.6000	1.000	0.7990	0.0830	0.7300

ROW	C17	C18	C19	C20	C21	C22	C23	C24
Continue?								
1	1.1900	1.530	1.020	0.3200	0.430	1.630	2.240	1.750
2	1.2000	1.240	1.200	0.4700	0.480	1.240	2.500	2.311
3	0.5900	0.670	0.460	1.0800	1.310	1.450	1.800	2.870
4	0.9000	1.360	0.690	0.2600	0.400	1.500	1.900	6.100
5	1.2300	1.570	1.070	0.2800	0.360	1.270	1.480	3.340
6	1.5600	1.700	1.560	0.9500	1.040	1.380	5.430	2.311
7	1.1780	1.420	1.060	0.4600	0.560	1.580	3.100	0.680
8	0.7500	1.160	0.965	0.4300	0.540	1.500	1.010	0.210
9	0.7200	0.930	0.625	0.4500	0.590	0.178	1.350	1.770
10	1.9600	2.300	1.750	1.3000	1.540	1.326	6.750	1.700
11	1.7000	1.870	1.310	0.7440	0.824	1.500	6.250	1.780
12	0.5270	0.780	0.645	0.2340	0.307	0.360	1.410	0.163
13	0.9800	1.415	0.932	0.4800	0.696	0.530	2.115	0.220
14	1.0340	0.880	1.004	0.3900	0.435	1.800	1.736	0.300
15	1.1600	1.290	1.040	0.8750	0.970	1.740	3.270	1.730
16	1.4500	1.900	1.300	0.8160	1.090	1.620	3.620	0.740
17	1.5600	1.690	0.970	0.3870	0.390	1.680	2.500	11.300
18	1.6800	1.850	1.400	1.2000	1.320	1.036	12.200	0.880
19	1.2600	1.500	1.105	0.0610	0.070	0.837	1.800	0.901
20	1.3600	1.980	1.240	0.4900	0.740	1.426	1.630	0.735
21	2.0520	2.480	1.020	0.3130	0.401	1.356	1.811	12.800
22	1.0815	1.096	0.523	0.8590	0.898	1.900	3.285	3.740
23	1.1800	1.180	0.760	0.8330	1.060	2.050	2.156	8.000
Continue?								
24	1.5890	3.200	1.052	0.4740	0.836	1.829	1.792	6.960
25	1.1420	1.143	0.860	0.9480	0.850	1.572	1.521	6.150
26	2.6400	2.630	1.160	1.1250	1.124	1.925	5.470	0.400
27	1.5860	1.580	1.330	0.8430	0.843	2.275	2.360	1.767
28	2.5300	2.530	1.285	0.6430	0.643	1.238	10.160	2.566
29	1.8990	1.899	1.466	0.3380	0.448	1.313	6.000	16.100
30	2.3750	14.600	1.705	1.2920	8.230	1.627	2.726	4.740
31	2.7700	8.900	1.080	0.0800	3.420	1.850	4.860	2.800

ROW	C25	C26	C27	C28	C29	C30	C31
1	0.700	0.143	0.070	0.027	1.760	0.023	0.0650
2	2.930	0.300	0.210	0.084	0.380	0.630	0.2100
3	0.320	0.280	0.450	0.080	0.800	0.250	0.1300
4	0.290	0.290	0.350	0.430	0.210	0.800	0.4700
5	0.500	0.410	0.220	0.140	0.970	0.725	0.2380
6	0.870	0.650	0.310	0.290	0.140	0.630	0.0130
7	0.280	0.210	0.510	0.530	1.000	0.630	0.4300
8	0.490	0.380	0.081	0.237	1.879	0.330	0.2100
9	0.225	0.270	0.700	0.220	0.350	0.095	0.8800
10	0.440	0.520	0.220	0.130	1.060	2.250	0.3400
11	1.370	1.050	0.400	0.240	2.860	1.780	0.3100
12	0.205	0.520	0.400	0.114	0.105	1.400	0.1600
Continue?							
13	0.550	0.255	0.154	0.142	0.623	0.345	0.1210
14	0.850	0.170	0.042	0.083	1.043	0.620	0.1470
15	3.250	1.210	0.196	0.500	0.830	1.170	0.4500
16	0.084	0.160	0.110	0.074	0.183	0.530	0.0660
17	7.300	1.400	0.145	0.316	0.600	1.330	0.1530
18	1.260	3.620	0.265	0.400	0.685	0.400	0.6240
19	0.860	0.068	1.280	0.920	0.840	0.343	0.1625
20	3.000	0.960	0.450	1.570	1.060	0.480	2.3200
21	1.000	0.056	0.500	0.570	0.125	0.500	1.2620
22	0.700	0.330	0.116	0.060	0.265	0.430	0.1140
23	0.600	0.835	0.157	0.155	1.550	0.441	0.0825
24	0.357	0.295	0.300	0.040	0.414	0.150	0.2220
25	0.011	4.900	0.200	0.180	0.198	0.690	0.2400
26	0.625	0.370	0.185	0.200	0.177	0.928	0.1800
27	0.569	0.210	0.590	0.785	1.575	5.485	0.4900
28	2.930	2.930	0.910	0.910	1.196	1.687	0.8260
29	0.543	0.600	0.260	0.007	0.213	0.500	0.1873
30	0.497	0.900	0.025	0.134	1.400	0.176	0.0037
31	0.398	0.576	0.480	0.833	1.070	2.500	0.4740

#TB > print c34

C34

1.4401	3.1135	2.2240	-0.2700	0.3030	1.9579	1.9749	3.0666
1.6517	0.2229	1.6284	1.9778	3.3910	2.7992	2.7024	0.6598
1.0660	2.6437	1.7752	1.9594	-4.0570	-3.4950	-2.4775	-1.1400
-4.5116	-4.0330	-2.5189	-3.1102	-3.3787	-3.4541	-4.1112	

mid / DESC C PCSI

	N	MEAN	MEDIAN	TRMEAN	STDEV	SEMEAN
C1	31	0.0721	0.1150	0.1040	0.1805	0.0324
C2	31	0.1306	0.1270	0.1344	0.2529	0.0454
C3	31	0.1217	0.1100	0.1184	0.2015	0.0362
C4	31	0.1270	0.0850	0.1123	0.1034	0.0186
C5	31	0.0413	0.0470	0.0445	0.0579	0.0104
C6	31	0.0463	0.0600	0.0571	0.0807	0.0145
C7	31	0.0809	0.1000	0.0974	0.1722	0.0309
C8	31	0.8443	0.7300	0.7558	0.5533	0.0994
C9	31	0.6605	0.5600	0.6350	0.3433	0.0617
C10	31	0.3610	0.3300	0.3564	0.1955	0.0351
C11	31	0.3362	0.3230	0.3338	0.1888	0.0339
C12	31	0.4856	0.3150	0.4371	0.4679	0.0840
C13	31	0.9890	0.8900	0.9285	0.5239	0.0941
C14	31	0.7911	0.7600	0.7856	0.2935	0.0527
C15	31	0.1332	0.0950	0.1272	0.1053	0.0189
C16	31	0.7347	0.7270	0.7005	0.2853	0.0512
C17	31	1.446	1.260	1.419	0.582	0.105
C18	31	2.267	1.570	1.679	2.698	0.485
C19	31	1.0835	1.0600	1.0796	0.3178	0.0571
C20	31	0.6266	0.4800	0.6182	0.3532	0.0634
C21	31	1.060	0.740	0.771	1.456	0.261
C22	31	1.4361	1.5000	1.4687	0.4665	0.0838
Continue?						
C23	31	3.427	2.360	3.019	2.627	0.472
C24	31	3.478	1.780	2.909	3.942	0.708
C25	31	1.097	0.569	0.865	1.456	0.262
C26	31	0.802	0.380	0.601	1.089	0.196
C27	31	0.3318	0.2600	0.2974	0.2687	0.0483
C28	31	0.3355	0.2000	0.2917	0.3523	0.0633
C29	31	0.825	0.800	0.763	0.644	0.116
C30	31	0.911	0.620	0.746	1.047	0.188
C31	31	0.3737	0.2100	0.2956	0.4570	0.0821

Continue?

MIN MAX N --

Continue?

	MIN	MAX	Q1	Q3
C1	-0.5900	0.2440	0.0755	0.1580
C2	-0.5900	0.8230	0.1000	0.1890
C3	-0.5590	0.7500	0.0630	0.1760
C4	0.0280	0.5680	0.0680	0.1550
C5	-0.1740	0.1700	0.0177	0.0680
C6	-0.2490	0.1460	0.0387	0.0900
C7	-0.5330	0.4000	0.0520	0.1420
C8	0.3000	2.9850	0.4470	1.0800
C9	0.0800	1.5600	0.4200	0.8200
C10	0.0330	0.7320	0.2070	0.4980
C11	0.0200	0.7300	0.2100	0.5000
C12	0.0197	1.6900	0.1580	0.6260
C13	0.3000	2.7600	0.6300	1.1700
C14	0.2770	1.4100	0.5700	0.9735
C15	0.0001	0.3700	0.0430	0.2100
C16	0.2900	1.9500	0.5900	0.8000
C17	0.527	2.770	1.081	1.700
C18	0.670	14.600	1.180	1.980
C19	0.4600	1.7500	0.9320	1.3000
C20	0.0610	1.3000	0.3380	0.8750
C21	0.070	8.230	0.435	1.060
C22	0.1780	2.2750	1.2700	1.7400

Continue?

C23	1.010	12.200	1.792	4.860
C24	0.163	16.100	0.740	4.740
C25	0.011	7.300	0.357	1.000
C26	0.056	4.900	0.255	0.900
C27	0.0250	1.2800	0.1540	0.4500
C28	0.0070	1.5700	0.0840	0.5000
C29	0.105	2.860	0.213	1.070
C30	0.023	5.485	0.345	1.170
C31	0.0037	2.3200	0.1300	0.4700

MTB > step c34 c1-c31

STEPWISE REGRESSION OF C34 ON 31 PREDICTORS, WITH N = 31
Continue?

STEP	1	2	3	4	5	6	7
CONSTANT	4.148	2.512	3.273	2.973	2.809	3.040	3.007
C17	-2.87	-2.25	-1.95	-2.10	-2.84	-3.14	-2.87
T-RATIO	-4.31	-3.99	-4.23	-6.05	-7.86	-11.91	-17.39
C6		16.14	13.99	13.65	15.34	14.77	15.66
T-RATIO		3.96	4.20	5.45	7.11	9.62	16.68
C12			-2.26	-2.58	-2.08	-1.82	-1.85
T-RATIO			-3.99	-6.00	-5.37	-6.51	-10.90
C25				0.628	0.581	0.642	0.660
T-RATIO				4.69	5.12	7.88	13.37
C23					0.282	0.439	0.446
T-RATIO					3.45	6.67	11.19
C26						-0.630	-0.647
T-RATIO						-5.05	-8.57
C30							-0.459
T-RATIO							-6.52

Continue? regr c34 5 c17 c6 c12 c25 c23

S	2.12	1.73	1.44	1.05	0.880	0.425	0.378

To print more output, type Y or YES or push return.

To terminate printing, type N or NO.

For more information, see HELP OUTPUT.

(Note that before typing HELP OUTPUT, you must either finish printing or terminate this OUTPUT.)

Continue?

R-SQ 39.02 60.92 75.43 86.68 90.98 95.63 98.47

MORE? (YES, NO, SUBCOMMAND, OR HELP)

SUBC> abort

MTB >

MTB > regr c34 5 c17 c6 c12 c25 c23

The regression equation is

C34 = 2.81 - 2.84 C17 + 15.3 C6 - 2.08 C12 + 0.581 C25 + 0.282 C23

The regression equation is

$$C34 = 2.81 - 2.84 C17 + 15.3 C6 - 2.00 C12 + 0.581 C25 + 0.282 C23$$

Predictor	Coef	Stdev	t-ratio
Constant	2.8093	0.4977	5.65
C17	-2.8426	0.3618	-7.86
C6	15.336	2.156	7.11
C12	-2.0020	0.3876	-5.37
C25	0.5807	0.1134	5.12
C23	0.28192	0.08161	3.45

s = 0.8798 R-sq = 91.0% R-sq(adj) = 89.2%

Analysis of Variance

SOURCE	DF	SS	MS
Regression	5	195.194	39.039
Error	25	19.350	0.774
Total	30	214.544	

Continue?

SOURCE	DF	SEQ SS
C17	1	83.707
C6	1	47.000
C12	1	31.114
C25	1	24.138
C23	1	9.236

The regression equation is

$$C32 = 3.47 + 74.5 C4 - 14.7 C11 + 3.37 C26 - 5.17 C13$$

Predictor	Coef	Stdev	t-ratio
Constant	3.469	1.873	1.85
C4	74.547	5.297	14.07
C11	-14.667	3.505	-4.18
C26	3.3720	0.7933	4.25
C13	-5.168	1.672	-3.09

s = 2.465 R-sq = 95.0% R-sq(adj) = 93.6%

STEP	1	2	3	4
CONSTANT	-3.1850	1.7778	0.2507	3.4685
C4	76.1	69.7	74.7	74.5
T-RATIO	8.89	9.00	11.39	14.07
C11		-13.4	-17.0	-14.7
T-RATIO		-2.70	-4.00	-4.18
C26			2.95	3.37
T-RATIO			3.04	4.25
C13				-5.2
T-RATIO				-3.09
S	4.32	3.77	3.05	2.46
R-SQ	81.45	87.01	91.77	94.98
MORE? (YES, NO, SUBCOMMAND, OR HELP)				
CURSOR movement				

MTB > hist c1-c31

Histogram of C1 N = 31

Midpoint	Count
-0.6	1 *
-0.5	1 *
-0.4	0
-0.3	0
-0.2	1 *
-0.1	1 *
-0.0	2 **
0.1	14 *****
0.2	11 *****

Continue?

Histogram of C2 N = 31

Midpoint	Count
-0.6	1 *
-0.4	1 *
-0.2	1 *
-0.0	4 ***
0.2	21 *****
0.4	1 *
0.6	1 *
0.8	1 *

Continue?

Histogram of C3 N = 31

Midpoint	Count
-0.6	1 *
-0.4	0
-0.2	1 *
-0.0	9 *****
0.2	17 *****
0.4	1 *
0.6	1 *
0.8	1 *

Continue?

Histogram of C4 N = 31

Midpoint	Count	
0.05	10	*****
0.10	11	*****
0.15	3	***
0.20	5	*****
0.25	1	*
0.30	0	
0.35	0	
0.40	0	
0.45	0	
0.50	0	
0.55	1	*

Continue?

Histogram of C5 N = 31

Midpoint	Count	
-0.15	1	*
-0.10	0	
-0.05	2	**
-0.00	5	*****
0.05	17	*****
0.10	5	*****
0.15	1	*

Continue?

Histogram of C6 N = 31

Midpoint	Count	
-0.25	1	*
-0.20	0	
-0.15	1	*
-0.10	1	*
-0.05	1	*
-0.00	2	**
0.05	11	*****
0.10	11	*****
0.15	3	***

Continue?

- - - -

Continue?

Histogram of C7 N = 31

Midpoint	Count	*
-0.4	0	
-0.3	1	*
-0.2	1	*
-0.1	0	
-0.0	3	***
0.1	18	*****
0.2	4	****
0.3	2	**
0.4	1	*

Continue?

Histogram of C8 N = 31

Midpoint	Count	*
0.4	13	*****
0.8	9	*****
1.2	7	*****
1.6	0	
2.0	1	*
2.4	0	
2.8	1	*

Continue?

Histogram of C9 N = 31

Midpoint	Count	*
0.0	1	*
0.2	2	**
0.4	8	*****
0.6	7	*****
0.8	6	*****
1.0	4	****
1.2	1	*
1.4	1	*
1.6	1	*

Continue?

Histogram of C10 N = 31

Midpoint	Count	
0.0	1	*
0.1	5	*****
0.2	2	**
0.3	9	*****
0.4	6	*****
0.5	1	*
0.6	3	***
0.7	4	****

Continue?

Histogram of C11 N = 31

Midpoint	Count	
0.0	3	***
0.1	3	***
0.2	2	**
0.3	9	*****
0.4	5	*****
0.5	4	****
0.6	4	****
0.7	1	*

Continue?

Histogram of C12 N = 31

Midpoint	Count	
0.0	4	****
0.2	11	*****
0.4	5	*****
0.6	4	****
0.8	1	*
1.0	2	**
1.2	0	
1.4	2	**
1.6	2	**

Continue?

Histogram of C13 N = 31

Midpoint	Count	
0.4	4	****
0.6	5	*****
0.8	7	*****
1.0	6	*****
1.2	3	***
1.4	1	*
1.6	3	***
1.8	0	
2.0	0	
2.2	1	*
2.4	0	
2.6	0	
2.8	1	*

Continue?

Histogram of C14 N = 31

Midpoint	Count	
0.3	2	**
0.4	2	**
0.5	2	**
0.6	5	*****
0.7	2	**
0.8	5	*****
0.9	3	***
1.0	5	*****
1.1	1	*
1.2	1	*
1.3	2	**
1.4	1	*

Continue?

Histogram of C15 N = 31

Midpoint	Count	
0.00	6	*****
0.05	3	***
0.10	8	*****
0.15	2	**
0.20	5	*****
0.25	4	****
0.30	2	**

Histogram of C16 N = 31

Midpoint	Count	
0.2	1	*
0.4	4	****
0.6	8	*****
0.8	12	*****
1.0	5	*****
1.2	0	
1.4	0	
1.6	0	
1.8	0	
2.0	1	*

Continue?

Histogram of C17 N = 31

Midpoint	Count	
0.6	2	**
0.8	2	**
1.0	4	****
1.2	8	*****
1.4	2	**
1.6	5	*****
1.8	2	**
2.0	2	**
2.2	0	
2.4	1	*
2.6	2	**
2.8	1	*

Continue?

Histogram of C18 N = 31

Midpoint	Count	
0	4	****
2	24	*****
4	1	*
6	0	
8	1	*
10	0	
12	0	
14	1	*

Continue?

Histogram of C19

Midpoint	Count	
0.4	1	*
0.6	4	****
0.8	2	**
1.0	11	*****
1.2	5	*****
1.4	5	*****
1.6	1	*
1.8	2	**

Continue?

Histogram of C20 N = 31

Midpoint	Count	
0.1	2	**
0.2	1	*
0.3	5	*****
0.4	3	***
0.5	6	*****
0.6	1	*
0.7	1	*
0.8	3	***
0.9	3	***
1.0	1	*
1.1	2	**
1.2	1	*
1.3	2	**

Continue?

Histogram of C21 N = 31

Midpoint	Count	
0	10	*****
1	18	*****
2	1	*
3	1	*
4	0	
5	0	
6	0	
7	0	
8	1	*

Continue?

Histogram of C22 N = 31

Midpoint	Count	
0.2	1	*
0.4	1	*
0.6	1	*
0.8	1	*
1.0	1	*
1.2	3	***
1.4	6	*****
1.6	9	*****
1.8	4	****
2.0	3	***
2.2	1	*

Continue?

Histogram of C23 N = 31

Midpoint	Count	
2	12	*****
3	6	*****
4	1	*
5	3	***
6	2	**
7	1	*
8	0	
9	0	
10	1	*
11	0	
12	1	*

Continue?

Histogram of C24 N = 31

Midpoint	Count	
0	10	*****
2	11	*****
4	3	***
6	3	***
8	1	*
10	0	
12	2	**
14	0	
16	1	*

Histogram of C25 N = 31

Midpoint	Count	
0	12	*****
1	14	*****
2	0	
3	4	****
4	0	
5	0	
6	0	
7	1	*

Continue?

Histogram of C26 N = 31

Midpoint	Count	
0.0	7	*****
0.5	15	*****
1.0	5	*****
1.5	1	*
2.0	0	
2.5	0	
3.0	1	*
3.5	1	*
4.0	0	
4.5	0	
5.0	1	*

Continue?

Histogram of C27 N = 31

Midpoint	Count	
0.0	4	****
0.2	13	*****
0.4	8	*****
0.6	3	***
0.8	1	*
1.0	1	*
1.2	1	*

Continue?

—Histogram of C28 N = 31

Midpoint	Count	
0.0	8	*****
0.2	12	*****
0.4	3	***
0.6	3	***
0.8	2	**
1.0	2	**
1.2	0	
1.4	0	
1.6	1	*

Continue?

Histogram of C29 N = 31

Midpoint	Count	
0.0	6	*****
0.4	6	*****
0.8	7	*****
1.2	6	*****
1.6	4	****
2.0	1	*
2.4	0	
2.8	1	*

Continue?

Histogram of C30 N = 31

Midpoint	Count	
0.0	4	****
0.5	17	*****
1.0	3	***
1.5	3	***
2.0	1	*
2.5	2	**
3.0	0	
3.5	0	
4.0	0	
4.5	0	
5.0	0	
5.5	1	*

Histogram of C31 N = 31

Midpoint	Count	
0.0	5	*****
0.2	14	*****:*****
0.4	7	*****
0.6	1	*
0.8	2	**
1.0	0	
1.2	1	*
1.4	0	
1.6	0	
1.8	0	
2.0	0	
2.2	0	
2.4	1	*

MTB >

APPENDIX D

CORRESPONDENCE, DIAGRAMS, CASE STUDIES AND QUESTIONNAIRE

1. INTRODUCTION

This appendix consists of five sections as follows:

- D-1 Includes results of survey of 25 London authorities obtained from London Borough of Richmond-upon-Thames (research section), about financial appraisal procedure - approved list of contractors and competitive tendering. An analysis of the results of the survey is attached.
- D-2 Includes certificate obtained from London Borough of Camden concerned with the validation of multiple regression model on those private companies dealing with LBC.
- D-3 Contains the Z-score trends during the period 1982-1986 for the "non-failed 20" companies and the last three years before failure for the "failed 11" companies
- D-4 Includes three case studies obtained from Cork Gully Chartered Accountants, and these include the following companies declared bankrupt with Cork Gully appointed as liquidators:
1. Southern Construction Ltd
 2. Crouch Construction Ltd and Crouch Group plc
 3. Mears Bros Holdings Ltd.
- D-5 Includes a questionnaire designed to identify the managerial defects and mistakes related to failure, and includes 27 questions investigated by using the multiple choice method.

APPENDIX D-1

RESULTS OF SURVEY ABOUT FINANCIAL APPRAISAL PROCEDURE

by

LONDON BOROUGH OF RICHMOND-UPON-THAMES RESEARCH SECTION

APPROVED LIST OF CONTRACTORS - FINANCIAL APPRAISAL PROCEDURES
RESULTS OF SURVEY CARRIED OUT BY L.B. RICHMOND UPON THEMES

TABLE 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	SUBJECT
1. GENERAL																										
1.1. Financial Appraisals Carried Out?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	24-Yrs. into Mo
1.2. How Frequently are Appraisals Done? (Years)	3	3	1	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	Modern 3 Years
2. FINANCIAL APPRAISAL PROCEDURES																										
2.1. Perusal of Firms' Accounts? (How many years' Accounts?)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	24-Yrs. into Modern 2/3 Years
2.2. Company Searches Used? (If Indicates Online Accounts)	M	Y	M	M	Y	M	M	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	18-Yrs. into 5 online
2.3. Ratio Analysis Used?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	19-Yrs. into 14-Yrs. into
2.4. Bankers' References Obtained?	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	
3. FINANCIAL LIMITS ON CONTRACT SIZE																										
3.1. Ceiling Imposed on Value of Contracts Awarded to Individual Contractors?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	22-Yrs. into
4. USE OF FINANCIAL GUARANTEE, PERFORMANCE BONDS Etc.																										
4.1. Are Financial Sureties (e.g. from Holding Companies) Used?	M	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	21-Yrs. into 14-Yrs. into 22-Yrs. into
4.2. Are Performance Bonds Used? (e.g. always, sometimes, never)	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	S	24-Yrs. into
5. NEW AND EXISTING BUSINESSES																										
5.1. Is Work Given to Firms With Little or No Track Record?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	19-Yrs. into

Financial Appraisal Procedures
Approved List of Contractors and Competitive Tendering
Results of Survey Carried Out by L.B. Richmond Upon Thames

Introduction

Table 1 summarises the responses to questions requiring Yes/No type answers. As a number of authorities preferred not to be identified the results are presented anonymously. Responses were received from 25 of the 33 London authorities surveyed, a response rate of 76%. These notes summarise and comment upon the results shown in Table 1 and discuss the results of the more detailed questions. The results have not been converted into percentage terms as little would be gained from doing so.

1. General

All 25 authorities carry out financial appraisals of firms applying to do work for them, whether for a select list of contractors, annual maintenance contracts or other ad hoc contracts. Table 2 summarises the answers to Q. 1.2 concerning the frequency of reappraisal, the most common response being 'every 3 years' (10 authorities).

Table 2 (Q.1.2)

<u>Frequency of Reappraisal</u>	<u>No. Responses</u>
Annual.	5
2 years	3
3 years	10
4 years	1
5 years	2
Ad Hoc Basis	4
	<u>25</u>

2. Financial Appraisal Procedures

2.1 Table 3 summarises the sources of information and techniques used in carrying out financial appraisals.

<u>Table 3 (Q.2.1)</u>		<u>Yes</u>	<u>No</u>	<u>Total</u>
a)	Perusal of Firm's Accounts	24	1	25
b)	Company Searches	18	7	25
c)	Ratio Analysis	20	5	25
d)	Bankers' References	14	11	25

a) Companies' Accounts

The majority of authorities (24 out of 25) examine firms' financial accounts, with only 1 authority relying solely on company status reports produced by outside agencies. Eleven respondents prefer to see accounts for the last 3 years, a further 11 expect to see the last 2 years' accounts, and the remaining 2 base their appraisals on the most recent year's results alone.

b) Company Searches

Eighteen authorities use company searches produced by outside agencies (of which the most popular are Infocheck (8) and Dunn and Bradstreet (6)). Only 5 authorities have access to company searches on line. Seventeen authorities obtain information both directly from firms' accounts and from company searches with only one using company searches alone.

c) Ratio Analysis

Twenty authorities use ratio analysis (to a greater or lesser extent) to assess the financial standing of prospective contractors. Four authorities rely on company status reports produced by outside agencies, some of which quote ratios as part of their analysis of course.

Use of Z-Score Analysis

Of the 20 authorities using ratios 6 use Z-score analysis (mainly Altman's Z-score) to assess the solvency of potential contractors.

A Z-score for a particular firm is calculated by adding together a number of ratios, each having been weighted according to its usefulness. The formula results in a single score which is compared with standard bench marks e.g. a score greater than 3.0 indicates that the company should be safe whilst a score below 1.8 indicates that the company is at risk of failure. The ratios incorporated into Z-score analysis include: working capital/total assets; retained earnings/total assets; profits before interest and tax/total assets; market capitalisation/book value of debts; and, sales/total assets.

Given its comparative complexity, Z-score analysis requires the use of spreadsheet software if it is to be carried out on a regular basis.

Further information on the Z-score technique can be found in an article by David Citron and Richard Taffler: "The Financial Vetting of Contractors" in PFA (Sept 9th 1988). This also discusses the use of risk indices and PAS-scores or performance measures.

Traditional Ratio Analysis

Fourteen authorities use traditional ratio analysis i.e. selected ratios are calculated and the results used to make professional judgements as to the continuing financial viability of potential and existing contractors. Table 4 (overleaf) outlines the different ratios used and the number of authorities using each one.

Table 4 Use of Selected Ratios

<u>Ratio</u>	<u>No. Authorities</u>
Current Ratio (Curr.Assets/Curr.Liabs)	14
Acid Ratio (Curr. Assets-Stock and WIP/ Curr. Liabs)	12
Profitability Ratios(various)	9
Gearing	3
Net Worth/Turnover	2
Working Capital/Turnover	1
Return on Capital Employed	2
Debtors/Turnover	1
Creditors/Cost of Sales	1
Earnings Per Share	1

All of the authorities using traditional ratio analysis calculate the current ratio and most use the acid or quick ratio in addition. The majority of authorities expect to see minimum values of between 0.7 and 1.0 for the current ratio, and between 0.5 and 1.0 for the acid ratio.

Nine authorities use profitability ratios, most commonly net profit before interest and tax/turnover, although gross profit margins are also used. Two authorities expect to see net profit margins of at least 3%, and one 0%. The remaining authorities do not set minimum levels.

Only 3 authorities calculate gearing ratios and these would normally expect to see results of less than 1.0, although some flexibility is allowed.

In most cases the minimum/maximum acceptable ratio values are set for guidance rather than being applied rigidly. The inter-relationship between ratios, together with other information given by the accounts, is examined to assess the significance of any departure from the normally expected levels.

Traditional ratio analysis, as used by the authorities responding to this survey relies heavily upon an assessment of liquidity. This is to be expected given that a major concern is to avoid letting contracts to firms which are likely to go out of business. Profitability is also seen as important, followed by gearing, with a few authorities calculating additional ratios as shown in Table 4. However, most authorities look not only at the ratios they have calculated but also at the overall financial position as indicated by the accounts. Ratios are used to focus attention on the salient points. Therefore, it would not be correct to assume, for example, that the five authorities which do not calculate profitability ratios do not take any account of this aspect in their appraisals.

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d) Bankers' References

Fourteen of the 25 respondents seek bankers' references in support of applications from potential contractors. Some seek bankers' references in every case, others use them on a selective basis depending on the size of the firm, how well known or otherwise it may be and the type of contract.

3. Financial Limits on Contract Size

Twenty two of the 25 authorities impose some form of limit on the value of contracts which may be awarded. These limits take one of three forms: a) a limit on the maximum total value of contracts which may be awarded to a particular contractor in any one year; b) a limit on the value of work which a particular contractor may have outstanding at any one time; c) a limit on the value of individual contracts which may be awarded to particular contractors (but no limit on the number of contracts which may be won). The results are broken down as follows:-

<u>Table 5 (Q.3.1)</u>	<u>No. Authorities</u>
a) Annual Limit on Total Value of Contracts	12
b) Limit on Value of Work Outstanding at Any One Time	6
c) Limit on Value of Individual Contracts (but no Overall Limit)	4
	<u>22</u>

The following tables show the values used.

Table 6 shows the values used by the 12 authorities which set annual limits.

<u>Table 6</u>	<u>a) Annual Limits</u>	<u>No. Authorities</u>
	100% turnover	1
	(1) 50% turnover	4
	25%-28% turnover	4
	20%-25% turnover (or less)	3
		<u>12</u>

Note (1) 3 authorities use 50% of the average previous 2 years turnover

Table 7 (overleaf) shows the limits set by the 6 authorities which control the amount of work outstanding at any one time.

<u>Table 7</u>	<u>b) Limits on Work Outstanding at Any One Time</u>	<u>No. Authorities</u>
	50% turnover	4
	25% turnover	1
	Unknown	1
		<u>6</u>

c) Limits Per Contract (But no Overall Limit on Number of Contracts)

One of the 4 authorities which limit the value of individual contracts uses limits recommended by Infocheck. (Recommended contract limits do not appear as part of the usual on line company status reports which Infocheck produce but may be provided by special arrangements). Another uses a limit of 25% turnover or 50% turnover depending on the type of contract. The others set limits averaging approximately 15% depending upon the results of the financial appraisal.

Irrespective of the type of limit applied, most authorities apply more restrictive limits to firms with less favourable financial appraisal results.

Why are Financial Limits Used?

The responses show a broad consensus as to the reasons for applying financial limits. These are summarised below:-

- firms should not take on work beyond their capacity: authorities do not wish to encourage over-trading and consequent receiverships.
- the risk of mid-contract liquidation or other default should be minimised in order to avoid additional costs, administrative inconvenience, problems in getting defects remedied etc.
- firms should not be over-reliant on Council business; if for any reason the Council were to cease providing the level of work expected, the firm might suffer financial difficulties with consequent job losses in the local area, bad Council public relations image etc.
- the authority should not allow itself to become over-dependent upon a few contractors as this could encourage the formation of cartels and provide the opportunity for collusion between officers and contractors.
- there should be as wide a choice of suitable firms as possible to ensure that tenders are competitive and the authority gets value for money.

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- the use of financial limits based on standard criteria ensures that applicants are treated fairly.

Most authorities find it necessary to allow some exceptions to the rules, for example if there is a shortage of firms on the list for particular types of work. One authority notes that the set limits may be exceeded by up to 10% without consultation to allow some flexibility. Some authorities require committee approval for limits to be exceeded.

Whilst the use of financial limits in some form is seen as essential by most authorities for the reasons mentioned above, most agree that monitoring adherence to those limits is problematic. Unless an authority has a computerised system which can combine both tendering and payments histories for individual contractors, it can prove difficult to apply the limits. A few authorities responding to this survey are moving in this direction but as yet none has such a system in full operation. Therefore, the use of annual limits relies to a large extent on keeping running totals of the amount of work awarded to individual contractors. Limits on the amount of work outstanding at any one time also require payments to be checked on a regular basis so that payments can be subtracted from the value of contracts awarded to determine the available limit.

Keeping track of contracts and payments in this way is time-consuming and difficult given that a number of different departments and even sections within departments are involved in letting contracts.

4. Use of Financial Guarantees, Performance Bonds Etc

4.1 Financial Guarantees

As shown in Table 1, 21 authorities use financial guarantees from parent companies.

4.2 Performance Bonds

<u>Table 8</u>	<u>Are Performance Bonds Used?</u>	<u>No. Authorities</u>
	a) Always	1
	b) Sometimes	22
	c) Never	2
		<u>25</u>

Most of the authorities responding to the survey use performance bonds under certain circumstances, whether for contracts over a certain value, of a particular type (e.g. all new build works) or for firms which fail to satisfy the usual financial requirements. Nineteen authorities quoted a threshold contract value above which performance bonds are usually sought. A wide range of threshold values was quoted as illustrated in Table 9.

Table 9 (Q.4.3)

Contract Sum Above Which
Performance Bonds are
Usually Required

<u>Threshold</u>	<u>No. Authorities</u>
£ 30,000	1
£ 50,000	2
£ 60,000	1
£100,000	7
£125,000-£150,000	3
£200,000-£250,000	4
£500,000	1
Special Circumstances	4
	<u>23</u>

5. New and Emerging Businesses

Nineteen of the 25 authorities are prepared to give work to new or emerging businesses with little or no financial track record.

The arguments in favour of using new and emerging businesses were as follows:-

- lack of suitable established firms available to do the job
- local economic development issues: e.g. new businesses cannot be expected to develop unless they are given a chance to demonstrate their capabilities; being accepted for local authority contracts acts as a good reference and can help firms secure work from other sources.

If new and emerging businesses are to be offered work, most authorities find it necessary to relax the financial appraisal criteria normally applied. In the absence of audited financial accounts, some authorities seek other forms of financial references such as bankers' and accountants' references, details of financial backing, details of previous contracts carried out, business plans and financial forecasts etc. Some authorities assess such firms on the basis of technical criteria alone.

Given the degree of risk associated with awarding contracts to new firms, some authorities restrict the types of contracts which may be awarded e.g. to jobs of a fragmented nature such as painting and decorating or minor landscaping works. Many authorities restrict the value of contracts which may be awarded. Ten authorities mention specific sums, ranging from £500 per contract to £20,000 per annum.

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Some respondents mentioned the danger of encouraging new businesses to rely too heavily on Council contracts. One authority adopts a system of banding in setting its financial limits, with the financial limit progressively reduced as a proportion of turnover as a firm's size increases. Thus a firm with an annual turnover of less than £10,000 would be allowed a contract limit of 150% of turnover, reducing to 100% when turnover rises to £10,000-£50,000, and 75% for turnover of £50,000-£100,000. When turnover rises above £100,000 the authority's normal limit (maximum of 50% of turnover) then applies. In this way, firms are encouraged to seek work from other sources.

To minimise the risk involved in giving work to new businesses, many authorities insist on financial guarantees or performance bonds. Some authorities ensure stage payments are made whilst others take the opposite view and only pay on completion. A few authorities require specific committee approval before firms with no track record can be added to an approved list. Other safeguards include regular monitoring of firms both from a financial and technical point of view with a few authorities having formal reporting procedures.

APPENDIX D-2

VALIDATION OF MULTIPLE REGRESSION SECOND VERSION MODEL

AT LONDON BOROUGH OF CAMDEN

London Borough of Camden

Finance Department
Peter Derrick BA IPFA — Director of Finance
The Town Hall Euston Road London NW1 2RX Telephone: 01-278 4444
FAX — 01-860 5748

A Abidali Esq
Civil Engineering Department
Loughborough University
of Technology
Loughborough
Leics LE11 3TU

Date 7 December 19

Your reference

Our reference FIN/SPO/LP

Inquiries to Mr L Pardhana:
Ext. 2222

Dear Mr Abidali

RE: FINANCIAL APPRAISAL OF CONTRACTORS

I am pleased to confirm that this Council has made use of the appraisal model developed by you.

Financial appraisal at this authority is very much in a state of flux and presently we employ a combination of the Altman formula, several 'key' Accounting Ratios, as well as your model to assist us with our appraisal processes. From time to time we also make use of other facilities such as those offered by Credit Ratings Ltd, programmes developed by other local authorities, as technical aids in the appraisal process.

Speaking from the point of view of someone who has needed to analyse a number of Annual Reports and Accounts over the past few months, I am able to say that your model with its heavy reliance on the profitability factor has proved discriminating and interesting. Having said this, I am sure you are only too well aware of the potential dangers of relying exclusively upon the results of a single test, which is why we make use of several tests including yours to supplement our judgemental processes.

I hope this letter is useful to you and I would like to close by thanking you for your help and to wish you every success for the future.

With kind regards.

Yours sincerely

L PARDHANANI
SPECIAL PROJECTS OFFICER

All correspondence to be addressed
to the Director of Finance

—

APPENDIX D-3

Z-SCORE TRENDS

ABERDEEN CONSTRUCTION PLC

BARRATT DEVELOPMENT PLC

BENBAILY CONSTRUCTION PLC

BENLOX HOLDING PLC

BOULTON & PAUL PLC

M.J.GEESON GROUP PLC

GEORGE WIMPY PLC

HENRY BOOT & SON PLC

A.MONK COMPANY PLC

NEWARTHILL PLC

RUSH & TOMKINGS GROUP PLC

TAYLOR WOODROW PLC

BEECH WOOD GROUP PLC

COCKSEGE PLC

DAVID CHARLES LTD

CROUCH GROUP PLC

JAMES H. DENNIS PLC

MEARS BROSE LTD

MILBURY PLC

MODERN ENGINEERING OF BRISTOL

APPENDIX D-4

CASE STUDIES

Shelley House 3 Noble Street
London EC2V 7DQ

a member firm of
Coopers & Lybrand (International)

telephone 01-606 7700
 cables Groprovis London
 telex 884730 Corkgy G
 fax groups 11/11 01-606 9887

when telephoning please
ask for

your reference

Mr. E. Williams
Ext. 3217

our reference
SH 501

PRIVATE & CONFIDENTIAL

30th March, 1988.

To the Shareholders and Creditors of Crouch Group Plc

Dear Sirs,

CROUCH GROUP PUBLIC LIMITED COMPANY
(In Receivership & Liquidation)
Trading Address prior to Receivership:
Sutherland House, Surbiton Crescent, Kingston-upon-Thames, KT1 2JU

I write to advise you that meetings of Members and of the Creditors of Crouch Group Plc were duly convened and held pursuant to Section 98 of the Insolvency Act 1986 at these offices on Friday 18th March 1988.

Mr. P.J.H. Meyer, Director of the Company, acted as Chairman.

A summary of the Statement of Affairs as at 18th March 1988, as sworn to by the Director, Mr. Meyer, was presented to the meetings, together with a Group family tree, copies of which are attached.

The meetings were advised that Cork Gully had been instructed by Mr. Meyer on 16th February 1988 to assist in convening the meetings of Members and Creditors and preparation of the Statement of Affairs for presentation thereat for which a fee of £5,000 plus VAT had been voted but not yet paid. It was pointed out that neither I nor my firm had previously acted for the Company or for any of its directors other than in regard to placing certain subsidiaries into creditors' voluntary liquidation.

On 2nd July 1984, the Group's Bankers, Midland Bank Plc, had appointed Mr. D.L. Morgan and Mr. N.H. Russell of Spicer & Pegler, as Joint Receivers and Managers to Crouch Group Plc and certain of its principal subsidiaries, namely:-

Crouch Homes Limited
Crouch Developments Limited
Crouch Investments Limited
Crouch Group Services Limited
Crouch Civil Engineering Limited
Crouch Painting Limited
Crouch Joinery Limited

Cont.

[illegible]

Mr. N.H. Russell died on 21st March 1986, since when Mr. Morgan had continued to act as sole Receiver.

The appointments of Joint Receivers to Crouch Group Plc were made by the Bank under the terms of Debentures registered 4th May 1950 and 9th April 1984, granting fixed and floating charges over all assets of the Company.

Prior to the appointment of the Joint Receivers on 2nd July 1984, one of the principal trading subsidiaries, namely Crouch Construction Limited, was placed by the Members into Voluntary Liquidation on 21st May 1984, and on 12th June 1984 this company went into creditors' voluntary liquidation. The company had suffered substantial losses on two major contracts due to industrial relation problems and it was apparent that further severe losses were being incurred.

Following the appointment of the Joint Receivers on 2nd July 1984, a number of the Group's subsidiaries went into liquidation as follows:-

Crouch Developments Limited	- 4th October 1984 - Creditors Vol. Liq.
Crouch Leisure Developments Limited	- Compulsory Liquidation - 17th December 1984
Crouch Homes Limited	- Compulsory Liquidation 8th February 1985
Crouch Painting Limited	- Compulsory Liquidation 25th February 1985
Crouch Investments Limited	- Creditors Vol. Liq. - 20th July 1985

Earlier on 18th March 1988, the following dormant subsidiaries were placed in Creditors' Voluntary Liquidation:-

Museum Estates Limited
Dovemart Limited
The Philip Flooring Co. Limited
Crouch Joinery Limited
Crouch Plant Limited
Crouch Civil Engineering Limited
Crouch Group Services Limited

In each case, I was appointed Liquidator for the purpose of the winding-up.

Cont.

The meetings were advised that the Company was incorporated in 1931 when it traded in the name, G.T. Crouch Limited, as residential, commercial and industrial property builders and developers. The name was changed to Crouch Group Limited in January 1969 and to Crouch Group Public Limited Company in March 1982.

The Company was converted into a public company on 20th February 1969 when the authorised share capital was increased from £35,000 to £1 million and the £1 ordinary shares sub-divided into ordinary shares of 25 pence each. On the same date, £966,667 of the Company's reserves was capitalised and issued pro-rata to the members as 3,866,668 ordinary shares of 25 pence each.

The shares in the Company became quoted on the London Stock Exchange in 1969 being 4 million ordinary shares of 25 pence each.

In June 1981, in order to strengthen the long term capital base of the Group, certain of the short term borrowings were replaced by the issue of £2 million of 9% Convertible Unsecured Loan Stock 1993/96.

In December 1982, the Company reported a Group loss for the six months ended 30th September 1982 of £1.329 million, the first reported loss incurred by the Group since its shares were listed on the Stock Exchange in 1969. A re-appraisal of the Group's trading and financial situation took place and it was resolved to reduce the Group's borrowings. At a Board meeting held on 13th December 1982, Mr. Clempson, who was appointed executive chairman in 1978, was removed from his executive duties and also removed as Chairman of the Board.

The audited accounts for the year ended 31st March 1983, which were finalised in August 1983, disclosed that provisions of £1.787 million were required to be made in respect of developments and £1.889 million against losses incurred in the U.S.A. As a consequence, the net tangible assets of the Group were shown to have reduced to £3.906 million from £7.745 million at 31st March 1982.

On 28th December 1983, the Board of Crouch Group Plc announced that the Group had entered into conditional agreements with Mr. P.J.H. Meyer who was then (with his family interests) a substantial shareholder.

Details of these agreements were set out in a formal circular issued to all shareholders of the Group Company dated 4th January 1984. This circular was issued by the then Board under the chairmanship of Mr. Campailla.

Cont.

Group shareholders were reminded in the circular that, in August 1983, the Group Board had resolved to ensure a reduction in overheads and borrowing charges and to bring about an optimum balance of house building, construction and commercial development. Unfortunately, it had not been possible within a short time to find tenants for a substantial part of the completed developments and consequently this had delayed the sale of the properties concerned. Furthermore, difficulties had been encountered in selling the Crouch Group investment properties and in reaching speedy conclusions to the partnership agreements in Florida, and therefore it had not been possible to reduce borrowings quickly. The circular stated that the Group Board was under pressure from its bankers to accelerate disposals which meant that working capital was not available for Crouch Homes to replace its stock of land for private house building purposes.

It was now the Group Board's view, the circular explained, that the continuing shortage of working capital had begun to prejudice the long term viability of Crouch Homes. It was therefore necessary to adopt a new approach if the Group was to survive. The Board had therefore welcomed an approach by Federated Housing Plc, a company controlled by Mr. Meyer who also held 18.5% of the existing ordinary share capital of Crouch Group Plc, whereby a subsidiary of Federated Housing would take over the responsibility for and some of the benefits of, managing and financing the development and sale of the Managed Land Bank of Crouch Group.

This agreement would provide an initial cash injection of £750,000 into Group and would alleviate the burden of providing working capital to develop the Managed Land Bank. The agreement would also ensure that the Managed Land Bank would realise its current value and thereby provide an uplift to reserves. The terms of the management agreement would not restrict the continuation of house building by the Crouch Group.

It was also proposed, (amongst other things) shareholders were advised, that Crouch Group would acquire 20 per cent of Federated Housing in return for an issue of new ordinary shares.

The implementation of these proposals, the circular continued, would fundamentally restructure Crouch Group's balance sheet by reducing gearing and give the Group time to reorganise its business within a more reasonable time scale.

Shareholders were advised that upon the agreements detailed in the circular becoming unconditional, Mr. P.J.H. Meyer would be invited to join the Crouch Group Board and become its Chairman. On Mr. Meyer joining the Board of Crouch there would be a complete review of the operations of the Group in the light of which decisions would be taken as to the Group's future direction. In the meantime the present Directors of Crouch Group believed that the Group had adequate bank facilities for its present requirements.

Cont.

The proposals were duly approved by shareholders at a meeting held on 27th January 1984. Subsequently, the Company's authorised share capital was increased from £1,500,000 to £1,950,000. The issued share capital was increased from £1 million to £1,450,000, through the issue of 1,800,000 new ordinary shares at 25 pence each, in exchange for the Company's £900,000 investment in Federated Housing.

The Directors at the time of the re-organisation were:-

Mr. F.D.N. Campailla	(Chairman)
Mr. J.M. Bishop	(Managing)
Mr. T.M. Hearley	
Mr. A. Longman	
Mr. D.L. Shaw	
Mr. A. Stephenson	

On 13th January 1984 shareholders had been advised that the Group's unaudited half year results for the six months ended 30th September 1983 had resulted in a loss for the period of £1.171 million on a turnover of £9.096 million.

No audited accounts had been prepared since 31st March 1983.

Following implementation of the Board's proposals at the Extraordinary General Meeting of the Company on 27th January 1984, Messrs. Bishop, Hearley, Longman and Stephenson resigned and Mr. Meyer became Chairman in place of Mr. Campailla.

Notwithstanding the inflow of funds to the Crouch Group arising from the agreements with Federated Housing and the liquidation of Crouch Construction Limited which relieved the Group from pressure from that Company's creditors and continuing losses on contracts, the Group Board found it impossible to continue trading without additional Bank support. The Bank was unable to agree to provide an increased facility in excess of the borrowings which at that time totalled some £3.3m., and following legal advice, the Directors considered they had no alternative other than to request the Midland Bank to appoint Receivers to the Group.

Subsequent to the appointment of Joint Receivers on 2nd July 1984, the remaining Directors (with the exception of Mr. Meyer), together with the Secretary, Mr. Homer, resigned on 13th September 1984.

The Statement of Affairs as at 2nd July 1984, as lodged with the Receivers and Managers, indicated the following assets and estimated realisations as regards Crouch Group Plc:-

Cont.

	<u>Book Values</u> £'000	<u>Estimated to</u> <u>Realise</u> £'000
Assets subject to Debenture Holders fixed charge:		
Shares in Federated Housing Plc	900	720
Amounts owed by Subsidiaries	3,233	-
	<u>4,133</u>	<u>720</u>
<u>Deduct:</u>		
Midland Bank Plc		
Fixed Charge Security	3,318	720
	<u>815</u>	<u>-</u>
Assets subject to Debenture Holders Floating Charge:		
Investments in Subsidiaries	42	-
	<u>42</u>	<u>-</u>
<u>Estimated Total Net Assets</u>	<u>£ 857</u>	<u>-</u>

A summary of the Receivership receipts and payments for Crouch Group Plc covering the period 2nd July 1984 to 18th March 1988 was provided as follows:-

	£'000	£'000
Receipts: Sale of Federated Housing Shares	720	
<u>Less: Expense of Sale</u>	<u>3</u>	
		717
Dividend (Net)		18
Interest on Deposit		14
Other Receipts		14
		<u>763</u>
Payments: Debenture Holder	600	
Receivers Remuneration	77	
Disbursements and VAT	36	
	<u>713</u>	
Balance in Hand		<u>£ 50</u>

The summary of the sworn Statement of Affairs as at 18th March 1988, includes the funds in the hands of the Receiver, £50,266, from which there must be provided further costs and expenses, in particular professional charges incurred in dealing with Group taxation affairs, leaving a net realisation estimated at £30,000 for Statement of Affairs purposes.

Cont.

The meetings were advised that amounts owing by Subsidiaries were as follows:-

	<u>Book Value</u>	<u>Estimated to</u>
	<u>£</u>	<u>Realise</u>
		<u>£</u>
Crouch Group Services Limited	2,522,622	-
Crouch Homes Limited	330,000	33,000
Crouch Developments Limited	134,094	-
Crouch Leisure Developments Limited	185,000	-
Crouch Investments Limited	1,381	-
The Philip Flooring Co. Limited	8,500	-
	<u>3,181,597</u>	<u>33,000</u>

It was explained that asset realisations are subject to the subrogation claim of Crouch Homes Limited whose contribution towards settlement of the Debenture Holders' indebtedness entitled it to stand in the place of the Charge Holder. Such was the contribution from Crouch Homes compared with all other contributories, that inevitably the surplus fixed and floating charge realisations from the Receiverships and Liquidations of the Group companies would require to be passed to the Liquidators of Crouch Homes Limited.

It was stated that the unsecured creditors listed on the sworn Statement of Affairs as at 18th March 1988, were partly based upon those listed in the Statement of Affairs as at the date of receivership, and partly upon claims notified since that date. In this connection, the Trustees for the Holders of the Crouch Group 9% Convertible Unsecured Loan Stock had claimed £2,000,000 in respect of loan stock outstanding and £684,269 for interest, fees and expenses outstanding at 18th March 1988.

It would be a matter for the Liquidator to agree unsecured claims in due course, but present indications were that only those creditors who have valid claims in the liquidation of Crouch Homes Limited, have any prospect of receiving a dividend.

It was regretted that no surplus funds were expected to become available for distribution to unsecured creditors of Crouch Group Plc, or to shareholders. Shareholders wishing to make a claim under Section 22 CGTA 1979 should communicate with their own Inspector of Taxes. The estimated deficiency as regards creditors was shown to amount to £3,277,172 and as regards members, was estimated at £4,727,172, subject to costs.

Cont.

In arriving at the overall deficit of approximately £4.7 million, the principal items contributing to the deficiency since the date of the last published and audited accounts, 31st March 1983, when net shareholders funds were shown to amount to £1 million, were as follows:-

	£'000
(a) Inter-company debts written down	3,149
(b) Investments in Subsidiaries	42
(c) Interest and Expenses outstanding on Unsecured Loan Stock	684
(d) Guarantee liabilities re. Performance Bonds, brought in	291
(e) Loss on sale of Federated Housing shares	180
(f) Guarantee Liability of Debenture Holder settled in Receivership	356

The Receiver had advised that the total receipts and payments in the eight Group company receiverships were as follows:-

	£'000
Receipts	6,777
Payments	6,036
Balances in Hand	<u>741</u>

Settlement of the Debenture Holders' indebtedness plus interest thereon had accounted for £3,402,077. In addition, payments to other secured creditors had accounted for £1,533,627.

Action had been taken by the Receiver to protect the interests of Creditors should it be possible to claim from the trustees of the Pension Fund that any surplus therefrom be made available for the benefit of creditors. The trustees were expected to apply to the Court for further instructions in the matter.

The Receiver also advised that the overseas investments owned by Crouch Investments Limited (In Liquidation), in Florida and Phoenix Arizona, in which the Group had invested over £3.8 million at 31st March 1982 had failed to produce any realisation.

At the Members' meeting, a Resolution for the Company to proceed to Creditors Voluntary Liquidation was passed and I and my partner, Michael Anthony Jordan, were appointed Joint Liquidators of the Company. At the subsequent meeting of Creditors, our joint appointment was confirmed.

Cont.
Cont.

No Liquidation Committee was appointed.

A formal notice for claims is enclosed and I would be obliged if you would supply a detailed statement of your claim to Crouch Group Plc (In Liquidation), c/o Shelley House, 3 Noble Street, London EC2V 7DQ (Ref: SH501) in order that it may be scheduled.

I also attach duplicate VAT Debt Relief Forms both copies of which should be completed and returned to me if you wish to seek such relief. In that event, your claim in the liquidation must not include the VAT element.

If you require any further information, please do not hesitate to contact me.

Yours faithfully,

R.M. ADDY

Joint Liquidator of Crouch Group Plc

Distribution:- 1 copy - Each Creditor - Secured, Unsecured & Preferential
(700) 1 " - Each Director and Shareholder
1 " - Each Member of the Committee of Inspection
1 " - The Royal Insurance Co. Limited.
1 " - The Commercial Union Group - (Insurance)
1 " - Bradstock, Blunt & Thompson Limited - (Insurance)
1 " - Record File (Cork Gully)
5 copies - General Files (Cork Gully)

CROUCH GROUP PLC
(In Receivership - 2nd July 1984)

Summary of the Estimated Statement of Affairs as at
18th March 1988

	<u>Book Value</u>	<u>Estimated to Realise</u>
	£	£
<u>ASSETS:</u>		
Assets not specifically charged:		
Funds in the hands of Receiver	50,266	30,000
Amounts owing by Subsidiaries	3,181,597	33,000
Investments in Subsidiaries	42,010	-
	<hr/>	<hr/>
Estimated total assets, subject to costs	£ 3,273,873	63,000
	<hr/>	
<u>LIABILITIES:</u>		
Subrogated Debenture claim of Crouch Homes Limited		63,000
		<hr/>
Non-preferential claims:		
Trustees for the unsecured loan stockholders	2,684,269	
Preferential creditors in the receivership	48,754	
Trade and Expense	223,238	
Performance bonds and insurances	290,662	
Amounts owing to Subsidiary companies	30,249	
	<hr/>	3,277,172
Estimated deficiency as regards Creditors, subject to costs		<hr/> 3,277,172
<u>ISSUED SHARE CAPITAL</u>		1,450,000
		<hr/>
Estimated total deficiency as regards Members, subject to costs		£ 4,727,172
		<hr/>

Note: The above is a summary of the sworn Statement of Affairs as at 18th March 1988, which is available for inspection by Members and Creditors.

CROUCH GROUP PUBLIC LIMITED COMPANY
(In Receivership - 2nd July 1984)

CROUCH INVESTMENTS INTERNATIONAL NV
Based in Dutch Antilles
[SEE: OVERSEAS INVESTMENTS]

NOTICE to CREDITORS to SEND CLAIMS

IN THE MATTER of THE INSOLVENCY ACT 1986

- a n d -

IN THE MATTER of CROUCH GROUP PUBLIC LIMITED COMPANY

(In Voluntary Liquidation)

NOTICE IS HEREBY GIVEN that the Creditors of the above named Company, which is being voluntarily wound up, are required, on or before 13th May 1988 to prove their debts by send to the undersigned R.M. Addy, of Cork Gully, Shelley House, 3 Noble Street, London EC2V 7DQ the said Liquidator of the Company, written statements of the amount they claim to be due to them from the Company and, if so requested, to provide such further details or produce such documentary or other evidence as may appear to the Liquidator to be necessary. A Creditor who has not proved his debt before the declaration of any dividend is not entitled to disturb, by reason that he has not participated in it, the distribution of that dividend or any other dividend declared before his debt was proved.

D A T E D this 18th day of March 1988

R. M. ADDY

Liquidator

Cork Gully

Shelley House 3 Noble Street
London EC2V 7DQ

a member firm of
Coopers & Lybrand (International)

telephone 01-606 7700
telegrams Groprovis London
telex 884730 Corkgy G

The effective business address
for all partners is
Abacus House, Culter Lane
Cheapside London EC2V 8AH

when telephoning please
ask for

your reference

Mr Rishi
Ext. 3257

our reference SH 502

PRIVATE & CONFIDENTIAL

10th July, 1984.

Dear Sirs,

Re: Crouch Construction Limited
(In Liquidation)
Registered Office and Business Address:
Sutherland House, Surbiton Crescent,
Kingston-on-Thames, Surrey.
Builders and Contractors

We write to inform you that a Meeting of Creditors of the above-named Company convened pursuant to Section 293 of the Companies Act, 1948, was held at the Chartered Insurance Institute, Aldermanbury, London, EC2 on Tuesday, 12th June 1984.

An approximate Statement of Affairs as at the 21st May 1984 was presented to the Meeting and a copy is attached.

The Meeting was informed that the Company was incorporated as a private limited company on the 16th July 1969 in the name of Cavus Contractors Limited, in which name it traded as building contractors until 4th May 1978 when the name was changed to Crouch Construction Limited. Between 1970 and 1978 the Company traded on a small scale, and during the early years, only two shares of £1 each were issued; one being held by the founder of the Company, a Mr. Flux, and the other by M & J.P. Plant Hire Limited which was a subsidiary of Crouch Group Limited.

Mr. J.J. Crouch was appointed a Director in November 1970 but he died in February 1973. Although he was replaced with other members of the Group in the ensuing years, the Company traded without any particular success but continued in business.

In April 1978 the Company became a wholly-owned subsidiary of Crouch Group plc when 998 additional Ordinary Shares of £1 each were allotted to Crouch Group for cash at par, and embarked upon a rapid expansion in contract works, mainly in the Southern Counties and particularly involving local authority housing. Since that time the Company has continued to trade as a wholly-owned subsidiary of Crouch Group plc which became a Public Company in February 1969 and has been quoted on the Stock Exchange since that time.

In September 1979 the Company adopted a new set of Articles of Association and its authorised Share Capital was increased to £10,000 although the issued capital remained at £1,000. There had been numerous changes in the Board of Directors since 1982 but at the present time the Directors were as follows:-

London: Michael A. J. San, David R. Chubb, Roger W. Cox, Raymond L. Emmet, C. Brindley Cough, Christopher J. Hughes, J. Martin Hughes, Michael J. Jordan, John D. Kestel, John F. Power, Paul F. M. Shawell
Cardiff: Christopher J. Hughes, J. Martin Hughes, Michael J. Jordan, John D. Kestel, John F. Power, Paul F. M. Shawell
Edinburgh: Michael A. J. San, David R. Chubb, Roger W. Cox, Raymond L. Emmet, C. Brindley Cough, Christopher J. Hughes, J. Martin Hughes, Michael J. Jordan, John D. Kestel, John F. Power, Paul F. M. Shawell
Birmingham: Michael A. J. San, David R. Chubb, Roger W. Cox, Raymond L. Emmet, C. Brindley Cough, Christopher J. Hughes, J. Martin Hughes, Michael J. Jordan, John D. Kestel, John F. Power, Paul F. M. Shawell
Glasgow: Michael A. J. San, David R. Chubb, Roger W. Cox, Raymond L. Emmet, C. Brindley Cough, Christopher J. Hughes, J. Martin Hughes, Michael J. Jordan, John D. Kestel, John F. Power, Paul F. M. Shawell
Manchester: Michael A. J. San, David R. Chubb, Roger W. Cox, Raymond L. Emmet, C. Brindley Cough, Christopher J. Hughes, J. Martin Hughes, Michael J. Jordan, John D. Kestel, John F. Power, Paul F. M. Shawell
Newcastle: Michael A. J. San, David R. Chubb, Roger W. Cox, Raymond L. Emmet, C. Brindley Cough, Christopher J. Hughes, J. Martin Hughes, Michael J. Jordan, John D. Kestel, John F. Power, Paul F. M. Shawell
Sheffield: Michael A. J. San, David R. Chubb, Roger W. Cox, Raymond L. Emmet, C. Brindley Cough, Christopher J. Hughes, J. Martin Hughes, Michael J. Jordan, John D. Kestel, John F. Power, Paul F. M. Shawell
Also at Aberdeen, Southampton, and Birmingham

Mr. Peter Meyer	- Appointed 29th February 1984	- Chairman
	having been appointed to the Group Board on 1st February 1984	
Mr. Leslie Andrews	- Appointed 29th February 1984	- Managing Director
Mr. Trevor Slater	- Appointed 1st February 1984	
	having been appointed Group Managing Director 1st February 1984.	
Mr. David Shaw	- Appointed 5th October 1983	- Surveyor/Non Executive
Mr. F.D.N. Campailla	- Appointed 1st August 1978	- Solicitor/Non Executive
Mr. Richard Meinertzhagen	- Appointed a Director on 1st July 1978	

The Secretary of the Company and of the Group Companies is Mr. Barry Homer.

The previous trading results for the four years ending 31st March 1983 extracted from the Company's audited accounts were summarised as follows:-

Year ended 31st March	<u>1980</u> £'000	<u>1981</u> £'000	<u>1982</u> £'000	<u>1983</u> £'000
Turnover, being the value of contracts carried out	<u>3,258</u>	<u>4,947</u>	<u>7,714</u>	<u>12,319</u>
Profit/(Loss), before taxation	<u>(172)</u>	<u>(62)</u>	<u>(356)</u>	<u>102</u>
The Profits/(Losses) have been arrived at after charging or (crediting) the following:-				
Depreciation	-		6	10
Plant Hire	195	215	431	37
Directors' emoluments	13	32	42	56
Loss on sale of Fixed Assets	-	1	1	1
Bank Interest	-	(50)	(50)	(28)
(Group in overdraft but not Company)				

The taxable profits in the years 1982 and 1983 were eliminated by the utilisation of losses brought forward and by the receipt of group relief for taxation purposes, for which the Group received no payment.

No audited accounts had been prepared for the Company since the 31st March 1983.

Directors' emoluments for the year to 31st March 1984 amounted to £73,715 made up as follows:-

Mr. A. Stephenson	29,793 (Resigned 29.2.84)
Mr. R. Meinertzhagen	16,002
Mr. L. Andrews	2,500
Mr. R.J. Weavers	16,670 (Resigned 31.1.84)
Mr. A.G. Britton	8,750 (Resigned 31.10.83)

The turnover of the Company for the year ended 31st March 1984 was estimated to amount to approximately £11.2m. Based upon a realistic appraisal of contracts in progress it becomes apparent that the Company had suffered

severe losses since 1st April, 1983. All the current contracts were taken on prior to the main board changes, which took place early in 1984. In May of this year the gross value of contracts in progress amounted to approximately £20m of which approximately £10m of work remained to be completed.

On 8th November 1983 the Company granted to Midland Bank plc a Fixed Charge over its Book Debts as additional security for the overdraft (previously secured by a Floating Charge granted in June 1978) and in support of the Long standing Cross-Guarantee liability for the Group indebtedness to the Bank.

On 28th December 1983, the Board of Crouch Group plc announced that Crouch Group had entered into a conditional agreement with a Mr. P.J.H. Meyer who was then (with his family's interest) a substantial shareholder. Details of these agreements were set out in a formal circular issued to all shareholders of the Group Company and dated 4th January 1984.

Shareholders were advised that upon the agreements detailed in the circular becoming conditional Mr. P.J.H. Meyer would be invited to join the Crouch Group Board and become its Chairman. Upon Mr. Meyer joining the Board of the Group Company there would be a complete review of all operations of the Crouch Group in the light of which decisions would be taken as to the Group's future direction. These proposals were approved by the Shareholders of Crouch Group plc at a meeting held on the 27th January 1984.

On 29th February 1984 Mr. L. Andrews was appointed Managing Director of Crouch Construction Limited in place of Mr. Stephenson who had resigned on that day.

It was reported that the trading position of Crouch Construction Limited during 1983/84 suffered as a result of two major loss-making contracts at Shirley and Dulwich and also from poor trading on other contracts taken on at tight margins during a period of recession. Problems had also arisen from the numerous changes in directors and senior staff.

Referring to the Approximate Statement of Affairs, the meeting was informed that the Midland Bank had a Fixed Charge over all Book Debts and other debts and held a Floating Charge over all other assets and the Statement of Affairs was drawn up so as to reflect this situation.

The debtors included completed contract balances relating to some 31 contracts where, according to the Company's records, there were total sums outstanding of approximately £231,000 including retention moneys in the region of £211,000. These debts exclude ex-contractual claims which have not been agreed.

After making an appropriate provision for nominated sub-contractors' liabilities, estimated at £2,520 and a provision for maintenance and damages of £30,000 the net book value of the contract debtors amounted to approximately £198,000, estimated to realise £152,000. The Directors, however, were of the opinion that if the ex-contractual claims were to be pursued some additional sums should be realised, but it was difficult to quantify the sums involved at this stage.

Amounts owed by fellow subsidiaries of the Company were estimated to have a book value of £276,000 made up as follows:-

Crouch Group Services Limited	£. 136,000
Crouch Homes Limited	97,000
Crouch Leisure Developments Limited	43,000
	<hr/>
	£276,000
	<hr/>

The meeting was advised that no significant payments had been made to an other Group Company since November 1983. However, receipts received during 19 included amounts of £50,000 from Museum Estates Limited and £250,000 from Crouch Group Services Limited, the latter amount being cash introduced by Mr. P.J.H. Meyer personally to assist Group liquidity.

The Shares in the wholly-owned subsidiary Company, Crouch Printing Limited acquired in April 1978 were shown in the books at £12,000. As, however, this subsidiary suffered losses resulting in a deficiency in net assets in excess of £150,000, no realisable value was attributed to the investment.

Stock and work in progress related to 17 contracts outstanding for completion as at 21st May, although 4 of the contracts were virtually complete.

It was reported that James R. Knowles and Associates, Quantity Surveyors had been instructed to carry out an appraisal of each contract and had been actively engaged in endeavouring to arrange possible assignments of the contract to other contractors with the consent of the employing authorities. However, based on the negotiations which the Surveyors were undertaking it was considered unlikely that any substantial sums would be received from the work in progress contracts and for this reason the realisable value in the statement of affairs shown at only £53,000 after making provision for liabilities to nominated sub-contractors and reservation of title claims by suppliers to materials on various of the contract sites.

After taking into account preferential liabilities estimated at £174,000 including a claim by the Bank for moneys advances to pay salaries and wages, it was apparent that there was little or no prospect of funds becoming available to enable a dividend to be paid to Unsecured Creditors estimated to total some £2.4m, excluding contingent liabilities under contract performance bonds having a gross value of £1.36m.

The meeting was advised that the deficiency as shown by the Statement of Affairs in the sum of £2,714,000 was computed as follows:-

	£'000
Amounts written-off from the assets	
against book values	464
<u>Less:</u> Excess of Assets over Capital and	
Liabilities as at 31.3.83	87
	<hr/>
	377
Balance being estimated trading losses	
for the period 1.4.83 to 21.5.84	2,337
	<hr/>
	£2,714
	<hr/>

The meeting was advised that on 21st May 1984 the Parent Company, Crouch Group plc, as Shareholders of the Company, passed at short notice a Resolution immediately placing the Company in liquidation and appointed Mr. M.A. Jordan and Mr. R.M. Addy of Cork Gully as Joint Liquidators. This action had been

taken on the basis that if funds were not available to pay for materials and sub-contractors and indeed to pay to staff and employees of the Company, the security of the contract sites, which represented on the face of it the largest asset, would have been put at risk.

Following a considerable amount of discussion, creditors present at the meeting confirmed the voluntary liquidation of the Company together with the appointment of Mr. Jordan and Mr. Addy as Joint Liquidators with a Committee of Inspection comprising of:-

A representative of Digby Scaffold Co. Limited
" " of G.K.N. Kwikform Limited
" " Roberts, Adlard plc
" " R.M.C. Group
Mr. J. Kelly representing various creditors

A formal Notice for claims is enclosed and if you have not already done so, we should be pleased if you would supply a detailed Statement of your claim to Crouch Construction Limited (In Liquidation) c/o Shelley House, 3 Noble Street, London, EC2V 7DQ (Ref. SH502) in order that it may be scheduled.

We also attach in duplicate V.A.T. Bad Debt Relief forms, both copies of which should be completed and returned to us if you wish to seek such relief. In that event your claim against the Company must not include the V.A.T. element.

Meanwhile, if there is any further information you require, please do not hesitate to write to this office.

We are,

Yours faithfully,

CORK GULLY

Distribution:- 1 copy - Each Creditor - Secured, Unsecured and Preferential
(800) 1 " - Each Director and Shareholder
1 " - Each Member of the Committee of Inspection
1 " - James R. Knowles & Associates - (Quantity Surveyors)
1 " - Raffety Buckland - (Agents)
1 " - Clintons - (Solicitors)
1 " - The Royal Insurance Co. Ltd.
1 " - The Commercial Union Group - (Insurance)
1 " - Bradstock, Blunt & Thompson Ltd. - (Insurance)
1 " - E.P.A. Dept. (Cork Gully)
1 " - Records (Cork Gully)
1 " - Record Book (Cork Gully)
10 copies - General Files (Cork Gully)

NOTICE to CREDITORS to SEND CLAIMS

THE COMPANIES ACTS, 1948 to 1981

CROUCH CONSTRUCTION LIMITED

NOTICE IS HEREBY GIVEN that the Creditors of the above-named Company are required on or before the 10th day of August 1984, to send their names and addresses and the particulars of their debts or claims, and the names and addresses of their Solicitors if any, to ROBIN MICHAEL ADDY of Shelley House, 3 Noble Street, London, EC2V 7DQ the Joint Liquidator of the said Company, and, if so required by notice in writing from the said Liquidator, are by their Solicitors, or personally, to come in and prove their said debts or claims at such time and place as shall be specified in such notice, or in default thereof they will be excluded from the benefit of any distribution made before such debts are proved.

D A T E D this 21st day of June, 1984.

R.M. ADDY,
Joint Liquidator.

Re: CROUCH CONSTRUCTION LIMITED
(In Liquidation)

Registered Office and Business Address:
Sutherland House, Surbiton Crescent,
Kingston-on-Thames, Surrey.

APPROXIMATE STATEMENT of AFFAIRS

- as at -

21st MAY 1984

	<u>Approximate Book Values</u>			<u>Estimated to Realise</u>		
	£'000	£'000	£'000	£'000	£'000	£'000
<u>ASSETS:</u>						
<u>Assets subject to Fixed Charge:</u>						
Completed contract debtors		231				
Less: Nominated sub-contractors	3					
Provision for defects and damages	<u>70</u>	<u>33</u>				
		198			152	
Amounts owed by Crouch Group Companies		276			276	
		<u>474</u>			<u>428</u>	
Deduct: Midland Bank - fixed charge security		<u>474</u>	-		<u>428</u>	-
<u>Assets subject to Floating Charge:</u>						
Shares in Subsidiary Company			12			-
Furniture, equipment, site huts etc.			16			15
Stock and work-in-progress		656				
Less: Nominated sub-contractors	65					
Provision for reservation of title claims	<u>133</u>					
Excess cost of completion	Uncertain	<u>198</u>	<u>458</u>			<u>53</u>
			<u>£486</u>			<u>68</u>
<u>LIABILITIES:</u>						
<u>Preferential Creditors:</u>						
P.A.Y.E. Income Tax and M.I.C.				70		
Wages, Salaries and Holiday Pay				33		
Rates				1		
Midland Bank plc for advances of wages and salaries				<u>70</u>		<u>174</u>
<u>ESTIMATED DEFICIENCY as regards Preferential Creditors</u> <u>subject to Costs of Realisation</u>						<u>£106</u>
<u>Debenture-holder - Midland Bank plc:</u>						
Direct Indebtedness					613	
Less: Fixed Charge security deducted above				428		
Preferential claim - (expected to produce)				<u>20</u>	<u>448</u>	
<u>ESTIMATED DEFICIENCY as regards Debenture-holder, subject to</u> <u>Costs of Realisation</u>						<u>165</u>
<u>Unsecured Creditors:</u>						
Trade and Expense				1050		
Sub-contractors				1530		
Less: Nominated sub-contractors dealt with above				(68)		
Provision for reservation of title claims				<u>(133)</u>	2379	
Amounts owed to Crouch Group Companies					<u>63</u>	<u>2442</u>
<u>ESTIMATED DEFICIENCY as regards Unsecured Creditors, subject to</u> <u>Costs of Realisation</u>						<u>2713</u>
<u>ISSUED SHARE CAPITAL</u>						
						<u>1</u>
<u>ESTIMATED DEFICIENCY as regards Contributors, subject to Costs of Realisation</u>						<u>£2714</u>

- NOTES:
1. The above Statement of Affairs must be read in conjunction with the verbal report given to the Meeting of Creditors, a summary of which is issued to all known Creditors.
 2. There may be Contingent Liabilities in respect of uncompleted contracts, the amount of which cannot at present be ascertained, but part of which may be secured by contract performance bonds.

CORK GULLY,
Chartered Accountants,
Shelley House,
3 Noble Street,
London, EC2V 7DQ

12th June, 1984

Re: CROUCH CONSTRUCTION LIMITED

LIST of UNSECURED TRADE and EXPENSE CREDITORS
with claims in EXCESS of £20,000

	£.
F.J. Chalcroft (Construction) Ltd.	- 150,617
R M C Group	- 124,422
K.P. Hoare Contractors Ltd.	- 67,640
Cameron Shuttering Ltd.	- 66,144
J. Devine	- 54,753
The Museum Estates Ltd.	- 49,893
G K N Kwikform Ltd.	- 45,308
Burt Boulton (Timber) Ltd.	- 27,176
Faithfull's Limited	- 27,041
Vazgien Ltd.	- 25,471
I E I Southern Ltd.	- 25,335
How Engineering Services	- 24,548
John Carr Joinery Sales Ltd.	- 23,110
London Brick Products Ltd.	- 21,332
Roberts Adlard (Builders Merchants) Ltd.	- 20,937
Bracknell Roofing Co. Ltd.	- 20,809
Husmac Construction Ltd.	- 20,670
Crendon Timber Components Ltd.	- 20,640
M. Felton & Partners Ltd.	- 20,460
Boulton Paul (Joinery) Ltd.	- 20,034
M. Pelton & Partners Ltd.	20,460

APPROXIMATE
STATEMENT of AFFAIRS

- as at -

21st MAY 1984

CORK GULLY,
 Chartered Accountants,
 Shelley House,
 3 Noble Street,
 London, EC2V 7DQ

COOPERS & LYBRAND,
Abacus House,
Cutter Lane, Cheapside,
London, EC2V. 8AE.

Telephone:

01-606 4040

W. H. CORK, GULLY & CO.,
Guildhall House,
81/87, Gresham Street,
London, EC2V. 7DS.

Telephone:

01-606 7700

PRIVATE & CONFIDENTIAL

Ref. N5602

Ref.12J/MAJ/ARB/5091

12th September, 1979.

Dear Sirs,

Re: Mears Bros. Holdings Limited
(In Liquidation and Receivership)
Registered Office:
Dorcan House, Dorcan Way, Swindon, SN3. 3TS.

We write to advise you that Meetings of Members and Creditors of the above-named Company pursuant to Section 293 of the Companies Act, 1948, were held on the 24th August 1979. Sir George Middleton, a Director of the Company, presided. An estimated Statement of Affairs and notes thereon which had been prepared by the Directors as at 18th January 1979, the date of the appointment of the Receivers and Managers, was presented to the Meeting. A copy of the Statement of Affairs, together with related notes, is attached. The following is a summary of a report presented to the Meetings by Mr. M.A. Jordan and Mr. P.F.M. Shewell on behalf of the Directors prepared from information provided by them and by the Receivers and Managers.

Mr. A.M. Homan and Mr. B.E. Larkins of Price Waterhouse & Co., were appointed Receivers and Managers by Barclays Bank Limited on the 18th January 1979.

The Directors in office at the time of the Receivers' appointment were:

	<u>Appointed</u>
Sir George Middleton	16. 1.1976
Brigadier I.R.R. Hollyer	1. 7.1971
Mr R.G. Norcy	1.10.1967
Mr. R.W. Bale	1. 4.1977
Mr. A.S. Wheate	11. 4.1978

It was reported that the Company had been incorporated as a private Company on 14th June 1967, and became a Public Company on the 16th May 1968. The present Issued Share Capital was £1,750,000 consisting of 7m. Ordinary Shares of 25p. each, fully paid.

Mears Bros Holdings Limited ("Mears Holdings") was the Parent Company of a Group of building, civil engineering and contracting Companies. The main trading Companies comprised Mears Construction Limited, (now known as M.C. Swindon Realisations Limited (In Liquidation)), A. Long & Co. Limited and A. Long Products Limited. A fourth Subsidiary, Mears Properties Limited, held the Group's larger freehold and leasehold properties; there are also some minor Subsidiaries. Mears Holdings, the U.K. trading Subsidiaries and Mears Properties were all parties to a single Joint Account with Barclays Bank ("the MASS account")

In the mid-seventies the Group decided to expand its activities overseas. As part of this effort Mears Construction formed a Liechtenstein Subsidiary, Mears

International Anstalt, to act as civil engineering contractors in the Middle East. During this period Mears Construction expanded its U.K. operations, the bulk of which consisted of civil engineering works such as roads, reservoirs, sea defences, public building works and public sector housing.

At this time the Group also decided to transfer its headquarters from Sydenham to Swindon. When the move was made early in 1978, however, the Group's trading position had deteriorated considerably partly due, in the view of the Directors as regards Mears Construction, to the adverse weather conditions in the second half of 1977 and to the fact that certain major contracts proved to be loss-making. Also in early 1978 a request for substantially increased overdraft facilities was made to the Group's Bankers who as a condition for granting the increase took Fixed Charges over the Group's properties and requested a report on the Group's financial position to be presented by Price Waterhouse & Co. This report showed the need for additional Group facilities and a further increase to £3.25m. was granted in April 1978, in exchange for Fixed and Floating Charges over assets of the Long Companies. As a result of a loss of £1,026,000 incurred by Mears Construction for the half year to 31st March 1978, and to trading losses elsewhere in the Group amounting to £470,000 revised cash-flow projections prepared in June 1978, showed a requirement for an additional £3m. which the Bank subsequently agreed to grant in exchange for the execution on 6th July 1978, of full Fixed and Floating Charges by Mears Construction and other major Companies in the Group that had not already given Floating Charges, supported by Cross-Guarantees.

Following the Price Waterhouse report, plans were made to reduce overheads throughout the Group, although in the event they were not fully implemented. However, Mears International and part of the Long business were sold to third parties and purchasers were also sought for the Group as a whole or for particular activities.

Despite a turnaround in Mears Construction's trading results from an estimated loss of over £1,000,000 in the six months to the 31st March 1978, to an estimated loss of only £12,000 in the six months to the 30th September 1978, the expected improvement in the Group overall did not materialise and negotiations for the sale of the Company were unsuccessful with the result that on the 18th January 1979, Barclays Bank appointed a Receiver and Manager over each Company which was party to the MASS account.

It was reported that the failure of the Group was attributed by the Directors of Mears Holdings to the following factors:

- (a) the losses incurred by Mears Construction during late 1977 and the early part of 1978.
- (b) the delay by clients in the settlement of certain substantial claims on contracts.
- (c) the demands made upon the Group Banking facility due to losses incurred by other Companies within the Group.
- (d) the financial drain caused by the attempts to establish a contracting trading base overseas.
- (e) the short term cash effects of the move to Swindon.

Details of the trading results of Mears Holdings for the three years to 30th September 1978 were given as follows:

	Year to 30. 9. 1976	Year to 30. 9. 1977	Year to 30. 9. 1978
	£'000	£'000	£'000
Excess of Expenditure over Income	(2)	(114)	(212)
Extraordinary items	(267)	(320)	(327)
	(269)	(434)	(539)
Dividends received	510	-	-
	241	(434)	(539)
Dividends paid	(125)	(125)	-
Results for year	116	(559)	(539)
Closing Surplus (deficiency)	938	379	(160)

The Meetings were advised that each of the MASS account Companies is, as between itself and the Bank, responsible for the whole of the MASS account overdraft and, through Cross-Guarantees, for other liabilities of the Group Companies to the Bank. The whole liability to the Bank was therefore shown in the enclosed Statement of Affairs. The Receivers and Managers were of the opinion that the Group could have funds in excess of £1,500,000 available for Unsecured Creditors after the discharge of Preferential claims and the liability to the Bank but the rights of individual Companies and their Creditors to share in any surplus involved complex legal issues which could take a considerable time to resolve.

The deficiency estimated in the Statement of Affairs to amount to £4,517,000 had been computed as follows:

	£'000	£'000
Surplus of assets over liabilities as at 1.10.1975		822
<u>Deduct:</u> Net Trading losses from 1.10.1975 to 18. 1. 1979	687	
Dividends paid during period	250	
	£ 937	
<u>Less:</u> Dividends received	510	427
		£ 395
<u>Deduct</u> other amounts written off in accounts:		
Advance Corporation Tax irrecoverable	253	
Amounts written off Investments in Subsidiaries	393	646
Deficiency per Accounts as at 18. 1. 1979		£ 251
<u>Add:</u> Amount written off in respect of Subsidiaries in preparing Statement of Affairs	2,912	
Contingent Liabilities	46	
MASS Account	1,308	4,266
Estimated Total Deficiency		£4,517

At the Extraordinary General Meeting of Members it was resolved that the Company be wound up voluntarily and Mr. M.A. Jordan of W.H. Cork, Gully & Co. and Mr. P.F.M. Shewell of Coopers & Lybrand were appointed Joint Liquidators. The Shareholders also nominated to the Committee of Inspection:

Mr. H.W. Aplin
Mr. H.C. Lester
Mr. P.M. Turner

The Creditors at their Meeting confirmed the voluntary liquidation and approved the appointment of the Joint Liquidators together with a Committee of

Inspection consisting of the Shareholders' nominees.

Shareholders are advised that the Share Register will remain closed except for the Registration of Grants of Probate. It is not necessary for them to take any further action unless and until requested otherwise by the Liquidators.

In accordance with the attached Notice, Creditors are requested to forward to Coopers & Lybrand at the address shown above a detailed statement of their claims against Mears Bros. Holdings Limited together with details of any security held. We would draw your attention to the legislation relating to Value Added Tax relief on bad debts. Creditors who wish to claim such relief should deduct the amount of Value Added Tax from the claim to be submitted to the Liquidators and should inform the Liquidators accordingly that their claim in the liquidation is net of V.A.T.

Please quote the name of Mears Bros. Holdings Limited (In Liquidation) in all correspondence relating to this Company.

Yours faithfully,

P. F. M. SHEWELL, M. A. JORDAN,

as Joint Liquidators of Mears Bros. Holdings
Limited.

<u>Distribution:-</u>	1 copy	- Each Creditor - Secured, Unsecured and Preferential
(1,950)	1 "	- Each Director and Shareholder
	1 "	- Debenture-holder
	1 "	- Each Member of the Committee of Inspection
	1 "	- The Royal Insurance Co. Ltd.
	1 "	- The Commercial Union Group - (Insurance)
	1 "	- Messrs. Bradstock, Blunt & Thompson Ltd. - (Insurance)
	1 "	- Record Book (W.H. Cork, Gully & Co.)
	1 "	- Records (W.H. Cork, Gully & Co.)
	1 "	- Records (Coopers & Lybrand)
15 copies	- General Files	(Coopers & Lybrand)
15 "	- General Files	(W.H. Cork, Gully & Co.)

MCNAB BROS. HOLDINGS LIMITED (In receivership)
Directors estimated Statement of Affairs as at 18th January 1979
(the date of the receiver's appointment)

	Book value £	Estimated to realise £	Note
Assets subject to a fixed charge			
Debtors	1'000	1'000	
	648	61	2, 3
	<u>648</u>	<u>61</u>	
Assets subject to floating charge			
Cash in hand	1	1	
Furniture and fittings	5	-	
Plant and machinery	13	13	
Investment in subsidiary companies	<u>2,321</u>	<u>-</u>	
	<u>2,340</u>	<u>14</u>	
Preferential creditors			
Salaries and wages		5	4
P.A.Y.E.		2	
Pension fund contributions		3	
Customs and Excise		23	
Rates		8	
Social Security contributions		<u>2</u>	
Deficiency regarding preferential creditors		<u>43</u>	
Deficiency regarding debenture holders		29	
Debenture holders		2,650	
Total liability to Barclays Bank on MBS account		<u>17</u>	
Contingent liability re performance bonds for subsidiaries		<u>2,667</u>	
Less available under fixed charge as above		<u>(61)</u>	
Deficiency as regards debenture holders		<u>2,655</u>	
Unsecured creditors			
General, per list		<u>132</u>	5, 6
Deficiency as regards creditors		<u>2,767</u>	
Share capital			
7,000,000 ordinary shares of 25p each, fully paid		<u>1,750</u>	
Deficiency		<u>£4,517</u>	

MEARS BROS. HOLDINGS LIMITED
in receivership

Notes to Directors' Estimated Statement of Affairs

1. This estimate, which is subject to the costs of receivership and liquidation, should be read in conjunction with the reports to the shareholders and creditors.
2. It has been assumed that the fixed charge over debtors given by the debenture is valid. This point will only be relevant if the bank seeks to enforce its own subrogated claim in competition with other preferential creditors.
3. The debtors include £587,000 from other group companies in receivership and considered irrecoverable. Debts due to and from group companies may however alter substantially as a result of the claims made against the companies by the bank and any subsequent payments under the debenture. At this stage the amounts involved cannot be gauged and the legal rights likely to arise therefrom are unclear.
4. The preferential salaries and wages do not include any subrogated claim that may be made by the bank.
5. The company has guaranteed performance bonds, hire purchase and bank and other loans for its subsidiaries. For the purposes of the statement of affairs the directors have not attempted to assess any contingent liability since they are unaware of any claim which has been made under this heading.
6. No provision has been made for possible redundancy payments.

MEARS BROS. HOLDINGS LIMITED IN RECEIVERSHIPUnsecured Creditors as at 18th January 1979

	£
Automatic Cleaning Services Ltd.	566
Barclays Bank (London & International) Ltd.	1,390
Baring Bros. & Co. Ltd.	8,640
Coward Chance & Co.	9,777
Coys of Kennington (Motors) Ltd.	564
Deloitte Haskins & Sells	10,480
East-West Europe	1,464
IEOS Finance Ltd.	45,000
Inland Revenue	1,712
R.C. Leighfield & Sons Ltd.	17,795
Lextertan Ltd.	931
Lombard North Central Ltd.	1,558
Mears Properties Ltd.	3,749
Nelson Hurst & Co.	3,344
New Opportunity Press Ltd.	1,042
Post Office	671
Price Waterhouse & Co.	11,488
Thames Water Authority	4,220
Walter Son & Packman	1,719
A.S. Wncate	1,756
Unclaimed dividends	761
Sundry Creditors under £500	3,270
	<u>£131,897</u>

RADFORD, SONS & CO.

Chartered Accountants

MICHAEL G. V. RADFORD

Consultant :
Gordon E. Radford

12 PORTLAND STREET
SOUTHAMPTON SO9 4LA
Telephone (0703) 25101

Southern Counties Construction Co. Limited

The first Meeting of Creditors of the above-named Company, convened pursuant to provisions of Section 293 of the Companies Act, 1948, took place at Centre Hotel, Portsmouth, on Friday 30th January, 1981. The Chairman of the Meeting was Mr. R.A. Boyce who was accompanied by Mr. Michael Andrews, the Chairman of the Board of Southern Constructions (Holdings) Ltd. (the Holding Company of the Group), and Mr. Richard Stone of Messrs Cork Gully who was appointed Joint Receiver by the Debenture Holder on the 12th May, 1980. A copy of the Statement of Affairs and list of principal Creditors which was submitted to the Meeting is enclosed herewith.

The Meeting was addressed by Mr. Michael Radford of Messrs Radford, Sons & Co., who reported that he had recently been instructed by the Directors of the Company to assist them with the formalities for winding-up the Company. He outlined the history of the Company, which was incorporated in 1936 and continued trading until March, 1941, when it closed down because of the war. It re-commenced in 1946 and expanded steadily. In 1956 the shares were acquired by the holding company, Southern Constructions (Holdings) Limited which later became a publicly quoted Company. There were many changes of Directors and, at the date of the Meeting, those who remained in office were:-

R.A. Boyce	appointed 1st January, 1972
Norman Thomas	" 31st August, 1979
Arnold G. Selby	" 29th March, 1977
Trevor Rees	" 1st April, 1974
Barry Heather	" 1st August, 1975
Peter J. Sawtell	" 1st April, 1979

Mr. Michael J. Stallard was appointed Secretary on 1st September, 1977, but, after assisting the Receivers for several months, he took a post abroad and Mr. Boyce was appointed Secretary on 30th December, 1980.

Over the years additional businesses were acquired to work with the Company and parts of the Company's activities were separated into individual limited liability Companies, as subsidiaries of the Holding Company. Certain of these Companies ceased trading and, at the date of the appointment of the Receivers, there were four other active subsidiaries, as follows:-

Southern Constructions (Property) Ltd.
Southern Constructions (Plant) Ltd.
Bleach Haulage Ltd.
Cresta Technology Limited

The bulk of the business carried on by other subsidiary Companies was on behalf of Southern Counties Construction Co. Ltd., which was the principal trading Company within the Group. The Companies were inter-dependent and, in considering the trading results, it is more relevant to refer to the Group results rather than those of the Company solely. The following are the summarised trading results for the 5 years ended 31st January, 1978

2/.....

	1978 £	1977 £	1976 £	1975 £	1974 £
Turnover	12,221	13,709	10,737	9,929	7,363
Profit (loss) before taxation	(293)	(1,452)	160	554	223
Taxation	(9)	(765)	85	316	159
Net profit (loss) after tax	(284)	(687)	75	238	64

The interim results for the six months ended the 30th June, 1979 were published in October 1979 and showed the following:-

	6 months to 30th June		Year
	1978	1979	1978
Turnover	6,858	4,663	12,221
Profit (Loss)	33	(398)	(293)

As will be seen the Company's turnover had fallen substantially compared to 1978, and this trend continued in the latter part of 1979 as the Company re-organised its affairs. The accounts for the year have not been completed, but the turnover was approximately £10 million, and the estimated trading loss was nearly £800,000.

The summarised figures above show that the Company had been very prosperous up to 1975, but suffered a gradual deterioration thereafter. In March, 1977, following the collapse of the Ernest Ireland Group of Companies the Company acquired the Caffin Division of that Group, including its offices at Rickmansworth and various employees, and it took an assignment of a number of contracts. Unfortunately the activities did not fit in well with the existing business, and it is estimated that losses on the contracts taken over amounted to £½ million.

Regular management accounts were prepared and, although these showed a continuing trend of losses throughout 1979, the Directors were confident that the Group was solvent, and due to the remedial steps that had been taken, it would overcome its difficulties. Finance was provided by National Westminster Bank Ltd. with an overdraft limit of £765,000 but with a "bounce-up" facility of £300,000 to cover periodic pressures due to delays in obtaining certificates on contracts and payments thereunder. There were various cash flow crises in early 1980, and the Directors realised that the Company would need additional finance, and Bonds totalling £600,000 in respect of contracts amounting to £7 million that had been secured. An approach was made to the Bank for assistance and the Bank insisted that the Group's affairs be investigated by an independent firm of Accountants, and this exercise was carried out at the end of April and the first week of May. The contracts were examined by an independent firm of Surveyors, and the properties valued. The reports that went to the Bank showed that, on a going concern basis, the assets of the Group exceeded its liabilities by £577,081, although on a break-up there would be a substantial deficiency. The Directors were optimistic that, in the light of the report, the Bank would accept their request for further assistance but, when the Bank refused, the Directors had no alternative but to formally request the Bank to appoint Receivers.

The Receivers continued trading for a short while attempting to finish off a small job and to assign contracts. As a result of the termination of certain contracts and losses sustained through the assignment of others, the value of debts and work in progress has been

3/.....

reduced by approximately £1.4 million. The deficiency account can be summarised as follows

Deficiency at 31st December, 1978	273,121
Amount written off debts and work in progress	1,419,694
Contingent liabilities under performance bonds	386,753
Redundancy pay, holiday pay and notice payments	114,721
	<hr/>
	2,194,289
Balance being estimated trading loss for the period 1st January, 1979 to 1st May, 1980	1,236,578
	<hr/>
Deficiency per Statement of Affairs	<u>£3,430,867</u>

At the date of the appointment of the Receivers the total indebtedness to the Bank was £815,353, and there was a contingent liability of £226,867 in respect of Bonds. The funds at present held by the Receivers from the realisation of the assets of Southern Counties Construction Ltd., are quite small, but they estimated that approximately £500,000 remains to be realised, principally in respect of final accounts and claims on completed contracts.

Unfortunately the Receivers have not yet succeeded in disposing of any of the Group's properties and the funds held by them at present from the realisation of the assets of the associated Companies is in the region of £400,000, and thus interest continues to accrue on the overdraft. The estimated value of the Company's properties is £750,000 and thus, provided the debts and retentions realise the amount estimated by the Receivers and their Surveyors, a fund should be available for the Creditors of the Group in due course.

The Statement of Affairs shows that there are no assets available for Unsecured Creditors. Other Companies within the Group however show substantial surpluses. Mr. Radford expressed the view that, when the assets of all the Companies had been realised and it is known what funds (if any) are available for Creditors, consideration should be given to combining the assets and liabilities and equating the dividends payable across the Companies within the Group. Understandably objections to the proposal might be received from Creditors of the other Companies but, bearing in mind that the liabilities of Southern Counties Construction Co. Ltd., constitute 90% of the liabilities of the Group and, moreover, the other Companies where there are substantial assets would not have existed but for the fact that those assets were hived off from Construction, the proposal has the merit of equity. When the position is clearer, Creditors will be asked to express their views, and it may be necessary even to make an application to Court.

The Meeting resolved that Michael G.V. Radford, F.C.A. be appointed Liquidator, with a Committee of Inspection consisting of the representatives of:-

The Davum Steel Co. Ltd.
W. & J. Glossup Ltd.
Ready Mixed Concrete Group
Tarmac Roadstone (Southern) Ltd.
Shell UK Oil

Would those Creditors who did not submit claims in response to the Notice of the Meeting of Creditors please be good enough to do so, and where appropriate submit the forms of acknowledgement for V.A.T. purposes. Forms previously submitted are returned herewith.

Yours faithfully

RADFORD, SONS & CO.

SOUTHERN COUNTIES CONSTRUCTION CO. LTD.

Approximate Statement of Affairs at 12th May, 1980

<u>Liabilities</u>		<u>Assets</u>	
Trade and Expense Creditors		Debts and Work in Progress	177,00
Performance Bonds		Claims under Completed Contracts	477,00
Redundancy Pay and Notice		VAT Recoverable	106,97
Caffin & Co. Ltd.		Trade Debtors	123,00
Hire Purchase	22,392	Loans	6,00
Less value of Equipment	<u>17,500</u>	Trust Monies	20,00
		Stock of Materials	20,00
		Plant and Machinery	5,00
		Office & Surveying Equipment	16,90
			<u>951,37</u>
Holding Company & Associates :-		Deduct claims of Preferential Creditors	180,96
Southern Constructions (Holdings) Ltd	917,109		<u>770,41</u>
J.J. Bleach & Sons Ltd	170,399		
Southern Constructions (Precast) Ltd	47,982		
Southern Constructions (Plant) Ltd	<u>17,548</u>	Associated Companies :-	
	1153,038	Bleach Haulage Ltd	11,282
		Cresta Technology Ltd	56,561
		Southern Constructions (Property) Ltd	<u>321,869</u>
			-
Issued Capital	1,040	National Westminster Bank - debt secured by floating charge	693,73
			<u>76,68</u>
		Estimated Deficiency	3342,13

£3418,818

£3418,818

RADFORD, SONS & CO.

Chartered Accountants

MICHAEL G. V. RADFORD

Consultant :
Gordon E. Radford

12 PORTLAND STREET.
SOUTHAMPTON SO1 0EB

Telephone (0703) 330703
Facsimile (0703) 330099

Our ref. MR/CJ/C.GEN
Your ref.

PRIVATE AND CONFIDENTIAL

26th August, 1988

Dear Sirs,

Southern Constructions (Holdings) Limited

The first Meeting of Creditors of the Company convened pursuant to the provisions of Section 98 of the Insolvency Act 1986, took place at the Southampton Park Hotel, Southampton, on Wednesday, the 17th August, 1988.

The Chairman of the Meeting was Mr. J.M.G. Andrews. The Statement of Affairs sworn by Mr. Boyce, one of the Directors, showed that the only assets of the Company are certain claims against subsidiary Companies, which are also in the course of being wound-up.

The Receivership of the principal trading subsidiary, Southern Counties Construction Co. Ltd., will not be completed for several months. However, it is anticipated that when the Receiver has completed his work, certain funds will flow back to the Holding Company which might result in a dividend being payable to the Creditors whose claims appear to amount to the following:-

	£
Trade and Expense Accounts	59,871
Subsidiary Companies	105,793
Guarantee Liability	140,073
Claims from Directors and Ex-Directors	18,930
Ex-employees	9,100

The Meeting resolved that Mr. Michael G.V. Radford, FCA, be appointed Liquidator. Mr. Radford is also Liquidator of the subsidiary Companies.

Would those Creditors who did not submit claims in response to the Meeting of Creditors, please be good enough to do so and where appropriate submit forms of acknowledgement for V.A.T. Bad Debt Relief purposes.

Yours faithfully,

RADFORD, SONS & CO.

APPENDIX D-5

QUESTIONNAIRE

QUESTIONNAIRE

Please tick the appropriate box for question 1-10 and Yes or No for questions 11-17.

- 1 - Please state whether the chief executive is the sole authority or has an assistant or deputy in the company.

Sole authority

☐

Assistant or deputy with
authority

☐

- 2- Please state whether the chief executive is the same person acting as both chief executive and chairman of the company.

Chief executive and chairman
same person

☐

Chief executive and
chairman not same
person

☐

- 3- Please state whether the Company Board comprises persons not working in the company.

Comprises only members
working in the company

☐

Comprises of members
not working in the company

☐

- 4- Please state the average experience in years of the majority of the company's site Engineers up to section Engineers.

Over 10 years

Less than 10 years

[]

[]

- 5- State whether the financial director has sole authority for financial decisions or shared by other senior managers.

Sole acting person
with authority

Shared authority

[]

[]

- 6- State the average experience years of the majority of the company's management staff (site and service manager including at Head office).

Over 10 years

Less than 10 years

[]

[]

- 7- State whether the company produces cash flow plans.

Cash flow plan prepared
and reviewed periodically

No cash flow plan

[]

[]

8- State whether the company has a budgetary control system.

Budgetary control system
available in the company

[]

No budgetary control system
available in the company

[]

9- State whether the senior management staff carry all the responsibility for tendering.

Senior management staff
experienced in bidding
and taking bidding decisions

[]

Bidding decision not taken
at middle management level

[]

10-State how your company responds to market changes.

Quick response

[]

Fair response

[]

11- Did the company issue debentures before 1986?

12-Did the company expand its business before 1986 and did this result in over trading? —

13-Did the company under-take a specific project before 1986 which caused significant losses?

14-Did the company take over an other firm before 1986 which resulted in significant losses?

15- Did the company diversified its business before 1986? If Yes does it relate to the same line of your business?

16-Did the company under-take a specific project including contract claims before 1986 which caused significant losses?

17- Did the company under-take a specific overseas projects before 1986 which caused significant losses?

APPENDIX E

- E.1 Introduction
- E.2 Test the Goodness of Fit
- E.3 The F-Test
- E.4 Test of Model 2
- E.5 Test on Financial Ratios
- E.6 Test on A-Score Model
- E.7 Test on Relationship Between Z-Score and A-Score
- E.8 Appendix References

APPENDIX E

STATISTICAL TESTS

E.1 INTRODUCTION

One of the main objectives of statistical analysis in a situation of uncertainty, unavailable mathematically, or otherwise to produce the right answer, is that the information derived from samples drawn according to specific criteria can be used to make estimates of and inferences about the characteristics of populations.

Statistical analysis can do no more than help to assess the level of risk involvement. This idea is central to the whole concept of statistical analysis, which is concerned not with the impossible task of finding the right answer but with measuring the level of uncertainty. This inevitably throws the final decision back on the researcher's judgement.

E.1.2 CHOOSING A SAMPLE

A sample, of whatever size, should be randomly chosen. In practice it is not easy to meet this condition so that various devices are used to keep the sample as close to the ideal as possible. Despite much effort, few data were collected with sufficient information.

The rules for choosing an appropriate size of sample in this research were based on:

- availability of data
- qualitative analysis.

Unfortunately, due to lack of information available only 22 failed companies have been collected. Eleven were used to develop the model and 11 used to test the model. Also 20 continued companies were used to develop the model and 70 companies were used to test the model.

The selection criterion adopted for the "non-failed 20" group was as follows:

- continuing in business for at least four years and also had to have continued in operation for two years after the focal year 1986
- has not been exposed to continuous losses for the last four years in business, some of them may have made losses over one or two years
- finally, appearing solvent, but not necessarily considered healthy companies.

While the selection criterion for the "failed 11" group consisted of those declaring bankruptcy and into receivership between 1978 through 1986, a period of 8 years.

E.1.3 TEST ON NORMALITY OF DATA

The standard discriminant analysis procedures assume that the variables used to describe or characterise the member of the groups being investigated are multivariate normally distributed.

In practice, deviations from the normality assumption in finance appear more likely to be the rule rather than the exception [see Deakin, 1977].

Violations of the normality assumption may bias the test of significance and estimated error rates.

In the applied literature, the problem of testing for the appropriateness of the distributional assumption has been largely ignored. This is due in part, one would presume, to the fact that most available normality tests are for univariate and not multivariate normality [1]. In our case a reasonable approximation normality has been taken by calculating the financial ratios for four years for the "non-failed 20" groups and the last three years for the "failed 11" group, and averaging the ratios in order to smooth the means. Also logarithmic and reciprocal transformation is adopted to improve normality.

E.1.4 TEST ON RELATIONSHIP BETWEEN VARIABLES

Correlation between variables were tested. Previous studies (2)(3) suggested that any ratio highly correlated with other ratios that describe similar aspects of the company's financial structure should be discretised for example, correlation between any two variables 0.7 or greater, one of them should be selected for inclusion in the analysis. This research adopted similar concepts as shown in Figure E.1.

E.2 TEST THE GOODNESS OF FIT

In order to test the goodness of fit of the normal distributions characterised by the mean and standard deviations of the two samples, the Kolmogorov-Smirnov test is employed. The hypothesis tested is that the normal distribution fits the data.

If the computed value of the greatest absolute difference between the distribution functions exceeds the tabular value, the hypothesis is rejected.

The "Z" values for the "non-failed 20" and "failed 11" groups are shown in Table E.1. The range of "Z" values is divided into segment 3 units, and the frequency indicated on the graph is the number of "Z" values failing within that particular segment.

The histograms closely resemble the superimposed normal curve as shown in Figure 6.2 (see Chapter 6). The greatest difference between actual proportion and expected proportion is shown in Tables E-2 and E.3.

The hypothesis is not rejected at the 0.05 level of significance for either group, as the tabular value for the samples size of twenty and eleven are 0.26 and 0.36 respectively, and the assumption of normality is presumably satisfied.

	C33	C1	C2	C3	C4	C5	C6	C7
C1	-0.443							
C2	-0.153	0.814						
C3	-0.589	0.715	0.559					
C4	-0.243	-0.114	0.139	0.136				
C5	-0.545	0.768	0.632	0.975	0.119			
C6	-0.622	0.893	0.694	0.820	0.001	0.887		
C7	-0.298	0.064	0.920	0.669	-0.150	0.776	0.843	
C8	0.278	0.318	0.114	-0.405	-0.009	-0.344	-0.378	-0.188
C9	-0.194	0.234	0.280	0.386	-0.752	0.213	0.247	0.232
C10	-0.044	0.092	0.226	0.225	0.137	0.101	0.080	0.070
C11	0.222	-0.086	-0.069	-0.193	-0.265	-0.279	-0.165	-0.091
C12	0.573	-0.006	-0.015	-0.317	0.443	-0.236	-0.210	-0.023
C13	0.485	-0.451	-0.550	-0.674	0.090	-0.603	0.587	-0.554
C14	0.348	-0.298	-0.223	-0.524	0.055	-0.444	0.284	0.269
C15	-0.351	0.203	0.186	0.337	-0.094	0.339	0.371	0.312
C16	0.361	-0.647	-0.570	-0.807	0.079	-0.774	-0.736	-0.693
C17	0.625	-0.227	0.062	-0.326	-0.074	-0.263	-0.275	-0.007
C18	0.426	0.001	0.606	-0.067	-0.134	-0.002	-0.037	0.394
C19	0.005	0.212	0.278	0.002	0.045	0.111	0.245	0.252
C20	0.153	0.254	-0.109	-0.306	-0.256	-0.373	-0.244	-0.221
C21	0.337	0.062	0.574	-0.002	-0.188	-0.054	-0.054	0.335
C22	0.438	0.151	-0.031	0.217	-0.217	-0.754	-0.247	-0.146
Continue?								
C23	0.125	-0.355	0.324	-0.314	-0.000	-0.374	-0.281	-0.284
C24	0.519	0.005	-0.054	0.202	-0.375	-0.219	-0.197	-0.053
C25	-0.194	-0.140	-0.189	-0.067	-0.001	-0.076	-0.030	-0.126
C26	0.215	0.107	-0.199	0.200	0.184	0.277	0.107	0.205
C27	0.077	-0.162	-0.123	0.076	0.579	0.045	0.011	0.011
C28	0.047	-0.101	0.033	0.017	0.274	0.090	0.072	0.010
C29	-0.152	0.002	0.164	0.758	0.004	0.367	0.238	0.209
C30	0.244	-0.034	-0.027	-0.092	0.001	0.074	0.059	0.032
C31	0.017	-0.077	-0.102	-0.011	-0.115	0.001	0.001	0.008
Continue?								
	C8	C9	C10	C11	C12	C13	C14	C15
C9	-0.175							
C10	-0.070	0.505						
C11	-0.179	0.295	0.113					
C12	0.013	-0.218	-0.173	0.062				
C13	0.276	0.324	-0.145	0.079	0.232			
C14	0.210	0.130	0.145	0.179	0.049	0.701		
C15	0.159	0.090	-0.108	0.235	-0.141	0.477	0.406	
C16	0.494	-0.434	0.405	0.070	0.156	0.653	0.440	0.205
C17	0.004	0.098	0.107	0.266	0.211	0.512	0.596	-0.543
C18	0.597	0.000	0.315	0.040	0.105	0.444	0.199	0.276
C19	0.005	0.237	0.435	0.103	-0.070	0.778	0.674	0.399
C20	0.255	0.469	0.100	0.417	0.007	0.279	0.466	0.327
C21	0.603	0.237	0.294	0.106	0.040	0.019	0.205	-0.205
C22	-0.027	0.064	0.164	0.766	0.320	0.706	0.129	-0.277
C23	-0.047	0.140	0.111	0.232	0.134	0.504	0.669	0.438
C24	0.014	-0.298	0.117	-0.077	0.917	0.200	0.094	0.172
C25	0.103	-0.177	0.057	0.014	0.177	0.100	0.043	0.277
C26	-0.100	0.432	0.099	0.004	0.079	0.233	0.239	0.041
C27	-0.093	-0.454	-0.210	-0.298	-0.145	0.163	0.035	0.017
C28	-0.197	0.007	0.107	0.015	-0.094	0.104	0.000	0.027
C29	0.068	0.114	0.115	0.100	0.191	0.094	0.076	0.014
C30	-0.148	-0.054	-0.143	0.414	0.017	0.200	0.332	0.336
Continue?								
C31	-0.195	0.031	0.147	-0.133	0.017	0.004	-0.002	0.167
	C16	C17	C18	C19	C20	C21	C22	C23
C17	0.023							
C18	-0.115	0.613						
C19	0.312	0.645	0.430					
C20	0.217	0.721	0.100	0.350				
C21	0.049	0.467	0.246	0.391	0.470			
C22	0.107	0.341	0.192	0.142	0.277	0.193		
C23	0.142	0.577	0.090	0.533	0.419	0.025	0.012	
C24	0.119	0.270	0.000	0.006	0.162	-0.003	0.104	0.054
C25	-0.034	0.172	0.004	0.003	0.000	0.130	0.006	0.115
C26	-0.040	0.166	0.000	0.114	0.354	0.060	0.021	0.467
C27	0.006	0.007	0.111	0.047	0.329	0.229	-0.356	0.105
C28	-0.150	0.261	0.079	0.157	0.227	0.046	0.031	0.104
C29	-0.133	0.003	0.160	0.219	0.061	0.104	0.274	0.003
C30	0.076	0.306	0.046	0.259	0.097	0.006	0.325	0.174
C31	-0.150	0.121	-0.056	0.044	-0.152	0.110	0.136	0.044
Continue?								
	C24	C25	C26	C27	C28	C29	C30	
C25	0.211							
C26	0.077	0.201						
C27	-0.101	-0.006	-0.003					
C28	-0.150	0.293	0.124	0.610				
C29	-0.265	0.041	0.070	0.007	0.154			
C30	-0.110	0.003	0.011	0.210	0.321	0.205		
C31	0.004	0.227	0.119	0.340	0.767	0.000	0.062	

FIGURE E.1: CORRELATION BETWEEN THE VARIABLES

TABLE E-1

Rank	"Non-failed" Group Z Values	"Failed" Group Z-Values	
1	13.27		
2	3.59		
3	14.9		
4	14.53		
5	6.4		
6	7.1		
7	3.52		
8	7.07		
9	18.22	$\mu_1 = 9.6$	
10	20.4		
11	6.32		
12	-1.85		
13	14.74		
14	8.25		
15	-0.96		
16	10.8		
17	17.7		
18	5.7		
19	6.8		
20	15.6		
21		-4.1	
22		-11.53	
23		-22.6	
24		-18.8	
25		-10.13	$\mu_2 = -14.3$
26		-8.8	
27		-16.0	
28		-18.3	
29		-21.3	
30		-18.0	
31		-7.66	

Range	Actual Frequen- cies	Actual Cumula- tive	Expected Propor- tion	Expected Cumula- tive	Actual Propor- tion	Expected Propor- tion	Diffe- rences	—
0-(-3)	1	1	0.76	0.76	0.05	0.053	0.003	
0-(+3)	2	3	0.06	0.82	0.15	0.057	0.093	
3-(6)	0	3	0.25	1.07	0.15	0.075	0.075	
6- 9	3	6	2.835	3.905	0.3	0.274	0.026	
9-12	5	11	3.78	7.685	0.55	0.539	0.011	
12-15	1	12	0.76	8.445	0.6	0.593	0.007	
15-18	4	16	5.67	14.115	0.8	0.99	-0.19	
18-21	2	18	0.06	14.17	0.9	0.995	-0.095	
21-24	2	20	0.06	14.23	1.0	1.0	0	

TABLE E-2: SHOWS DIFFERENCES BETWEEN ACTUAL AND EXPECTED PROPORTIONS IN "NON-FAILED 20" GROUP (Kolmogrov Smirnov Test)

Range	Actual Frequen- cies	Actual Cumula- tive	Expected Propor- tion	Expected Cumula- tive	Actual Propor- tion	Expected Propor- tion	Diffe- rences
(0)-(-6)	1	1	0.76	0.76	0.09	0.062	0.028
(-6)-(-12)	4	5	5.67	6.43	0.454	0.526	0.068
(-12)-(-18)	2	7	0.06	6.49	0.636	0.537	0.103
(-18)-(-24)	4	11	5.67	12.16	1.0	1.0	0

TABLE E-3: SHOWS DIFFERENCES BETWEEN ACTUAL AND EXPECTED PROPORTIONS IN "FAILED 11" GROUP (Kolmogrov Smirnov Test)

E-3 THE F-TEST

F-test: It enables us to compare two estimates of the same variance to give the likelihood that discrepancy would arise for the size we have got, the test depends vitally on degrees of freedom.

By establishing null hypothesis that all the figures come from the same distribution and then estimates are made of the variance of this distribution in a variety of ways. Comparison of these estimates allows a decision to be made on whether they are so different that the null hypothesis should be rejected.

The mean of the Z-value for the "non-failed 20" group is 9.60 and the sums of squares of differences:

$$s_1^2 = \sum (Z - \bar{Z}_1)^2 = 760$$

$$\text{s.d.} = \sqrt{\frac{\sum (Z - \bar{Z}_1)^2}{n-1}} = 6.324$$

and the variance is the square of standard deviation. Hence variance for the "non-failed" group = 39.9.

Similarly, the mean of the Z-value for the "failed 11" group is 14.30 and the sums of squares of differences

$$s_2^2 = \sum (Z - \bar{Z}_2)^2 = 375$$

$$\text{s.d.} = \sqrt{\frac{\sum (Z - \bar{Z}_2)^2}{n-1}} = 6.123$$

and the variance is 37.49.

The best estimate of s.d. of whole populations:

$$s.d. = \sqrt{\frac{\sum (z_1 - \bar{z}_1)^2 + \sum (z_2 - \bar{z}_2)^2}{n_1 + n_2 - 2}}$$

$$s.d. = \sqrt{\frac{759.38 + 375.25}{20 + 11 - 2}} = 6.253$$

Variance of whole population = 39.1.

Estimate sums of square for whole population:

$$39.1 \times 29 = 1133.9 \text{ with DF1.}$$

2. Estimate of variance for each column and averages:

$$\frac{37.79 + 39.9}{2} = \underline{38.69} \text{ with 29 degrees of freedom}$$

$$\frac{39.1}{38.69} = \underline{1.010}$$

Now we use the F-test to enable us to compare two estimates of the same variance to give the likelihood that discrepancy would arise from the size of samples we have got. There are two ways of making estimates of the variance:

i) Estimating variance group by group

On the basis of null hypothesis, the "non-failed" group is a sample sized 20 from the overall population. For this group the average Z-score is 9.6, the sum of the squares of the difference from this average is 759.4.

So the population variance is

$$\frac{759.9}{19} = 39.97$$

We can do the same with the "failed " group where the average is -14.30, the sum of squares of the differences from this average is 375.25 and the estimate of variance is:

$$\frac{375.25}{10} = 37.52$$

So that the best estimate of population variance is:

$$\frac{39.97 + 37.52}{2} = 38.75, \text{ call this estimate "A"}$$

ii) Estimating variance using group averages

The averages for each group are 9.6 and -14.3 respectively and this is a sample size of 2 of what might be a large number of averages.

We can make an estimate of the variance of this large number of averages from the two we have got. Average of the two:

$$\frac{9.6 + (-14.3)}{2} = -2.35$$

Sum of squares of differences:

$$[9.6 - (-2.35)]^2 + [-14.3 - (-2.35)]^2 = 285.6$$

Estimate of variance, by using 2 degrees of freedom:

$$\frac{285.6}{2} = 142.8$$

Now, the central limit theorem tells us that for sample size "n" out of a full population with standard deviation 'S' the averages will form a new distribution whose standard deviation will be $S/\sqrt{n}$. The variance is the square of standard deviation so that:

$$\text{Variance of average} = \text{variance of population}/n$$

If we considered the sample size the lowest is 11 instead of 20. In order to get lower estimates so that our final estimate of the overall variances $142.8 \times 11 = 1570.8$, call this estimate "B".

THE TEST

We now have two estimates of the variance of the Z-scores on the assumption (null hypothesis) that there is no difference between two groups, these estimates are:

- A. Estimating variance group by group and averaging 38.75
- B. Estimating variance using groups averages 1370.8

Before we must consider "degrees of freedom" again because the test depends vitally on this. Firstly when we used each group we got 19, 10

degrees of freedom respectively. Using both groups gives $20 + 11 - 2 = 29$ degrees of freedom. Secondly, when we used the averages of each group, there were only two figures. We are therefore comparing:

38.75 with 29 degrees of freedom
1750.8 with 2 degrees of freedom

The ratio $1570.8/38.75 = 40.5$.

The tabular value of F is 5.42 where $DF_1 = 2$ and $DF_2 = 29$ at the 1% significance level while the computed value of F is 40.5. Therefore the computed F-statistic for the overall function is good.

An F-ratio is the ratio between two variances and is used to test for homogeneity of variance and equivalence of two groups.

A value of 'F' larger than the tabular value for the degrees of freedom in the numerator DF_1 , and the degrees of freedom in the denominator DF_2 at an indicated level of significance leads to the rejection of the hypothesis that the two groups are samples from the same population with a confidence level of 99% or 1% level of significance.

Therefore, we can conclude that an increase in differences between means of the variables or decrease in the variability of variables improves the ability of discriminant models to differentiate between groups.

An alternative, and equally valid approach is to use the student t-test to compare the Z-scores of two groups.

The average Z-scores of group 1 +9.6

The average Z-scores of group 2 -14.3 ____

The best estimate for the standard deviation of common population

$$= \sqrt{\frac{s_1^2 + s_2^2}{N_1 + N_2 - 2}} = 6.253$$

The null hypothesis regards the two samples as samples from the same population. Therefore no difference in the averages of the populations from which the samples are taken have to be extended to include the assumption that the standard deviations are also the same.

The formula for different sized samples is:

$$t = \frac{\text{difference in averages}}{\text{best estimate of s.d.}} \div \sqrt{1/n_1 + 1/n_2}$$

$$t = \frac{9.6 + 14.3}{6.253} \div \sqrt{1/11 + 1/20}$$

$$= \frac{3.822}{0.374} = \underline{10.219}$$

The number of degrees of freedom = 11 + 20 - 2 = 29.

Tabular value of t = 2.462 at 1% significance level.

E.4 TEST OF MODEL 2

Each variable in the multiple regression second version model is tested for significant contribution to the coefficient of determination (R^2) which is a measure of the proportion of the variance of the dependent variable accounted for by the independent variables.

The amount of variance explained by the model is 89% of the total variance. The adjusted R-squared is 91%. The higher level of variance explained indicates the power of the model and that the most discriminant variables are included in the model.

Also, the t value of the model tested indicates that the calculated value (3.45) is greater than the tabular value (2.75) at 0.01 significance level.

E.5 TEST ON FINANCIAL RATIOS

The statistical method used to obtain the most correct predictor ratios was based on criteria that an increase in difference between means of the ratios or decrease in variability of ratios improves the ability of discriminant ratios to differentiate between groups.

The student t-test is employed to compare the financial ratio means of two groups for example. The means of current ratio for failed and non-failed groups were 1.16 and 1.66 respectively. The best estimate for the standard deviation of common population:

$$\text{s.d.} = \sqrt{\frac{\sum(r_1 - \bar{r}_1)^2 + \sum(r_2 - \bar{r}_2)^2}{n_1 + n_2 - 2}} = 0.511$$

The formula for t for different sized samples is:

$$t = \frac{\text{difference in averages}}{\text{best estimate of s.d.}} \div \sqrt{\frac{1}{n_1} + \frac{1}{n_2}}$$

$$t = \frac{1.66 - 1.16}{0.51} \div \sqrt{\frac{1}{20} + \frac{1}{11}}$$

$$t = 2.6$$

The number of degrees of freedom = 11 + 20 - 2 = 29. The tabular value of t = 2.46 at 1% significance level, therefore we can reject the hypothesis that the two groups are samples from the same population with a confidence level 99% or 1% level of significance.

Similarly, the t-values for NA/CL and EBIT/INT ratios are 5.16 and 2.56 respectively which are greater than the tabular value 2.46 at 1% level of significance.

TABLE E-4: SHOWS THE MEANS OF FINANCIAL RATIOS USED IN THE ANALYSIS

CA/CL	NA/CL	EBIT/INT
1.06	1.675	3.82
2.74	1.91	4.4
1.32	1.177	6.65
1.67	1.11	1.7
2.24	1.7	4.4
1.36	0.947	6.35
2.29	1.75	4.4
1.65	1.36	8.2
2.55	2.38	2.1
1.097	0.937	3.5
1.69	1.47	2.92
1.09	6.7	3.18
1.6	1.01	2.15
1.39	1.92	5.65
1.27	1.44	1.05
1.38	2.07	9.1
1.317	1.35	7.47
1.42	1.25	33.0
1.25	0.74	5.1
3.4	3.37	
1.66	1.765	4.7
1.47	1.34	0.90
0.5	0.49	3.07
1.72	1.13	1.64
0.59	1.08	1.42
1.01	1.02	0.85
1.25	0.68	1.34
1.34	0.64	0.71
1.22	0.92	0.19
1.28	0.79	2.15
1.06	0.58	1.43
1.36	0.46	2.2
1.16	0.816	1.44

E.6 TEST ON A-SCORE MODEL

The A-scores for the "at risk 7" and "solvent 7" groups are shown in Figures 10.1 and 10.2 as follows:

62, 72, 62, 96, 50, 69, 50
31, 45, 41, 29, 47, 28, 43

1) Testing by Using t-Test

In order to deal with the null hypothesis that there is no difference in the averages of both populations it has to be extended to include the assumption that the standard deviations are also the same.

The average of the first group is 65.85 and the average of the second group is 37.7.

For the first group the sum of the squares of the differences from the average is:

$$\begin{aligned} & (62-65.85)^2 + (72-65.85)^2 + (62-65.85)^2 + (96-65.85)^2 \\ & + (50-65.85)^2 + (69-65.85)^2 + (50-65.85)^2 \end{aligned}$$

Therefore the sum of squares of differences = 1488.78.

For the second group the sum of the squares of the differences from the average is:

$$\begin{aligned} & (31-37.7)^2 + (45-37.7)^2 + (41-37.7)^2 + (29-37.7)^2 \\ & + (47-37.7)^2 + (28-37.7)^2 + (43-37.7)^2 \end{aligned}$$

i.e. the sum of squares of differences = 393.25.

The best estimate of the standard deviation is given by:

$$\sqrt{s_1^2 + s_2^2 / 2(n-1)}$$

where n is the size of the sample. Therefore

$$\sqrt{(1488.78 + 393.25) / 2(7-1)} = \underline{12.52}$$

$$t = \frac{(\text{difference between sample average})}{\text{best estimate of standard deviation}} \times \sqrt{\text{sample size}/2}$$

$$t = \frac{65.85 - 37.7}{12.52} \times \sqrt{7/2} = 4.2$$

The tabular value of t with 12 degrees of freedom is 2.681 with 1% significance level. We are therefore justified in saying that there is a significant difference between the groups.

An alternative approach is to use the Wilcoxon (rank sum) test. The Wilcoxon test, starts by putting all the results in rank order, lowest first:

28	29	31	41	43	45	47	50	50	62	62	69	72	96
A	A	A	A	A	A	A	B	B	B	B	B	B	B
1	2	3	4	5	6	7	8	9	10	11	12	13	14

The sum of the A rankings is:

$$1 + 2 + 3 + 4 + 5 + 6 + 7 = \underline{28}$$

The sum of the B rankings is:

$$8 + 9 + 10 + 11 + 12 + 13 + 14 = \underline{67}$$

We test to see whether this difference is too great. The table shows that with 7 in each sample the tabular value is 39 [see page 130 (4)]. Therefore, we can reject the null hypothesis at the 5% level of significance.

E.7 TEST ON RELATIONSHIP BETWEEN Z-SCORE AND A-SCORE

In order to test the relationship between the Z-score and A-score, the correlation test is employed.

The 'Z' and 'A' values for the "At risk 7" and "Solvent 7" groups are shown in Table and their average Z- and A-values are 1.92 and 51.75 respectively.

The standard deviation of Z- and A-scores is calculated as follows:

$$S_Z = \sqrt{\frac{\sum (Z - \bar{Z})^2}{n-1}} = 14$$

$$S_A = \sqrt{\frac{\sum (A - \bar{A})^2}{n-1}} = 18.9$$

$$S_{AZ} = \sqrt{\frac{\sum (Z - \bar{Z})(A - \bar{A})}{n-1}} = 179.18$$

where $n = 14$.

The correlation coefficient is now given by:

$$r = \frac{S_{ZA}}{S_Z - S_A} = \frac{179.18}{14 \times 18.9} = 67.7\%$$

and the equation of the regression line is

$$A = \left(\frac{S_{ZA}}{S_Z^2} \right) (Z - \bar{Z}) + \bar{A}$$

$$A = \frac{179}{196} (Z - 1.92) + 51.75$$

$$A = 0.9Z - 1.75 + 51.75$$

$$A = 0.9Z + 50$$

where $Z = 0$, $A = 50$.

Clearly, the value of $r = 0.677$ which indicates that a real correlation exists, but is not strong enough, as usually a correlation coefficient of more than 0.7 indicates a strong relationship. However, the Z-score value of zero corresponded to an A-score cut-off value of 50, these being critical values in both models.

Z	A	$(A-\bar{A})$	$(Z-\bar{Z})$	$(A-\bar{A})^2$	$(Z-\bar{Z})^2$	$(A-\bar{A})(Z-\bar{Z})$
-8.1	62	10.3	-10.02	106	100	-105
-6.5	72	20.3	-8.42	412	70.9	-170.9
-4.47	96	44.3	-6.39	1962	40.8	-283
-8.23	50	-1.7	-10.17	2.89	103.4	+17.3
-26.3	69	17.3	-28.22	299	796.3	-488
-6.5	50	-1.7	-8.42	2.89	70.7	+14.3
-11.7	62	10.3	-13.67	106	186.8	-140.8
16.15	31	-20.7	+14.23	429	202.5	-294.5
14.0	43	-8.7	12.08	75.7	145.9	-105
7.6	41	-10.7	5.68	114.5	32.2	-60.7
10.5	29	-22.7	8.58	515.3	73.6	-194.7
23.2	47	-4.7	21.28	22	452.83	-100
10.0	45	-6.7	8.08	44.9	65.2	-54
17.3	28	-23.7	15.38	561.7	236.5	-364.5
26.88	725			4654	2577	-2329.4

$$\bar{Z} = 1.92, \bar{A} = 51.75$$

TABLE E.5

E.8 APPENDIX REFERENCES

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