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COMPANIES AT RISK:
A MULTIVARIATE ANALYSIS OF COMPANY PERFORMANCE USING ACCOUNTING DATA

by

RICHARD J. TAFFLER

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ABSTRACT

This research report essentially describes the development and some applications of a multivariate model for the identification of potentially bankrupt manufacturing companies in advance of failure so that appropriate action can be taken and its use, suitably transformed, as a more general multivariate performance measure which would appear to overcome many of the problems associated with the conventional univariate return on capital employed approach.

The final statistical model developed using a stepwise discriminant approach and financial ratio data appears able to identify subsequently failing companies on an ex post basis with a near 100% success rate. Application of the model to the accounts of failed companies for years prior to the last indicates that less than half the sample considered could have been classed as "solvent" on the basis of their accounts 4 years prior to failure.

It is estimated that nearly 10% of quoted manufacturing companies can currently be considered to be "at risk" and that if the economic situation does not improve only about 45% of these will be able to eventually recover without outside assistance. A list of companies "in danger" including some household names and several receiving government aid is provided as an appendix. A number of these have failed since the original analysis was undertaken and the list compiled.

When appropriately transformed this solvency model allows the simultaneous measurement in five distinct dimensions of a manufacturing company's performance level relative to that of other firms in the same and different industries and also over time and its expression in the form of a readily interpretable numeric index along a linear scale. A factor analysis of the data used in this study also enables the constituent ratio measures of this model to be interpreted as separately representing the underlying dimensions of accounting information expressed in ratio form.

Other areas examined here include an empirical consideration of the company age at failure distribution, a study of the normality of financial ratio data, and an investigation using hierarchical cluster analysis of the degree of similarity of manufacturing industries on the basis of their aggregate financial characteristics.

The operational utility of the concepts of the 'predictive ability' and 'materiality' of accounting data are also critically discussed.

Acknowledgements

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2. [redacted], investment analyst at Laurence, Prust & Co who taught the author about the vagaries of company accounts and abstracted much of the basic data used here.

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CHAPTER I: BUSINESS FAILURES

1. Introduction

On the 4th February 1971 Britain's most famous company declared itself bankrupt. As one shocked City broker said that very afternoon "Life will never be the same again", and with a fine sense of history, "it must be rather like the day Queen Victoria died". "The whole nation", a politician speaking at Derby was quoted as stating, "is shaken to its very foundations". (Quotations from Deeson, 1972:62.) Mr. Corfield, the then Minister for Aviation Supply admitted to the Commons that such a situation had never occured in his wildest dreams and that pillar of the financial establishment, the Financial Times, headed its report on the 5th February without mincing words: "The most prestigious name in private industry in the dust".

However the failure of Rolls Royce should not have been all that unexpected. As we shall see in chapter VI the position indicated by its published accounts for the years ending 31st December 1966 - 31st December 1969 was at no stage healthy. In fact even after the accounts were corrected for capitalisation of the RB211 research and development expenditures, Rolls Royce appeared to be in a worse financial state in 1966 and 1967 than in either of the next two years.

The typical reactions to the bankruptcy of Rolls Royce quoted above are an illustration of how imperfectly understood are the forces that bring a large quoted company to insolvency and it is our aim in this study, amongst other things, to shed a little more light on this under-researched area.

2. Why do Companies Fail?

For over 30 years business failure has been virtually ignored in both this country and the USA as a subject of academic and business interest with the occasional failure of a large company, even a Penn Central or a

Rolls Royce being largely treated as an exceptional event explainable by circumstances peculiar to the individual firm and not of any general significance. This has not always been so, however, in the early 1930s authors gave the subject considerable prominence in their writings due to the prevalence of company bankruptcies. Dewing's classic textbook (Dewing, 1941), for example, devotes approximately one third of its second volume (of over a thousand pages) to corporate bankruptcies and company reorganisation subsequent to failure. Currently, however, the subject is only mentioned in passing in the UK textbooks on finance in the context of company liquidity problems if at all and at the end of the occasional American text where the emphasis is on the different financial rehabilitation procedures open after failure.

The standard textbooks on company law, however, all have long sections dealing with the role of the receiver and the different forms of liquidation (eg: Gower, 1969 chs 19 and 27) and there are a number of more specialised books which refer to the actual conduct of receivership and winding up in detail such as Loose (1972). There is in addition a well developed case law. Nevertheless knowledge of the legal remedies available for the protection of creditors does not help directly in understanding why a company becomes insolvent in the first place.

Very recently, however, more interest has been shown in this question with commentators usually tending to see individual failures as being brought about by what is termed "bad management" within one or more of the different functional areas of the firm and particularly in the area of financial control. For example the report of the inspectors appointed by the Department of Trade and Industry to investigate the crash of Rolls Royce (McCrindle and Godfrey, 1973) blames the two former chief executives, the chairman Sir Dennis Pearson and

the managing director Sir David Huddle for "failing properly to discharge the responsibilities of stewardship which rest upon the directors of a public company". Travers (1972) quotes the official receiver for Handley Page as blaming its failure on "misjudgement by the directors at the material time".

A number of descriptive studies of recent failures have been published by consultants, accountants and journalists[1] although each group has tended to look at the causes of failure from its own particular viewpoint and little common theory has been developed. In fact until possibly Argenti (1976a) nothing of real relevance had been published anywhere in the general management and behavioural literature that sought to develop a consistent theory to explain the managerial processes which bring large companies to insolvency. The only thing every commentator appeared to be unanimous on was the unwarranted optimism that everything would turn out alright as failure approached and the refusal to face realities until it was too late exhibited by most company managements prior to bankruptcy, with the implicit or explicit recognition that if they had acknowledged their problems sufficiently early their firms could have been saved. As Hollier (1975) puts it in the subheading of his article 'Spot the Danger Signals and Avoid Disaster' - "Many companies are going blindly into bankruptcy. They often demonstrate an almost complete inability, even an unwillingness, to spot the danger signs that precede a crash". He quotes Kenneth Cork, the best known accountant working in this area "They seem to feel that the possibility of insolvency reflects on their honour

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[1] For example: Argenti (1976a) - Rolls Royce and Penn Central although he also refers to a number of other studies, Beale (1972) - Vehicle and General, Deeson (1972) - 10 case studies including Penn Central, Rolls Royce, Cyril Lord, Rolls Razor and Fire, Auto and Marine, Holmes (1971) - Pinnock Finance, (1973) - Rentavilla-Villaparties, (1974) - Court Line, (1976) - London and County, Salmon (1975) - British Leyland, Simmonds (1974) - Mitchell Construction and Travers (1972) - Handley Page.

and everything else. They see the warning signs and it gives them a sick feeling in their stomach. And they shut their eyes." Argenti (1976b) reports that until nine days before the receiver was appointed the great majority of Rolls Royce's directors did not know their company had failed and that Court Line's bankers only recognised "a new dimension of risk" 13 days before their receiver was called in.

There has however been some more general work in the area of small company failure (see The Bolton Report, 1971 and Boswell, 1972) and although it does not directly relate to the larger publicly quoted industrial companies with which we will subsequently be concerned, it is worth noting that detailed analysis of the small firm sector seems to indicate it is feasible and more meaningful to analyse small firm behaviour in terms of the economic, social and psychological needs of the owner manager (and a coherent operational theory can be developed) than in terms of conventional economic models. Small firms also appear to be able to exist for long periods of time in a "posture of malaise" and avoid liquidation (or merger) by recourse to a number of well-established "defence mechanisms" not open to larger companies (Boswell, ch9).

In the States failure causes are regularly tabulated and reported in Dun's Review based on the opinions of creditors and information in Dun & Bradstreet's own credit reports and are summarised in their annual 'Failure Record' publication. Table 1.1 reproduces the results for the year ended December 31 1974.

Percentage:	Mfg.	Whol.	Ret.	Const.	Comm Serv.	Total
NEGLECT	2.3	1.2	1.6	2.4	1.7	1.9
FRAUD	0.4	1.8	0.9	0.7	1.0	0.9
INEXPERIENCE, INCOMPETENCE	94.5	93.5	92.7	92.6	91.2	92.7
Inadequate Sales	54.4	54.2	49.4	40.7	50.9	49.2
Heavy Operating expenses	17.8	12.2	13.7	18.7	16.4	15.5
Receivables difficulties	16.2	14.6	3.3	14.0	6.5	8.8
Inventory difficulties	8.7	12.9	12.0	1.7	1.1	8.2
Excessive fixed assets	5.5	1.7	1.9	2.8	4.9	3.0
Poor location	1.2	1.9	6.8	0.6	2.7	3.8
Competitive weakness	18.4	18.2	22.9	29.9	19.7	22.6
Other	3.0	2.9	2.7	2.8	1.8	2.7
DISASTER	1.1	0.8	1.1	0.5	0.6	0.9
REASON UNKNOWN	1.7	2.7	3.7	3.8	5.5	3.6
TOTAL NO. OF FAILURES	1,557	964	4,234	1,840	1,320	9,915

(percentages under the third heading do not add up to 100% as some failures are attributed to a combination of causes.)

TABLE 1.1 : Why Businesses Fail : Year Ended December 31 1974

(Source, Dun & Bradstreet, 1975)

The high scores under the headings of 'Inadequate Sales' and 'Competitive Weakness' seem to indicate marketing problems as a prime cause of failure whereas lack of financial control ('Heavy Operating Expenses' and 'Receivables Difficulties') seems less important. Naturally one would expect managers or owners to give different reasons.

Sadd and Williams (1932:1) reported that the major causes of failure were inefficient management, unwise use and extension of credit, adverse domestic and personal factors

and dishonesty and fraud. In chapter 38, Dewing wrote of four fundamental economic causes of failure (i) competition (ii) unprofitable expansion (iii) cessation of public demand and (iv) excess payment of actual charges.

More recently Hartigan (1973), a professional accountant, has suggested on the basis of his experience that the causes of failure most commonly found in small businesses are (i) lack of capital (ii) undercosting (iii) lack of management control (iv) lack of adequate advice (v) government restrictions (vi) trade fluctuations and (vii) fraud; although he does not rank these in order of importance.

The basic causes of failure attributed by Deeson for the ten firms he studied are detailed in table 1.2 below:

Company (Deeson chapter order)	Life	Reasons for Failure
The Sunday Advertiser	1807-1829	Insufficient circulation to break even financially brought about by editorial weakness and the large number of competitors.
The City of Glasgow Bank	1839-1878	"Reckless mismanagement in the first place and then deliberate fraud, over a period of years on the part of the directors) designed to hide the mismanagement" (p23).
The Pennsylvania Central Railroad	1845-1970	"Bad management and bad supervision of management" (p48).
C & W Earle (Shipbuilders	1845-1932	"Problems of management, finance, labour and location" (p59).
Rolls Royce	1906-1971	"technical problems with the RB211" (p74).

Company (Deeson chapter order)	Life	Reasons for Failure
Lanchester Engine Co. Ltd.	1896-1904	"shortage of working capital and a development programme, instituted by a mechanical genius, which was entirely uncontrolled from the point of view of expense" (pp86/7).
Piggly Wiggly Stores (US Self Service)	1919-1923	A bear raid on Piggly Wiggly stock and subsequent stock exchange activities on the part of the company promoter.
Cyril Lord	1945-1969	Lord failed to appreciate "that by the Spring of 1967 the carpet market was beginning to change (p119)...Errors of judgement, insufficient research (into new products), too much enthusiasm for the grand gesture". (p114).
Rolls Razor	1958-1964	Bloom was a "spectacular promoter but completely untutored as financier". (p150).
Fire, Auto and Marine	1963-1966	Fraud and the lack of powers available to the Board of Trade under the Insurance Companies Act of 1958.

TABLE 1.2 : Causes of Company Failure Attributed by Deeson (1972)

In fact if the technical problems with the RB211 can be considered as a management error, we have 8 cases of mismanagement of different types and 2 of fraud.

J S Mill (Book 5, ch9) sees insolvency being caused by indolence (p273):

> "Many insolvencies are produced by tradesmen's indolence: they keep no books, or at least imperfect ones, which they never balance; they never take stock; they employ servants,

> if their trade be extensive, whom they are too indolent even to supervise, and then become insolvent."

And by misconduct (p272):

> "By far the greater part of all insolvencies arise from notorious misconduct; the proceedings of the Insolvent Debtors Court and of the Bankruptcy Court will prove it. Excessive and unjustifiable overtrading, or most absurd speculation in commodities, merely because the poor speculator 'thought they would get up'; but why he thought so he cannot tell; speculation in hops, in tea, in silk, in corn - things with which he is altogether unacquainted; wild and absurd investments in foreign funds, or in joint stocks; these are among the most innocent causes of bankruptcy."

Husband and Docheray (p664) stress that:

> "failure is dependent primarily, if not almost entirely, upon the degree of competence and experience of management...although concerns may, despite poor leadership, survive for years because of favourable environments or some particular skill."

They then go on to discuss in more detail some of the conditions which contribute to failure under the headings (i) inferior products or service (ii) improper pricing (iii) excessive costs (iv) lack of capital (v) fraudulent management (vi) adverse government action (vii) adverse labour or other group action and (viii) Acts of God.

Brough (1970) in a study of one hundred mainly small private companies wound up compulsarily in 1965 compared the principal causes of failure in the opinion of the official receivers and the directors of the insolvent companies. 'Mismanagement' and 'gross mismanagement' were given as causes of failure for 71 of the companies by the official receivers and in 51 cases 'insufficiency of capital' or of 'working capital' as important contributors to failure. Brough suggests that over half the companies were more or less doomed to fail from the beginning and that trade creditors appeared to be significant risk bearers. In fact 52 of his 100 companies had paid-up share capital of not more than £100,

including one company with an estimated deficit of more than £50,000. Needless to say mismanagement was in no case admitted by the directors although insufficiency of capital or working capital was admitted as a contributory cause of failure by the directors of 51 of the companies, however these were not the same cases as those similarly classified by the official receivers. The comparative results are given in table 1.3 below.

Principal Causes of Failure in the opinion of:	Official Receivers (Percentage of causes cited)	Directors
Mismanagement	42.7	-
Excessive remuneration to, or drawings by, directors	4.5	-
Gross mismanagement	2.5	-
Insufficient working capital	12.7	19.4
Insufficient capital	19.8	16.0
Bad debts	2.5	12.5
Inexperience	3.2	6.9
Poor labour and poor supervision	-	6.9
Keer Competition	-	6.3
Ill-Health	2.5	6.3
Under-estimating	1.9	4.9
Expansion too rapid	-	4.2
Shortage of materials	-	2.8
Bad weather	-	2.8
Pilfering or fraud	2.5	2.8
Inadequate accounting	3.2	2.1
Increasing overheads	1.9	2.1
Customers dissatisfied	-	2.1
Let down by customers	-	2.1
Total causes cited	157	144

TABLE 1.3 : Principal Causes of Failure

(Source, Brough, tables 5 and 6 - adjusted)

Argenti (1976a) in the most detailed study to date presents a synopsis of the views of many writers, some of whom we have met already, and experts in the insolvency field and examines certain case studies to arrive at a concensus view of the causes of company insolvency and suggests the following scenario of causes and symptoms (p122):

> "If the management of a company is poor then two things will be neglected: the system of accountancy information will be deficient and the company will not respond to change. (Some companies, even well-managed ones, may be damaged because powerful

constraints prevent the managers making the responses they wish to make.) Poor managers will also make at least one of three other mistakes: they will overtrade; or they will launch a big project that goes wrong; or they will allow the company's gearing to rise so that even normal business hazards become constant threats. These are the chief causes, neither fraud nor bad luck deserve more than a passing mention. The following symptoms will appear: certain financial ratios will deteriorate but, as soon as they do, the managers will start creative accounting which reduces the predictive value of these ratios and so lends greater importance to non-financial symptoms. Finally the company enters a characteristic period in its last few months."

3. The Contribution of the Economist

The micro-economic theorist is unable to contribute much in explaining the phenomenon, nevertheless certain images drawn from economic theory have affected our attitudes to business if not actually aiding us more in understanding failure. Perhaps the most powerful is derived from Classical Economics where the inefficient firm pulls its socks up, sells out or goes bust in response to market indicators of its inefficiency in the form of low profits or outright losses. Darwinian analogies such as those of Marshall carried over into business life have also had a profound influence on our economic thinking:

"But here we may read a lesson from the young trees of the forest as they struggle upwards through the benumbing shade of their older rivals. Many succumb on the way, and a few only survive; those few become stronger with every year, they get a larger share of light and air with every increase of their height, and at last in their turn they tower above their neighbours, and seem as though they would grow for ever, and for ever become stronger as they grow. But they do not. One tree will last longer in full vigour and attain a greater size than another; but sooner or later age tells on them all. Though the taller ones have better access to light and air than their rivals, they gradually lose vitality; and one after another they give place to others, which, though of less

material strength, have on their side the vigour of youth.

And as with the growth of trees, so it is with the growth of businesses. As each kind of tree has its normal life in which it attains its normal height, so the length of life during which a business of any kind is likely to retain its full vigour is limited by the laws of nature combined with the circumstances of place and time, and the character and stage of development of the particular trade in which it lies."

(Source: Marshall, 5th edition[1])

Failures in fact have always been looked upon ever since Adam Smith as an inevitable and necessary part of a healthy and competitive economy, Schumpeter argues for example that there are both direct and indirect benefits on competition and innovation from their cleansing effect (see Clemence and Doody, 1950:10/11), however, Boswell (ch9) and others have cast doubt on the role of bankruptcy as a significant purgative of long-established declining firms.

The macro-economist likewise has contributed little empirical explanation to the understanding of the underlying failure process, possibly because of the absence of any readily available statistical series either here or in the US and also maybe due to the believed lack of significant importance of business failures in a broader economic context. Nevertheless, general macro-economic forces, inflation and government activity are believed to be at least contributory causes of insolvency by many of the previously quoted commentators. One exception however, as reported by Altman (1971:37/8), is the US National Bureau

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[1] These quotations are taken from Prais (1974:273/4). Marshall in fact changed his views significantly in his 6th edition substituting the following for the second paragraph above: "And as with the growth of trees, so it was with the growth of businesses as a general rule before the recent development of vast joint-stock companies which often stagnate but do not readily die."

of Economic Research which has been analysing a large number of aggregate economic series with respect to its business reference cycle since 1920. Two series of particular interest are business failures and failure liabilities. Until recently it was concluded that the business failure liability series was a fairly consistent and leading business cycle indicator giving earlier warning of recession than of expansion; although the consistency of the indicator has recently been greatly called into question. Total business failures, on the other hand, are found to be a leading indicator only prior to business peaks while displaying roughly coincident patterns at the troughs.

In all cases, however, with the American data the relationship between failures and general business activity tends to be inverse, but because of problems with the British insolvency statistics (see below) it is not possible to determine whether this is so in the UK.

Altman himself (ch2) in attempting to quantify such a relationship developed a regression model relating the dependent variable - number of business failures - to a series of explanatory variables indicating different aspects of macro-economic activity, economic growth series, money market conditions and investor expectations etc and his final model was of the following form with 96 quarters of data from 1947-1970 analysed:

$$FR = 1.83 - \underset{(-2.41)}{.137^{b}}\Delta GNP_{t+1} - \underset{(-1.64)}{.128^{c}}\Delta SP_{t} - \underset{(-2.36)}{.598^{a}}\Delta MS_{t} + e$$

Where ΔFR=Change in the failure rate in quarter t
ΔGNP_{t+1}=Change in GNP in quarter t+1
ΔSP_{t}=Change in the Standard and Poor Index of common stock prices in quarter t
ΔMS_{t}=Change in money supply in quarter t
e=error term

The ratio was 7.97^{a}, DW = 2.24 and the standard error estimate = 2.70

(cont. overleaf)

a denotes significant at .01 level
b denotes significant at .05 level
c denotes significant at .10 level

The results, however, proved disappointing with a maximum r^2 of .19 for the 24 year period and Altman discusses why this should be in some detail. He suggests that the lack of predictive ability is due to problems with the data, particularly that it is not stratified by size and age at failure. However, this first model is an interesting avenue for further research and could be of considerable interest for economic planning purposes. Working with aggregate dollar business liabilities an even less significant result was achieved.

The industrial economist seems to have virtually ignored the area appearing far more interested in such things as mergers, concentration and company growth. The only work of interest to us here appears to be Boswell's study on small firms in which he views failure essentially from a behavioural point of view within the more general framework of company rigidity (lassitude) and decline. (See his chapters 8 and 9). However his conclusions, although interesting, are not directly relevant to the public company sector which we will be studying.

4. UK and US Failure Statistics

From the above discussions we can observe the lack of interest shown by commentators generally in the failure phenomenon and the lack of relevant empirical work aimed at explaining industrial insolvency, yet the level of failure is by no means insubstantial in this country as table 1.4 indicates. However these aggregate statistics, which are the only ones available from the Department of Trade (DOT, 1975:11) do not cover receiverships, do not indicate total liabilities nor are they broken down by size and age of company so detailed analysis is not possible. In any case since we do not know why an average of 16,600 businesses a year are struck off the company registers under section 353 of the 1948 Companies

Act, even if such disaggregated information were available it would not help very much. See also Brooker and Smith (1965).

Liquidations	Compulsory and Voluntary (Creditors)	Voluntary (Members)	Total
1965	2733	4351	7084
1966	3416	8647	12063
1967	3645	5224	8869
1968	3352	6503	9855
1969	3729	5269	8998
1970	3886	4896	8782
1971	3661	4751	8412
1972	3231	4984	8215
1973	2673	4567	7240
1974	3875	4010	7885

Table 1.4 : Liquidations Notified, England, Wales and Scotland, 1965-74

(Source: DOT, 1975:11)

The peak in total liquidations in 1966 was due to the very large number of voluntary liquidations (member) and when these are removed the resulting figures seem relatively insensitive to downturns in the economy (1966) but sensitive to easy money conditions (1973). They appear in addition to be unaffected by the number of new company registrations. As far as we are concerned here the term failure will be reserved for companies being compulsorily wound up, entering into voluntary liquidation (creditors) or into receivership. Members' voluntary liquidation, in that creditors suffer no material loss, is not so considered. Brooker and Smith in their analysis of 340 firms which entered into creditors' voluntary winding up in 1956 and 100 which were wound up by order of the court in the same year found that in 74% and 77% of the cases respectively the company officers themselves expected to be able to pay unsecured creditors less than 50p in the £ and of these 14% and 48% respectively expected to be able to pay less than 5p in the £!

In table 1.5 for comparison purposes the historical failure rate experience of US business is exhibited for the 10 years to 1974 when the total liabilities of failed companies were just over 3 billion dollars. The figures were compiled by Dun and Bradstreet Inc. based on analysis of the population of 2.5m firms listed in their reference book.

	Failure rate per 10,000 listed concerns	Average liability per failure in $'000
1965	53	97.8
1966	52	106.1
1967	49	102.3
1968	39	97.7
1969	37	124.8
1970	44	175.6
1971	42	185.6
1972	38	209.1
1973	36	246.0
1974	38	307.9

(Liabilities refer only to current liabilities)

Table 1.5 : US Failure Patterns 1965-74

(Source: Dun & Bradstreet, 1975:1)

5. The Age Distribution of Failed Firms

Some work has been carried out analysing the age distribution of firms on failure. The Bolton report (§§2.3-2.4) and Boswell (appendix 5 §3) concur that small manfacturing and construction firms are currently being liquidated or ceasing to trade through takeover or other reasons at an annual rate of about 1.5-2%. More importantly the longer established firms dropped from their samples less frequently than the more recently formed companies, although drawbacks in the sampling methodology and other problems do not permit the construction of an exact age distribution of companies on failure from their data. Brough found that in his sample of small companies 79% were less than 10 years old and 62% under five years and Brooker and Smith observed very similar results.

In the US a more detailed statistical breakdown is available (Dun & Bradstreet, p10). In 1974 80.7% of companies were less than 10 years old on failure, 59.9% under 5 years and 29.9% were aged 3 years or less.

Lomax (1954) in an interesting article analysing sets of failure series for different business activities in Poughkeepsie over the years 1844-1926 showed the conditional probability density functions of age of businesses at failure as closely following either the exponential or the hyperbolic distributions as illustrated in fig 1.1 below. However for manufacturing firms this is most certainly not so for the Dun & Bradstreet data in which the conditional probability of failure as demonstrated on the same diagram for manufacturing companies appears lognormal[1]. The data from which fig 1.1 is derived is provided in table 1.6.

Source of data:	Lomax	Dun & Bradstreet
Year (t)	$c_1(t)$	$c_2(t)$
1	.365	.017
2	.198	.112
3	.182	.197
4	.169	.208
5	.148	.164
6	.128	.138
7	.107	.149
8	.093	.094
9	.077	.071
10	.051	.084

Table 1.6: Conditional Probability Distributions of Age at Failure for Manufacturing Firms Given Nonfailure to Date (c(t) denotes the conditional probability of failure in year t)

[1] The distributions are calculated as follows:
If f(t) represents the age distribution of companies on failure and F(t) the cumulative distribution given by $F(t) = \int_0^t f(x)dx$, then the conditional probability density function of failure is given by

$$c(t) = \frac{f(t)}{1-F(t)} .$$

Lomax calculated the instantaneous probability rate whereas here the discrete probabilities given by

$$c(t) = \frac{f(t)}{1-\sum_{s=1}^{t-1} f(s)} \qquad \text{for } t = 1,2\text{----}10$$

were used. Little difference would have resulted if we had adopted Lomax's approach.

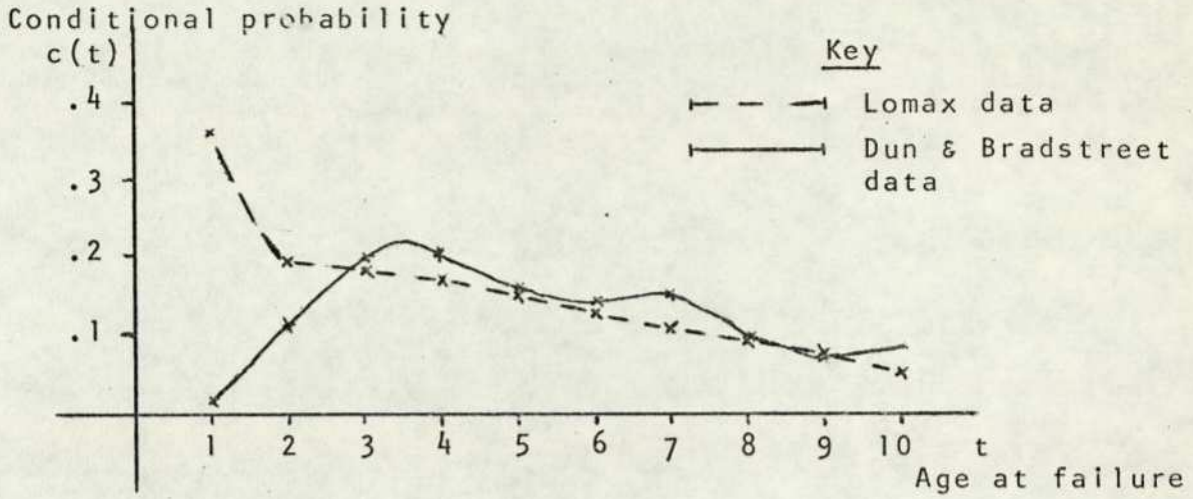


Fig 1.1: Conditional Probability Distributions of Age at Failure for Manufacturing Firms

(Source: table 1.6)

Although not too much should be read into these figures given the very different bases of computation, similar results obtain from analysing Brough and Brooker and Smith in this way. It might very well be that company behaviour in this respect is now very different. This is borne out by examining the age distribution at failure for companies just after the Second World War as given by Dun & Bradstreet (p1) which resembled the Lomax data rather more.

It is argued in the literature that infant mortality is to be expected as older firms should have been able to build up established markets, be larger in size and have considerable reserves upon which to fall back. Nevertheless young firms can often be more dynamic and flexible and their performance is frequently above average in terms of growth, profitability and innovation - See Boswell, chapter 4, 'Strengths and Trials of Young Firms' for an interesting behavioural and managerial analysis of this area.

The reasons for the differences between the recent empirical data and this existing theory, which hypothesises the existence of the type of relationship typified by Lomax, will not be pursued further here.

6. The Focus of This Study

What commentators there have been, as we have seen, seem to perceive company failure primarily at a micro-economic phenomenon and insolvency a state no well-managed company should find itself in irrespective of the general economic climate or particular industrial conditions. In times of a boom, easy money and low interest rates it is generally argued one would expect firms in difficulty to be able to borrow sufficient, at least in the short term, to avoid outright failure whereas in times of slump and tight money the marginal firms, it is believed, will go to the wall.

Examining the reasons for failure suggested by various observers and quoted earlier in the chapter one can note the virtual absence of causes of a macro-economic nature which are outside the direct control of the company. Of course firms in shipbuilding, building construction and steel manufacture etc are more subject to cyclical demand patterns than others but it can be argued that effective management implies that such companies should be able by diversification and other means to continue through troughs in business activity.

Deeson does point out that Penn Central was adversely affected by Nixon's control policies on money and credit (p36) and that the harsh winter of 1969/70 set the company back around 100 million dollars (p46), however, he sees these as only the final straws which toppled the company (p36). In the case of C & W Earle he considers the cyclical nature of the shipbuilding industry to have been important but sees it as essentially contributory and in commenting on the demise of the Lanchester Engine Co. he suggests that "Economic circumstances arising out of the South African war were sufficient to push a tottering company down a financial precipice." (p88). However in none of the other seven business histories does he see broader economic factors at work.

Hartigan warns against believing the excuses of bankrupts that the 'government is to blame'.

> "In times of difficulty it is the marginal firm that goes to the wall, the firm run on slender capital, the firm which has never accurately worked out which of its activities can be discontinued with the least loss." (p386)

He is equally critical of the argument that trade fluctuations and increased competition are a similar deus ex machina "Most businesses of any substance can meet the challenge." (p386)

Husband and Docheray do not consider that trade depressions are a real cause of business failure arguing that

> "the real underlying causes are to be found not in the depressions themselves but rather in the practices of firms which make them unprepared to institute needed adjustments to meet fluctuations in business conditions." (p673)

Argenti (1976a:137) uses a sinking ship analogy for the collapse of a company in discussing the role of normal business hazards in its failure:

> "If a ship is in good condition and the captain is competent it is almost impossible for it to be sunk by a wave or succession of waves. Even if there is a storm, the competent captain will have heard the weather forecast and taken whatever measures are needed...a manager who blames an economic recession for his company's collapse is like a captain who has not heard the weather forecast."

As pointed out in §2 above the only things the different commentators on the causes of company failure appeared to agree upon are the presence of warning signs well in advance and the ignoring of these by company management but that providing action is taken early enough bankruptcy can be avoided. Argenti in fact devotes a chapter of his book to 'Prevention and Cure'. Schendel et al (1976) in an analysis of the actions which turned around 54 companies with consistently declining profits over a four year period found that 39 had made general management changes, 36 had introduced new products, 22 had built new plants,

34 had undertaken product and 33 geographic diversifications and 22 had divested themselves of significant aspects of their activities. However although they compared the companies activities across their downturn and upturn phases with the former characterised by an average of 3.0 strategic activities/firm and the latter by an average of 6.8, they did not compare these firms with firms which subsequently failed or a control group. Nevertheless their conclusions that it is perfectly possible for firms to recover would probably not have been altered.

The one area concerned with company failure in which considerable progress has been made is that of financial analysis and the identification of companies at risk well in advance; although much of the work, which is quite new, has been strictly empirical and pragmatic with very little formal theoretical framework.

If, to continue with Argenti's seafaring metaphor, we have advance warning of the shoals ahead, then corrective action can be taken and those groups, such as employees, creditors and suppliers, banks and financial institutions, debenture holders and shareholders, which bear the losses on company failure can be protected.

In addition if we can measure the degree of insolvency of a company and examine how this changes the nearer the company gets to actual failure then we are in a position to analyse certain aspects of company behaviour eg the raising of new equity and long term debt for working capital purposes from a new vantage point. We might also be able to shed a little more light on certain economic processes such as take-overs which have not been considered to any great extent previously in this connection, and the role of government in the area.

In this study we are interested in developing a model that allows the measurement of the degree of company solvency/insolvency and the identification of firms at

at risk of failure and then employing it as a tool of economic analysis to examine a number of different hypotheses. We will also be using such a model appropriately transformed to provide a measure of company performance new to the literature which would appear, by explicitly measuring a company's level of risk and other financial dimensions simultaneously with its profitability, to overcome very many of the drawbacks associated with the use of return on capital employed and similar single measures.

In the next chapter the issues of the 'predictive ability' and materiality of accounting data are raised and the literature on financial ratio analysis discussed. In chapter III the previous work in the general area to which this study addresses itself will be commented upon and in the following chapter the data used in the empirical analyses will be described. Chapter V discusses the various statistical models built to arrive at an efficient solvency model and in chapter VI various tests of its effectiveness are measured. In chapter VII the model is used as a tool of economic analysis to investigate various current issues of interest and then finally, appropriately modified, its utility as a general performance model is examined in both cross-sectional and inter-temporal industrial analyses in chapter VIII.

CHAPTER II: THE CONCEPTUAL FRAMEWORK

1. Introduction

The basic data used throughout the different parts of this study consist primarily of financial ratios calculated from the annual profit and loss accounts and balance sheets of quoted British industrial companies.

Ratios of this type, which are measuring economic entities endogenous to the company concerned (contrasted with exogenous ratios containing stockmarket information such as price/earnings measures etc) are held by many commentators to be the prime source of information for financial analysis purposes. However no coherent theory has been developed to explain their construction, general utility or informational content nor to explain necessarily which ratios are likely to be relevant for which purposes.

In this chapter we will first examine recent studies relating to the value of the fundamental items of information which are combined conventionally to make up the accounting ratios we use namely those items of data published in the conventional sets of annual company accounts, from the point of their purpose, value and materiality (informational content). Next we will survey the limited amount of theoretical work published on the reasons for the use of financial ratios and discuss their utility in certain situations on a 'face value' basis. Finally the empirical work that has been carried out examining the amenability of financial ratios to statistical analysis will be commented upon and the relevance of this type of data to the particular needs of this study will be discussed.

2. The Rôle of Accounting, The Users of Financial Data and The Predictive - Ability Criterion

The fundamentals of accounting theory and practice have come under considerable scrutiny over the last ten years or so particularly from within the profession itself. Much of the debate has centred around the objectives of

published accounting reports, their content and best methods of preparation and in the UK has resulted in the creation of the Accounting Standards Steering Committee which is charged with recommending standards and has produced a number of controversial recommendations. Their discussion paper "The Corporate Report" (Institute of Chartered Accountants, 1975) will be examined in more detail below and answers certain of the critics of the work and pronouncements of the Committee such as those of Carsberg et al (1974) and Fisher (1974).

In the States more debate has taken place and a number of theoretical papers and empirical studies have been published although no generally applicable principles or conclusions have yet been arrived at.

Some ideas about the nature of accounting and accounting numbers have, however, received general support. Two different approaches can be identified, the axiomatic school - see for example Ijiri (1967), Mattersich (1964) and Moonitz (1963) etc - and what we can term the user-orientated school[1].

The axiomatic school in essence seeks by logic and deduction from the basis of postulates to derive principles and their practical rules and sees accounting to be independent of the users of financial information.

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[1] The author does not intend to consider the application of information theory and the Entropy Law to accounting data which has had some adherents (see for example Lev, 1969, and Theil 1969). As Rashad Abdel-Khalik (1974) has pointed out all that is effectively being discussed is "data decomposition theory" and in any case because of the nature of general purpose financial statements, it is infeasible to calculate any true measure of entropy. He concludes "Given that there is currently no other known decision situation in which the entropy is known to be useful; the benefits that could be obtained by using the entropy measures in accounting aggregation are still unknown" (p282).

> "accounting draws its real strength from its neutrality as among the demands of competing special interest. Its proper functions derive from the measurement of the resources of specific entities and of changes in those resources. Its principles should be aimed at the achievement of those functions." (Sprouse and Moonitz, 1962)

However as both Chambers (1966) and Shmueli (1973) have shown this approach, although of intellectual interest, is totally infeasible as a framework for practical application to the types of problem with which accountants amongst others have to deal. Consequently it will not be pursued further here.

The user-orientated approach examines the role of accounting and seeks to examine different accounting methods from the point of view of the end user of the accounting numbers and the use to which he intends to put the data. It views accounting as the process whereby financial information is provided to assist decision making. Accounting measures are examined using the 'predictive-ability' approach which sees "accounting as the process of identifying, measuring and communicating economic information to permit informed judgement and decisions by users of the information." (American Accounting Association, 1966:1, quoted in Ashton, 1974:719.) With the emphasis placed on future events:

> "[although] financial accounting reports may have an historical perspective, the value of those reports cannot be measured solely by the accuracy with which they reflect the past. It seems safe to say that most users, investors and creditors for example, are not interested at all in the past, per se, but only to the extent that the past can be used to reflect the future. In other words, firms' past records are useful to the extent that they help users to make investment decisions about an uncertain future." (Pankoff and Virgil, 1970a)

The criterion was developed by Beaver et al (1968) to evaluate accounting data and they define it as follows (p675):

> "according to this criterion, alternative accounting measurements are evaluated in terms of their ability to predict events of interest to decision-makers. The measure with the greatest predictive power with respect to a given event is considered to be the 'best' for that particular purpose."

A number of research studies have employed the methodology it implies including some addressing themselves to related questions to those examined here, and these will be discussed in detail in subsequent chapters, and it is consequently worthwhile examining in more detail exactly what the 'predictive ability' criterion means in an operational context.

In fact, even begging the question of what the term "accounting measurement" actually means, all that accounting numbers arrived at by applying different accounting methods per se can measure are the past and present. Only by means of a prediction model either intuitive or explicit, using these as data, can forecasts or predictions be made about the future. Consequently as Greenball (1971) argues:

> "Since an accounting method is expressly designed to measure past and present occurrences, but <u>not</u> to predict the future, it is incorrect to speak of the predictive ability of an accounting method or an accounting number."

In addition since there are any number of different types of end user of general purpose accounting statement numbers each applying different types of decision model for different purposes it is not possible to talk about any single accounting method being better than any other for all statement users. Greenball, p7, clearly points this out:

> "In a predictive-ability study, the results do not reflect on the predictive ability of the accounting methods tested, but only upon the predictive ability of the products of such methods, when used in conjunction with the particular prediction model selected by the investigator."

Consequently we would argue the approach is not soundly based as conventionally stated and that it is wrong to examine the value of accounting items for decision purposes out of context of the decision models employed. Accounting can be better viewed as the measurement-communication function of the decision process:

> "The decision model would specify what properties are to be measured. The accounting function would be to measure those properties that are specified by the decision model." (Committee on Accounting Theory Construction and Verification, 1971:61, quoted in Ashton p720).

Although clearly specification of the decision models for each type of user is beyond our present ability.

These arguments however do not invalidate the basic idea that accounting information should be considered in terms of its utility in a predictive context. If the predictive-ability criterion is restated thus:

> Accounting information can be evaluated in terms of its ability when used as data for (a) particular decision model(s) to provide predictions of relevance to a particular decision-maker (or class of decision-maker) in a particular decision situation at a particular point in time. The accounting number(s) taken in conjunction with their associated decision model(s) which jointly have the greatest predictive ability for the particular purpose under investigation can be considered to be the 'best' for that purpose.

then the problems discussed above are overcome and the concept can be made operational.

In their "Corporate Report" (ICA, 1975) The Accounting Standards Steering Committee express the sufficiently general and therefore unexceptionable view (p28) that

> "The fundamental objective of corporate reports is to communicate economic measurements of and information about the resources and performance of the reporting entity useful to those having reasonable rights to such information."

They consider 7 different classes of user group viz:- equity investors, loan creditors, employees, analyst-advisers, business contacts, the government and the public and in section 2 of the paper examine their respective information needs. In subsequent parts various comments and recommendations are made on such things as the additional statements required to fully meet the needs of these users.

Nevertheless, although the discussion paper with its stress on the provision of user information in a broad sense is a significant step forward on the conventional stewardship role of accounting, it would appear to lack operational utility. And of particular importance to us here, it nowhere recognizes the decision model link between published information and the needs of the different end users, nor how their different and conflicting needs can be reconciled.

Carsberg et al (1974) identify nine sets of potential uses and users of accounting information. The list, together with the associated results of a survey conducted to determine the opinion of a sample of members of British professional accountancy bodies on the relative importance of various objectives for published financial statements of companies with a stock exchange quotation, is given in table 2.1 below.

The respondents (121 usable replies out of the sample of 600) rated each objective from 1 to 7 depending on their valuation of its importance (1 = very important, 7 = negligible importance) and the average scores in table 2.1 consist of computed arithmetic means.

Purposes for the preparation of published accounts	Rated Importance	
	Rank	Average Score (Scale 1-7)*
(1) The provision of information to shareholders (actual and potential) to guide their investment decisions ie decisions on whether to buy, hold or sell securities.	2 (a) 3 (p)	2.4 (a) 3.0 (p)
(2) The provision of information to inform shareholders of the uses to which their funds have been applied and the legality of those uses with a view to enabling the shareholders to exercise any legal remedies available.	1	1.6
(3) The provision of information to guide creditors (long-term and short-term) in decisions on the allowance of future credit and the administration of existing indebtedness.	4=	3.3
(4) The provision of information to employees to guide their decisions on future relationships with the undertaking.	6	3.6
(5) The provision of information to managers to enable them to take efficient decisions in management.	7	4.1
(6) The provision of information to the representatives of society to enable them to judge whether the activities of the undertaking are consistent with national objectives.	9	4.9
(7) The provision of information to guide government officials in the assessment of taxation.	8	4.7
(8) The provision of information to guide government officials in the enforcement of statutory controls.	10	5.2
(9) The provision of information to assist in the negotiation of financial facilities.	4=	3.3

TABLE 2.1: The Objectives of Published Accounts

(Source: Carsberg et al p171)
(a) denotes actual and (p) potential
*For interpretation of scale see the accompanying text.

The practising accountant, at least in the UK, apparently still sees his role primarily in terms of stewardship, possibly as a result of the stress on this function in his professional training reinforced by certain of the pronouncements of the Institute of Chartered Accountants of England and Wales which Carsberg et al quote (p168) such as: "the purpose for which the annual accounts are normally prepared is not to enable individual shareholders to take investment decisions"and"the results shown by accounts prepared on the basis of historical cost are not a measure of increase or decrease in wealth." Also: "A balance sheet is mainly an historical document which does not seek to show the realizable value of assets...and so is not a statement of the net worth of the undertaking."

In fact although the results of the survey must be treated with considerable caution, not only because of the low response rate, it is interesting to note that 74% of respondents rated the stewardship purpose of published accounts with a 1 and a further 12% with a 2. There did not appear to be a great difference between those in professional practice, those in industry, commerce of finance, or those employed in other areas.

3. Materiality in Accounting Data: The Concept and Empirical Evidence

The concept of materiality is one of the most pervasive in accounting, nevertheless an agreement on an unambiguous and operational definition has proved elusive. Bernstein (1967:87) describes it thus:

> "The concept of materiality is part of the wisdom of life. Its basic meaning is that there is no need to be concerned with what is not important or what does not matter. Man's work is burdensome enough without the need to pay attention to trivia."

It is usually argued that the ultimate test of whether the disclosure of an item of financial information in a particular form is material or not depends on whether it is likely to affect the decision of the information user:

> "The materiality of an item entering into financial statements lies in its impact on the user. The question to be answered is: is it likely that an average prudent investor or a reasonable person would be influenced in his investment decisions if the matter at issue were disclosed or if net income or some other significant statement item were increased or decreased by the amount under consideration?" (Hicks, 1964:170)

However as pointed out above there are any number of different classes of financial statement user all with differing informational needs. Consequently, faute de mieux, the debate on what is material or not in a financial statement appears to have been reduced to a discussion about the best way to operate the 'ten percent rule' ie, if an item exceeds 10 per cent of net income, say, before excluding the item, then it is considered 'material'. (See Bernstein and Segal and Lebensbaum, 1975, for examples of the debate.)

In fact materiality per se can never be coherently defined operationally in any true or generally applicable sense because of the different information needs of different users of financial statement data and as with the 'predictive-ability criterion' disclosure or definitional questions cannot be considered without reference to their differing requirements nor to the different decision models employed. To the author's best knowledge this has nowhere to date been explicitly recognised in the literature. Accounting numbers as argued above can in no way be considered in an absolute sense independently of the decision model(s) for which they are the raw data.

Consequently, in the present state of our knowledge it is only meaningful to consider the concept as follows:

> The 'materiality' of (a) particular accounting number(s) can only be examined for a particular purpose and for a particular user on the basis of whether in conjunction with his decision model(s) the quality of his decision is significantly improved or not.

It will be noted that this definition is very similar to that suggested above for the 'predictive-ability criterion'. In fact this author would argue that the two concepts are virtually synonymous and will consider them here subsequently as such.

In this study we are predominantly interested in the materiality of the items of data used to construct the financial ratios employed from the point of view of a particular type of decision maker for a particular purpose and employing a specific multivariate decision model. The accounting numbers used are those published by listed manufacturing companies in the form of closing balance sheets and annual profit and loss accounts in accordance with the 1948 and 1967 Companies Acts.

Using the above criteria, then, it will be seen that in this research the accounting data used taken directly from the published accounts and arranged in a standardized format is relevant for our needs because in conjunction with the model employed it helps us to make better decisions in a particular situation. Hence the data would appear to be material for our purposes irrespective of questions relating to 'creative accounting' generally and such things as different methods of stock valuation, capitalization of leases and asset revaluations etc between companies.

In fact Morris and Breakwell (1975), in an empirical examination of manipulation of earnings figures in the UK concluded that (p183)"there is no evidence at all of widespread doctoring of earnings figures". Holdren (1964) in an examination of the effects of different inventory valuation procedures (LIFO v FIFO) on a number of important financial ratios taken separately showed that only in the case of stockturn (turnover/closing inventory) were there significant differences and Derstine and Huefner (1974) found similarly that (p225) "the LIFO - FIFO choice makes

no significant difference in the use of certain risk-orientated accounting ratios for making intercompany comparisons." These empirical results run contrary to popular belief. In addition a recent article by Elam (1975) on the effect of capitalising leases on the 'predictive-ability' of accounting data in an insolvency situation seems to indicate that worries by accountants on the treatment of leases are probably unfounded at least in the type of decision situation considered by him.

This author has been led to believe from his own work, and the results of these and other studies that other research on similar problems of accounting item definition etc would also show different approaches to be non-material at least in this class of decision situation despite a priori or theoretical arguments to the contrary. Reasons for this will be suggested in chapter VI.

Considerable other evidence can also be adduced to the utility of this kind of data for various purposes. Every successful study using published financial data (successful in that it meets the needs of the particular decision maker in question) effectively shows the underlying data used to be material in our sense (ie as valid input to the decision model employed).

A number of empirical studies into the materiality of the accounting data provided in the conventional sets of published accounts have been conducted both from the point of view of the preparer of financial statements or auditor and from the point of view of the user. This latter standpoint is more relevant to us here, nevertheless an interesting 'preparer-orientated' paper by Frishkoff (1970) is worth briefly mentioning.

Frishkoff examined the accounts of companies which had changed accounting practices from one year to the next and divided them into two groups on the basis of whether

the latter accounts had been qualified by the auditors (60) or not (130). All told about 10% of his sample of 2218 (217) companies had changed practices. (The other 27 companies were removed from his sample for various reasons.)

He then attempted to develop a decision model, using a multiple discriminant analysis approach and a classification of the companies in each group on the basis of 17 criteria, for the prediction of the qualification of a set of accounts by an auditor on the grounds of consistency ie to determine whether changes in accounting procedures from one period to the next are material or not. The conclusions appeared to be as expected in that there appeared to be little uniformity of approach in practise and that the materiality threshold tied in at about 25% of net income. The only really significant variable seemed to be the size of company ie the larger the company (and consequently audit fee) the smaller the likelihood of qualification! (The contributions of the discussants of this paper, Bernstein, 1970 and Stringer, 1970 are also of interest. A study with similar objectives is that of Boatsman and Robertson, 1974.)

Empirical studies in the States have predominantly focused upon the investor as the prime user group, nevertheless a number of studies have been published with the specific objectives of testing the value of conventionally published accounting data in other types of decision situation such as bond rating and prediction of failure and these will be discussed in more detail in Chapter III.

O'Connor and Collins (1974) provide a first class survey of the literature to date in the area of the relevance of accounting data to the investor from the point of view of materiality and it is only necessary for our purposes to examine separately one or two of the more relevant studies not discussed in detail by them. Buzby (1974) developed

a list of 38 items or types of financial or non-financial information which might appear in an annual report and using a survey questionnaire approach determined the relative importance of each of the items to a sample of 132 financial analyst respondents (proxies for the prime user group-investors) from the point of view of investment in equities. He then applied the results in the form of weights to the accounts of 88 small and medium size companies for a particular year and concluded (p433):

> "The results indicated that many of the items were inadequately disclosed in the sample and the correlation between the relative importance of the items and the extent of their disclosure was small. On the basis of these results, the writer has concluded that an opportunity exists for an expansion of the extent of disclosure in the annual reports of small and medium size companies."

And in an attempt to determine directly the materiality of financial accounting information to security analysts, Pankoff and Virgil (1970b) developed a laboratory stock-market in which participants were required to predict stock price movements on a period to period basis and were able to notionally purchase additional information relating to the general economy, industry or the particular companies under investigation.

By examining the patterns of the items of information 'purchase' by the 32 security analysts in the experiment the authors attempted to identify the most relevant data items however, although certain of their conclusions were interesting, they were forced to concede (p23):

> "Finally, we have not found much empirical support for the belief that accounting information is generally and highly useful for decision-making. So far, we have found fairly consistent evidence for usefulness only in the input demand sense; analysts want some kinds of accounting information badly enough to pay for them."

Other studies in general have been far less direct in their research methodology and despite affirmations of the value of conventional annual accounting information to investors by O'Connor and Collins and other commentators, the empirical results in general are not conclusive.

A study by O'Connor (1973) is a case in point. He regressed a measure of average rate of return to an investor from holding a common stock for different time periods, both unajusted and adjusted for market effects, on the average values of a number of commonly discussed financial ratios calculated over previous time periods of the same duration, both singly and in combination, in an attempt to investigate the utility of financial ratios for predicting future stock returns. He concluded (p351):

> "The evidence provided by the analyses of the predictive abilities of the various ratio-rate of return models casts strong doubts upon the usefulness of financial ratios, alone, to investors in common stock who are interested in forming expectations about future rate of return rankings."

This general lack of significant relationship is what possibly is to be expected from application of the efficient capital market hypothesis viz that security prices "fully reflect" all available information and react instantaneously to the flow. (See for example Fama, 1970, for a review of the theory and empirical research findings.)

So in the general case it would be expected that either investors anticipate the annual accounts (or at least the income figure) using quarterly income information and other data and continuously adjust their expectations in which case they could be viewed as finding the published accounting information material or they in fact find the annual information of little use and use other more immediate information from other sources.

In an attempt to overcome some of the methodological problems of previous studies Ball and Brown (1968) tried to measure the effect of the annual earnings figure on security price movements using a research design which, recognising that investors are likely to anticipate the annual earnings figure, measured cumulative price changes over the 12 months prior to an earnings announcement to represent investor reaction. Their conclusions indicate

that (p176):

> "Of all the information about an individual firm which becomes available during a year, one-half or more is captured in that year's income number. However the annual income report does not rate highly as a timely medium since most of its content (about 85-90%) is captured by more prompt media which perhaps include interim reports."

They effectively perceived the annual income figure as only providing new information if it were significantly different to expectations (better or worse) when the stock price would consequently move in the same direction.

In terms, then, of the materiality of much of the published annual accounting data, the case of its relevance for the decision models employed by the investor, who at least in the US is conventionally considered the most important user of financial information, is at best not proven.

However, as we shall see this is not necessarily true for other classes of user especially when more sophisticated multivariate statistical models are employed.

In fact it would appear that even for the investor in certain situations such as company bankruptcy, accounting number-based models are far superior to stockmarket price movement models. For example Blum (1974:11/12) pointed to "the stockmarket's inability to anticipate the timing of failure" and Gooi (1974) showed that UK stockmarket price movements were far inferior to the accounting number-based model developed in this study for the 'prediction' of company failure. His findings will be discussed in more detail in chapter VI.

4. Financial Ratio Analysis

The evolution of financial ratio analysis can be dated back to around 300 BC with Euclid's rigorous study of the properties of ratios in Book V of his 'Elements'[1]. It

[1] A first class history of the development of financial ratio analysis is provided by Horrigan (1968) from which this piece of wisdom is taken.

was originally developed for a single purpose, the evaluation of credit-worthiness and made use of a single ratio, the current ratio (current assets/current liabilities) which was first mentioned in the literature by Rosendale (1908). (Quoted in Beaver, 1966:71). However by the end of the 1920's a large variety of financial ratios had been suggested and were being used in a number of different areas.

Nevertheless until about ten years ago, although acknowledged as a basic tool in most accounting and finance texts, little coherent body of empirical knowledge about financial ratios had been assembled in any one place, nor probably more importantly, had a general theory of ratio analysis been developed.

Recently, however, there has been a renewal of interest in the intrinsic value and utility of ratios as financial (and more general micro-economic) measures of different aspects of a company and a number of attempts have been made to put the approach on a sounder empirical basis; these will be discussed below. Nevertheless although theoretical justifications for the use of new ratios have been published in the literature[1], a general operational conceptual framework, probably not surprisingly, has proved elusive and has not yet been provided[2].

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[1] For example Bierman (1960) suggests measures incorporating funds generated (or lost) by operations to measure financial liquidity. Lemke (1970), after an excellent critique of the value of the current ratio for the evaluation of liquidity, proposes a number of "liquidity flow indices" to meet the problems raised in the use of the current ratio (although none of them can actually be computed by the external analyst on the basis of published accounting data), and Sorter and Benston (1960) propose an "interval measure" as an alternative to the current ratio for measuring a firm's short run ability to pay its debts. A comparison of the two measures in practice is given in Davidson et al (1964).

[2] A few not totally successful attempts have been made however to provide a justification on theoretical grounds for the use of certain ratios such as the one by Staubus (1966) who working with an asset flow model of the firm uses it to explain the relevance of a number of different types of profitability and cash flow ratios, and Beaver (1966) and Blum (1974) who have both adapted the "liquid asset" view of the firm of Walter (1957), in which it is perceived for certain purposes as a resevoir of liquid assets supplied by inflows and drained by outflows of cash, to explain choices of financial ratios in their studies. Wilcox in two virtually identical articles (1971a and 1971b) by working with a Markov probability model of the risk of company insolvency also seeks a theoretical explanation of why certain ratios might be good predictors for this purpose and why others might not.

At first sight it may appear unnecessary to justify our use of financial ratios as the prime data source in this research. A brief look at the extent of publication and general widespread use of data in this form should confirm its potential relevance on a "face-value" basis.

In the UK, for example, trade associations and industry National Economic Devlopment committees regularly publish financial information about their members in ratio form (eg NEDO, 1971) and the Department of Industry Business Statistics Office publish detailed ratio statistics for different industrial sectors based on their analysis of company accounts in their Business Monitor Series (DOI, 1975). NEDO have also recently published inflation adjusted ratio data for the same industries (NEDO, 1975).

Extel Statistical Services Ltd. publish ratio information in certain of their company information services supplied to subscribers in card form and summary ratio information on company performance is published in the Times 1000 (1975), Management Today (1975) and the Financial Times etc. Commentators external to the firm such as financial journalists and stockbrokers analyse and report on companies and aggregate industrial trends in terms of the relevant financial ratio measures and most issues of the British journals for practising accountants (eg Buckley, 1972 and Kirkman, 1973) contain some reference to accounting data expressed in ratio form or provide guidance of a "how to" nature. Ratio analysis appears likewise in the syllabuses of the professional examinations for membership of all the UK accounting bodies.

The Centre for interfirm Comparison Ltd, which is regarded both nationally and internationally as a leading organisation in the field, has now prepared interfirm comparisons for its members based on management ratios in over seventy industries and trades and is increasingly carrying out work enabling subscribing companies to compare their

performance with that of firms in other countries (Centre for Interfirm Comparison, 1974). Likewise Inter-Company Comparisons[1] and Jordan Dataquest[2] both publish widely read ratio surveys of the major companies in a large number of different industrial sectors with ratios computed from published accounting data.

A number of books have been published specifically aimed at helping the manager to use ratio analysis such as Miller (1966) which although published in the USA has had a wide readership on this side of the Atlantic, Westwick (1973), Blyth and Smith (1966) and British Institute of Management (1968).

The academic UK literature in general management, finance and economics is likewise full of studies advocating the use of ratio analysis or using micro-economic published accounting information in ratio form as a data source in empirical research studies in such areas as company growth and profitability (eg Singh and Whittington, 1968 and Whittington, 1971) and take-overs (eg Tzoannos and Samuels, 1972 and Singh, 1971 and 1975). A journal 'Business Ratios' was actually specifically published from 1966-1971 by Dun & Bradstreet Ltd to provide industrial ratio summaries and articles on associated topics and most of the management accounting and finance texts contain significant sections on ratio analysis (eg Samuels and Wilkes, 1971). In the States, of course, ratio analysis is even more widely used both by the academic and the practitioner with commentators viewing it as one of the most important tools of financial analysis and Vice (1968) in describing Weinstock's approach to financial control at GEC seems to imply that his success was very largely due to his use of seven financial ratios - profits on capital employed, profits on sales, sales as a multiple of capital employed, sales as a multiple of fixed assets, sales as

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[1] Inter-Company Comparisons Ltd. 81 City Road, London EC1Y 1BD

[2] Jordan Dataquest, Jordan House, 47 Brunswick Place, London N1 6EE

a multiple of stocks, sales per employee and profits per employee.

The widespread acceptance of the technique however, as we have seen, has been predominantly pragmatic and the ratios used for particular purposes appear to have been selected very much on a rule of thumb basis. The mathematical simplicity of their computation is no doubt quite seductive.

It is probably helpful, at this stage, to distinguish between two classes of user of business ratio data, the 'outsider looking in' such as government agencies, trade creditors, financial analysts, investors etc and the 'insider looking out', the financial executive or manager wishing to measure and compare the results of his company relative to similar firms or over time (financial control is synonymous with this).

For the purpose of this study our use of ratio data is that of the 'outsider', nevertheless both types of user employ similar approaches in the selection of measures and are concerned predominantly so we are told (Barron 1968:16) with the 'profitability identity' (return on capital employed) together with a supporting pyramid of ratios to explain this measure. In fact this pyramid idea appears to be a central one in the literature on ratio analysis (see for example Taylor and Harrington, 1956), however some important recent empirical American work on the hierarchical classification of financial ratios by Pinches et al (1973a, 1973b and 1974) together with the results of our related work using British data to be discussed in chapter VI, indicate that at least as regards the 'external' user working with conventional published financial data, the pyramid concept, because of the high multi-collinearity between the ratios, is an ineffective

method of conveying information[1].

What essentially then are these ratios we are discussing and what are their advantages and disadvantages as a data source for different purposes over and above the underlying data items from which they are constructed.

"A 'financial ratio' is a quotient of two numbers, where both numbers consist of financial statement items" (Beaver 1966:71-2) and can be considered as a transformation of accounting statement data. This it is generally maintained in the literature (see for example Van Horne, 1968:508 and Jackson 1973, but contra, Amey, 1969:37-39) is made to aid different types of comparison by the decision-maker namely

(i) that of the present ratios with comparable historic and budgeted ratios for the same company, in which case trends over time can be examined, and

(ii) that of the ratios of one company with that for similar firms or industry averages at the same point in time when its comparative financial condition and performance can be examined.

Effectively ratios relate one item of financial data to another and only in this way it is argued can this data be interpreted meaningfully. A net profit figure before tax for example is effectively meaningless unless it is related to another measurement within the company such as that of its size in terms of for example net assets or turnover in which case the earning power of the company can be measured and compared 'internally' or 'externally'.

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[1] For example many 'pyramids' start off with the identity $\frac{\text{Profit}}{\text{Assets}} = \frac{\text{Profit}}{\text{Sales}} \times \frac{\text{Sales}}{\text{Assets}}$ (eg Barron 1968) but in terms of informational content because of the common numerators and denominators on a priori grounds at least the first and second and the first and third ratios could be expected to be highly correlated. This expectation is borne out in the empirical works mentioned, which consist of factor analysis studies, in which the relevant ratios appear to have high loadings on the same factors.

Another reason for use of data in ratio form, which has not apparently been mentioned in the literature to date is that just as the 'size' element is taken out of data by use of the appropriate denominator so are some of the effects of inflation, since both ratio numerators and denominators, if drawn from the balance sheet, are affected as a first approximation in a similar way. Given the present levels of inflation this is potentially very useful.

However the value of a ratio for whatever purpose it is used, ie its materiality, self-evidently depends on whether it consists of items which are logically related in some way together with the worth of the underlying data from which it is computed. The criticisms that have been levelled against ratio analysis, apart from those concerning its lack of a theoretical framework, have mainly related to just this latter point and most of the empirical studies using ratios as the prime data source ignore the problem entirely.

Singh and Whittington (1968:218-221) however discuss in some detail the defects of the accounting data in standardized format they usedin their study, in particular those problems related to the valuation of assets in the balance sheet. As far as current assets are concerned problems arise in the compatibility of treatment between companies in netting off 'cash' against 'bank overdraft and loans', the valuation of marketable securities (ie other liquid assets in the nomenclature of this study) and in particular the valuation of stock and work in progress. These they suggest are frequently likely to give rise to serious problems for the user of the data.

As regards fixed assets, the valuation of trade investments is subject to similar problems as that of the valuation of marketable securities, and intangible assets are also

likely to give rise to serious valuation problems[1] in that they do not necessarily relate to any true economic measure and are treated differently by different companies. The actual valuations of such items as land, plant, machinery and so on again give cause for concern to the user of the published balance sheet data. Problems associated with the revaluation of assets, the different methods of depreciation employed for different types of asset and the issues raised by the current cash equivalent (CCE) valuation argument immediately spring to the mind of the experienced financial analyst or investor. He is, in fact, frequently exhorted to go beyond the reported figures and examine critically certain of the published data and admonished that even with standardized figures considerable caution in interpreting any comparison results must be taken (eg Van Horne 1968:509).

As far as the profit and loss account is concerned problems arise with the measurement of turnover data (Westwick 1968:14), many of the depreciation measures employed can again be quite arbitrary, some capital profits are not shown at all whereas others due to stock appreciation which can be quite considerable in times of inflation (see NEDO, 1975 for an illustration), are not separated out and so on. (See also Bates, 1969 and Amey, 1969:chapter 6 from the point of view of performance measurement.)

Forrester (1973) in an interesting article attempted to actually measure the difference between the balance sheet valuation of assets by companies before liquidation and what the assets realised subsequently. Although his sample was of only twenty predominantly small companies drawn from very different industries, in fact none of them

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[1] They point out (p219) that generally two classes of 'goodwill' can be separated out, "expenditure of a capital nature designed to produce a permanent trading advantage to the company [and] the amount paid for a subsidiary company in excess of the book value of its shares". Bates (1969) makes some similar points to the above. See also Amey (1969:chapter 6) for an extended review of similar issues from the point of view of performance measurement.

had total assets valued in their balance sheets at more than £1m, and consequently its results cannot be generalised, he did find that the average ratio of total b/s asset valuation to money actually received was 1.95 and the average ratio of total asset as given in the statement of affairs to money actually received was 1.25 with standard deviations of .84 and .21 respectively[1]. The ratio results for the different assets classes were also computed and his weighted means[2] are reproduced in table 2.2 below:

Asset Class	No. of companies	Weighted mean of: Balance sheet valuation / Money actually received	Weighted mean of: Statement of affairs valuation / Money actually received
land	2	.99	1.11
land and buildings	15	1.10	1.07
plant and machinery	16	2.8	1.3
furniture and fittings	16	3.0	1.2
motor vehicles	18	1.8	1.2
stocks			
raw materials	7	1.6	1.1
work in progress	9	1.9	1.5
finished goods	7	2.6	1.4
consumables	3	5.4	2.7
debtors	17	1.5	1.2

TABLE 2.2: Ratios of Valuations to Realised Values for Asset Classes

(Source: Forrester, 1973:38, table 3)

[1] ie if V_{1i} is the balance sheet asset valuation of firm i, V_{2i} is the equivalent figure given in the statement of affairs and V_{3i} the money actually received, then we are saying

$$\frac{1}{20} \times \sum_{i=1}^{20} \frac{V_{1i}}{V_{3i}} = 1.95 \text{ and } \frac{1}{20} \times \sum_{i=1}^{20} \frac{V_{2i}}{V_{3i}} = 1.25$$

[2] The reason for selecting a weighted mean here is that the individual ratio figures differed considerably between the very small and larger firms "indicating that either the book-keeping and valuations for small companies are less prudent than for larger firms, or - more probably - that the markets wither in price and predictability for small firms and lots" (p37). Consequently weighting the data effectively by firm size would tend to give results more relevant to the firms considered in this study.

Although these results should be treated very cautiously, and Forrester does discuss fully the problems associated with a study of this nature, it does appear to reinforce the theoretical arguments against a literal interpretation of balance sheet data.

Westwick (1968) in fact goes so far as to argue that data drawn from the accounts of companies published in accordance with the requirements of the 1967 Companies Act is next to worthless for inter-firm comparison and only with a properly administered interfirm comparison scheme (such as the one run by the Centre for Interfirm Comparison, for whom he was working when the article was written) can effective analysis be carried out.

Holmes (1974:93) in an article on the Court Line débâcle is also sceptical: "Accountants in general do not concern themselves overmuch with net book value per ordinary share, arguing that the balance sheet is not a valuation statement and that the figure gives little idea of break up values".

This particular article is also of interest in that it demonstrates how confusing and misleading a set of accounts can be and how difficult their interpretation may be even, say, for the sophisticated investment analyst.

The only answers that the user of ratio transforms of such data can give in the light of the above are that

(i) Ex cathedra "It is inconceivable that accounting data can be analysed without transforming it into ratios, in one way or another". (Horrigan 1965:568)

(ii) Published financial statement data is the only readily available source for the 'external' user and consequently he is faced by a Hobson's choice.

(iii) Many of the theoretical problems associated with accounting data items may be overstressed in the literature and in practice only in the case of 'rogue' companies might misleading conclusions be drawn (see the discussion in §3 p31-32 above).

(iv) Whatever the theoretical arguments empirical studies using ratio data show that this data is nevertheless

highly material on a face-value basis for certain purposes and that probably the best way to evaluate it is by application of the 'amended predictive-ability' criterion in §2 p26 above[1].

(v) It is possible by an appropriate selection of ratios either by statistical or a priori means to avoid using those measures which are potentially more likely to give problems[2], and

(vi) The application of multivariate statistical techniques, by considering a number of different measures simultaneously, would appear to offer a significant advance (as has been found in this study) in that in many situations the net effect of different accounting procedures or conventions etc might not appear as significant, as in the univariate case, because of counterbalancing effects on the constituent ratios.

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[1] This study is a case in point. Using conventionally published accounting data it does seem possible to identify companies with high risk of insolvency very successfully in spite of apparent problems with the underlying data. The case of Court Line illustrates this well since as will be seen in chapter VI §7.1 despite serious problems with its accounts the model derived here indicated it resembled firms which had previously become insolvent for 3 out of the 5 financial years prior to its actual failure including the last one.

[2] Staubus (1966) for example shows how it is possible by substituting the net change in working capital (working flow) for the earnings figure to avoid problems associated with depreciation and provisions for deferred liabilities etc, by substituting the net change in quick assets (quick flow) - cash + marketable securities + debtors - for the working flow to eliminate inventory valuation and prepayment problems etc, and finally by substituting net change in cash (literal cash flow) for the 'quick flow' it is possible to avoid the problems of appraising the level of bad debts etc. Naturally enough there are losses as well as gains in this process.

5. The Amenability of Financial Ratios to Statistical Analysis

Finally, in this chapter, we examine some of the recent empirical studies into the statistical nature of the financial ratio data we will be employing here with a view to investigating the apparent amenability of this data to the type of multivariate statistical analyses undertaken. In Chapter III the results of previous research in areas related to the one under investigation here will be discussed to determine whether there are reasonable grounds on a "face-value" basis to expect successful results in our own work.

In 1965 Horrigan published a short but seminal study which sought to provide a "tentative synthesis of the empirical bases of financial ratio analysis" (p558). He examined the amenability of these ratios to statistical analysis and then discussed the evidence bearing on their utility for the prediction of financial difficulties.

He formulated a concensus list of 17 ratios for consideration "compiled [from] a large number of sources dealing with financial statement analysis in various contexts" (p559) and described the results of analyses of these ratios for 24 petroleum companies and 32 steel companies for the years 1948-1957 (the two industries chosen being very dissimilar).

Firstly he found that his individual ratio distributions resembled those of previous studies in that they were approximately normal but positively skewed (which is to be expected given that most of the ratios effectively had a lower but no upper limit) and consequently "that financial ratios can be subjected to the usual parametric statistical techniques" (p562) although logarithmic transforms may sometimes be necessary.

He then went on to illustrate the very high collinearity of many of his ratios with each other (as would have been

expected from a priori reasoning because of the common components of several of the ratios and the tendency of many accounting items to move together in similar proportions) and suggested that consequently only a small number of carefully chosen ratios are necessary to capture most of the information this type of measure can provide.

Horrigan argued that his seventeen ratios could be approximately classified into the following five fairly homogeneous groups

(i) short-term liquidity ratios
(ii) long-term solvency ratios
(iii) capital turnover ratios
(iv) profit margin ratios
and (v) return on investment ratios

and consequently that it should only be necessary, if the groupings are reasonably homogeneous, to work with a single ratio drawn from each heading.

A third aspect of his data was its high autocorrelation, although it was more pronounced with some ratios than others and tended to diminish as the time interval lengthened; thus he hypothesised that "firms within an industry tend to maintain stable relative financial ratio positions over very long periods of time, although the patterns vary between types of ratios and industries" (p563).

Finally Horrigan considered the interfirm dispersion present in ratio distributions. Previous discussions in the literature had suggested that this dispersion was likely to be high, consequently average ratio figures would not be too meaningful and it would be difficult to effectively discriminate between firms on the basis of their ratios, thus obviating their utility. Three main factors were adduced for this, the industry differences, the effects of the size of firms on their ratios and cyclical patterns in the economy.

Horrigan found fairly wide dispersions within his two samples for certain of the ratios, nevertheless, many of them differed significantly between the two industries. On the basis of this he made a case for the stratification of ratios by industry, although suggesting it might not be necessary within the manufacturing sectors[1].

As regards the effects of firm size, there was no evidence of significant relationships between size of firm and the various financial ratios in the study. Horrigan points out that as one of the basic functions of financial ratios is to deflate accounting data by size of firm, it is not to be expected that much size effect will be present. The previous evidence in the literature was summarised but appeared to conflict with his results, which it was suggested was because most of the previous studies employed aggregate not intra-industry data.

Lastly with respect to the question of economic cycles Horrigan found evidence that the effects of these were not surprisingly reflected in his data although they did not affect the dispersion of the ratios in a particular industry at any one point in time. Clearly, he concluded, it is unwise to pool financial ratios calculated for different time periods but if a cross-sectional analysis within a particular industry is being carried out, cyclical effects should not prove a problem.

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[1] If many industries are not homogeneous then this of course has a serious impact on the conclusions of those industrial concentration studies in which concentration is measured in terms of the percentage of an industry's output accounted for by the largest three or five firms etc. See Ornstein (1972) for a survey of empirical work in the area of industrial concentration and its effect on profitability.

On the basis of Horrigan's study, then, it would appear that financial ratios are amenable to statistical analysis for certain purposes particularly if they are stratified by industry, are used for cross-sectional studies and caution in their use is exercised.

Subsequent empirical work to be discussed briefly below has reinforced Horrigan's conclusions to a large extent and we ourselves will be commenting on different aspects of the issues raised in subsequent chapters.

As regards Horrigan's findings on the approximate normality of ratio distributions, this was not observed by Beaver (1966:94/5) for the six ratios he investigated, and logarithmic and square root transformations did not improve matters significantly. Pinches et al (1973b:390 and 1974:6) however applied a common logarithmic transformation to all of their ratios and this resulted in improved normality and homoscedasticity of the distributions and a reduction in the number of outliers. Their resulting distributions were in fact approximately normal (1974, footnote 6).

The recent study by Deakin (1976) examined this issue in detail from the point of view of the extent to which parametric statistical tests could be meaningfully applied to distributions of financial ratio data. He considered 11 ratios arbitrarily classified into four groups - asset turnover, liquid asset, profitability and debt/equity for populations of firms both unstratified and stratified by industry, separately for each of the 19 financial years to 1973.

For the unstratified data, using chi-squared tests, Deakin was unable to reject the null hypothesis of distribution normality consistently for only one of his ratios (total debt/total assets) and found that many of his ratios tended either to exhibit relatively flat histograms with

many outliers or be highly skewed. Application of square root and lognormal transforms to five of the measures only appeared to significantly reduce the non-normality of the net income/total asset ratios (square root transform) and current ratios (lognormal transform). Normality assumptions for the first differences in these ratios were even less supportable.

Nevertheless when all the 11 ratios were stratified into 6 industries for 1973 it was not possible to reject the null hypothesis in nearly 60% (38/66) of the cases quoted. It should be noted that 2 of the 6 industries chosen were retail and a third, metals-miscellaneous, was probably highly heterogeneous. The ratios with sales as denominators appeared to perform consistently badly. Deakin, though, does point out that it is not possible to determine whether these results are due to the smaller number of observations in each industry or to actual normality of the financial accounting ratios within industry groups. He concludes (p96) in a sentiment with which we here can fully concur:

> "that while probability statements from models based on financial accounting ratios may be subject to question because of the distribution of the data themselves, a user could be better off with a ball-park estimate than with no estimate at all. Thus, the ultimate test of the value of such a model lies not in its adherence to certain data assumptions, but, rather, in its adherence to its usefulness in decision making."

Most of the empirical studies we are interested in, in fact, have ignored this problem entirely although the multivariate techniques used in many of them require the data distributions to be multinormal[1].

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[1] Although individual ratios may be normally distributed this does not necessarily mean that when considered together the resulting distribution is multivariate normal. This question is considered in more detail here in Chapter V.

Because of the collinearity of financial ratios, in most of the empirical work using these as data the usual practice has been to classify potential measures into a number of a priori comparatively homogeneous and uncorrelated groups from which the individual ratios to be finally employed in the research are separately selected (see for example Beaver, 1966 , Horrigan, 1966 and Altman, 1968 etc). This is normally carried out on a fairly ad hoc basis and the classification systems used tend to identify four to seven groups similar to those of Horrigan quoted earlier and do not differ very significantly in terms of which ratios are assigned to which group.

In a set of first class studies Pinches et al (1973a, 1973b and 1974) examine the dimensionality of financial ratio data. We report on our findings with UK data in Chapter VI. In their latter paper they report on the application of oblique factor analysis to 48 commonly employed ratio measures calculated from the published accounts of 221 industrial companies for 1969. The resulting empirical classification identified 7 distinct factors accounting for 92% of the common variation among the ratios. These were labelled as:

(i) return on investment
(ii) capital turnover
(iii) inventory turnover
(iv) financial leverage
(v) receivable turnover
(vi) short term liquidity
and (vii) cash position

(The factor loadings matrix is given as appendix 6.3.) They point out (p6) that: "Although many of the groupings were anticipated on the basis of previous research and a priori treatments in the literature, some of the empirical results were not expected." A second-order factor analysis was also performed on the correlation matrix of the seven first order classifications and three final groupings resulted:

(i) return on invested capital (first order groups i and iv)

(ii) overall liquidity (first order groups ii, vi and vii)

and (iii) short-term capital turnover (first order groups iii and v)

Horrigan's findings on the autocorrelation of his ratios were confirmed in empirical studies by amongst others Pinches et al and Murphy and Nelson (1975).

Pinches et al (1973b) compared the factor patterns arrived at by oblique factor analysis of their 48 x 221 data set separately for four years 1951, 1957, 1963 and 1969 and classified their ratios to 7 groups containing ratios similar to the groupings discussed above. Then taking each of the groupings separately they calculated the correlation coeffecients between the loadings of the constituent ratios over four different time intervals and additionally carried out a differential R-factor analysis for the years 1951 and 1969 to analyse "the degree of involvement across industrial firms in the stability/change financial ratio factor patterns" (p390).

Detailed analysis of their results indicated, amongst other findings, that the same seven factor patterns (ie group classifications of ratios) occurred in each of the four years examined even though they spanned a 19 year period and consequently the composition of these groups appeared to be stable over time as Horrigan suggested they would be.

The differential-R analysis, however, made explicit the different trends across companies in the values of the constituent ratios of the seven different financial ratio patterns over the time period 1951-1969 and showed that certain of these were of considerable magnitude. These results coincide with those of Horrigan working with his restricted sample and add weight to his comments about the effect of wider economic trends on company ratios and the precautions which must be taken against pooling ratios

from different time periods.

A footnote in Pinches et al (1974 footnote 9) mentions the very high correlations between the factor patterns for sequential years between 1966-1969 (the lowest being .986) and this appears to indicate the very high stability in the groupings from one year to the next which as expected is far higher than over the 6 year time spans of their 1973 study.

Murphy and Nelson in a study that can be strongly criticised from a methodological point of view (see the paper's discussant, Hopewell, 1975[1]) calculated over 65,000 correlation coeffecients to investigate the extent to which values of predominantly stockmarket-orientated ratio variables (and also variables expressed in dollars) were correlated over time for a a group of firms, the extent to which the percentage changes in these ratio values were correlated over time and finally the extent to which these absolute ratio values were correlated with their percentage changes. They found that in their data sample company ratio variables were comparatively stable over time (as suggested by Horrigan and Pinches et al) but percentage changes (ie growth) in these ratios were completely uncorrelated over time as were the absolute values of the ratio variables with their percentage changes.

As regards the differences between industries, although several studies have been completed examining the extent of an "industry effect" in the movement of share prices (eg King, 1966, Brown and Ball, 1967, Meyers, 1973 and Newport, 1974 etc), little work has been carried out examining the differences in the financial structures of companies, as measured by their financial ratios, in different industries even leaving aside the question of what constitutes an industry.

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[1] Additionally the authors did not appear to recognise the problems associated with the measurement of the correlation between a variable and its percentage change - see Berieter (1967).

Lev (1969b) investigated the extent to which firms seek to adjust their financial ratios over time to predetermined targets related to industry averages and concluded they appear to although he did not deny the possibility of passive adjustment through the operation of industry-wide effects on the ratios. Nevertheless since he did not discuss the inter-industry differences in the 6 ratios he used nor the dispersion of the ratios of companies within a particular industry, his study cannot contribute all that much to the question under discussion.

A more relevant study is that of Gupta and Huefner (1972) who sought to relate the aggregate financial ratio values for 20 manufacturing industries at 2-digit level to their underlying industry attributes. Four ratios were eventually analysed, fixed asset turnover, inventory turnover, average collection period and cash velocity and the judgements of "a group of individuals knowledgeable in the area of industry economics" (p78) (their number and background were not specified), together with a "cluster analysis procedure" were separately used to assign each industry to one of four groups working with each ratio in turn.

The two sets of groupings broadly coincided for each ratio and they were interpreted on the basis of the underlying economic structure of the industries in such dimensions as nature of production process, degree of vertical integration, plant size and level of mechanisation etc by the authors in a consistent although fairly tenuous manner.

However the degree of dispersion of the data within each industry for each ratio was not considered nor were the ratio correlations between industries. The ratios selected seem to have been chosen very much on a priori basis to be those (because they all contain turnover items) which could be expected to differ most significantly between industries. In addition the interactions between the different ratio

averages for each industry were not considered as they would have been done if a clustering procedure working with all four measures simultaneously had been employed of the type we utilise in Chapter VIII §5 to examine related questions for UK industry data. Nevertheless we do gain some tentative insight into the relationship between industry economic structure and the values of certain financial ratios.

Another study by Gupta (1969) reports the results of related analysis using 18 ratio averages subdivided into four classes on an a priori basis viz:-

activity, leverage, liquidity and profitability

and these were computed for 21 manufacturing industries for the year 1961-2. He discusses the relationships between industry ratio averages and the underlying industry economic structures fairly plausibly and summarises the results in a table (p520) indicating how the different classes of ratio change (increase, decrease or exhibit a regular pattern) with such causal factors as mentioned previously, ie duration of the production process, degree of vertical integration, degree of market concentration and so on. However since he does not describe his methodology nor puts numeric values to any of his results, the article must be treated with circumspection and the reader is tempted to the conclusion that most of the results are probably not statistically significant.

Another study that is somewhat relevant to the question of the effect of industry type on financial ratio values is that by Williams and Goodman (1971) who, working with a function made up of 11 financial measures computed from data for the year 1966, were able to distinguish between 875 industrial companies and 131 utilities with 98% accuracy using a two-group discriminant analysis. They also obtained similar results working with 1967 data, however they did not test their 1966 function on their 1967 data. When they examined the industrial group in more

detail and considered five diverse industry classes, they found that a five group discriminant analysis working with a 14 variable function correctly classified 72.3% of firms when separate functions for each of 22 years were computed. A further analysis showed that 60.6% of companies were correctly classified by the previous year's discriminant function. Although this study has some methodological weaknesses in the way the discriminant analysis model is used[1], it may appear to offer some evidence for the need to stratify financial ratios by industry in certain situations. Alternatively their work can be used to argue that as the industrial classification system employed did not produce homogeneous groups it may be more meaningful to construct "psuedo-industries" independent of a priori end product classifications on the basis of groupings of companies homogeneous in terms of, say, financial characteristics.

This point is given more weight by the results of an unpublished study by this author working with data drawn from the 'Singh and Whittington' databank for the years 1954-60. It proved possible to correctly assign only 46 out of the 156 firms sampled from 5 diverse industries (non-electrical engineering, electrical engineering, food, clothing and footwear and wholesale and retail distribution) using a 5-group discriminant analysis and 6-variable functions with constituent 6-year average ratios a subset of those utilized in the 1968 Singh and Whittington study. Since these functions were calculated from the data they were subsequently used to classify even these poor results were probably biased upwards.

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[1] For example the size of the functions, particularly with respect to the numbers of the industrial firms in the 5-group analyses, would appear to indicate high multicollinearity and some "arm-twisting" of the data (see Chapter VI §6 for a further discussion of these points). Also the true percentages of "correct" classifications were marginally overstated in the industrials/utility discrimination and marginally understated in the 5 industry classification.

Additionally when a cluster analysis of 60 of these firms was undertaken, four homogeneous groups were formed which could be meaningfully interpreted on the basis of their underlying financial characteristics. However the firms in different industries were distributed apparently in a random fashion among these clusters. See also Elton and Gruber (1971) who constructed a set of "psuedo-industries" which "can lead to better estimates of earnings per share than a grouping based on SIC industrial classifications" (p444).

Finally the studies by Singh and Whittington (1968) and Whittington (1971) should be mentioned because they publish data which can be used to shed some light on the question of the inter-industry differences in financial ratios. In Chapter 2, Singh and Whittington publish tables containing aggregate statistics including mean and standard deviation figures relating to the distributions of the fourteen financial measures they work with (consisting of average figures for a number of return, long term finance and current finance ratios) for the four industries in their sample, in most cases calculated separately for the three periods 1948-54, 1954-60 and 1948-60.

To investigate the differences between industry ratio means a series of simple Student's t tests were undertaken (assuming the underlying distributions would not invalidate the conclusions) with the results given in table 2.3 below for the sub-period 1954-60 and $\alpha = .05$:

Ratio	Singh & Whittington Indicator	Significant industry mean differences at $\alpha=0.05$ Sub-period 1954-1960*
Return measures		
Rate of returns on net assets	5	NEE and all others only
Post-tax rate of return on equity assets	6	CLF and NEE only
Dividend return on equity assets	7	None
Long term Finance Indicators		
Retention ratio	8	NEE and all others only
Internal finance indicator	9	None
Gearing	10	CLF and NEE, CGI and NEE
Current Finance Indicators		
Liquidity	11	CLF and F, CLF and NEE only
Net trade credit given	12	NEE and all others only
Stocks/net assets	13	CLF and all others, F and all others

*Key: CLF = clothing and footwear
F = food
CGI = consumer goods industries, including tobacco
NEE = non-electrical engineering

Table 2.3: Significant Industry Financial Ratio Differences
(Source of data: Singh & Whittington, 1968, Chapter 2)

The discussion in the chapter attempts to explain qualitatively some aspects of the inter-industry differences in terms of their underlying economic/industrial structures however as can be seen from the above table statistically significant differences between these four diverse industries are not as frequent as might be expected on an a priori basis, possibly because of the effect of intra-industry dispersions in the ratio values or the use of 6-year averages. It may also be likely, in fact, that because of the increased degree of diversification since 1960, similar

calculations using more recent data would produce even less significant results. Note should be taken that even when statistically significant differences in mean values were apparent, in most cases the sizes of these differences were very small compared with the actual values of the measures being compared.

In Whittington (appendix to chapter 7) the annual mean and standard deviation figures for a number of financial measures for the years 1949-1960 for four industries (clothing and footwear, food, wholesaling and retailing) are shown.

A similar analysis to the above of the inter-industry differences for the year 1960 for five financial measures with only the return ratio (rate of return on net assets) similarly defined (although being the annual equivalent) gives the results of table 2.4 with $\alpha = .05$:

Ratio	Significant industry mean differences at α=0.05, year 1960*
Rate of return on net assets	F and all others, W and R
Liquidity	CLF and W, F and W, F and R
Net trade credit given	W and all others only
Current asset ratio	CLF and W, CLF and R, F and R
Stocks/Current Liabilities (Wholesaling and Retailing only)	No significant difference

*Key: CLF = clothing and footwear
F = food
W = wholesaling
R = retailing

Table 2.4: Significant Selected Industry Financial Ratio Differences

(Source of data: Whittington, 1971, appendix to Chapter 7)

However it should be borne in mind that distribution-based industries are likely to have very different characteristics to manufacturing industries.

On the basis, then, of the empirical work to date on the effects of industry on a company's financial ratios it would appear that although mean ratio measures across industry classes, considered separately, might suggest such industries are reasonably distinct, when the intra-industry dispersions are taken into account this picture may not be so valid. In addition when companies in different industries are considered in terms of their financial ratios taken in a multivariate context it would appear that industries as conventionally defined are not very homogeneous in a financial context; although broadly speaking their economic characteristics are reflected in the financial ratios of their constituent firms.

Nothing in fact has been adduced that can be used to argue on empirical grounds for stratification of companies in financial ratio studies by industry, at least within the general manufacturing sector, although of course this will not be true when distribution or construction companies are being considered. The increasing level of diversification and the problems of coherent definition of what constitutes an industry alluded to above (also see Amey, 1964 for a discussion on these issues), reinforce these conclusions on theoretical grounds.

The final question we need to examine in considering the use of financial ratios as a data source is that of the effect of a company's size on its financial ratios. Horrigan suggested much of the evidence was contradictory and that since one of the reasons for using ratios was as "size deflators" one would not expect too much size effect. Subsequent studies have in general been just as confusing in their conclusions although this author has found only two which address themselves specifically to the problems of interest here viz:- Singh and Whittington (1968) and Gupta (1969).

There have however been a number of studies specifically examining the relationships between size and profitability, size and growth and growth and profitability which questions are of particular interest to economists, although we are here only really interested in the first of these[1].

The results of the Samuels and Smyth study (1968) suggested (p32) that profit rates tend to decrease with the size of firm and that the difference in the profit rates of large and small companies were becoming more marked over time. Barron (1967) argues (p15) that larger firms are less profitable than smaller firms but that

> "There appear to be significant differences between industries for both average size and profitability which means that conclusions drawn from "across the board" samples must be treated with a certain amount of scepticism."

Singh and Whittington (1968) conclude (p144):

> "Average profitability was on the whole (with some exceptions) lower, the larger the size of the firm, but the difference in average profitability of firms between size classes were not found to be statistically significant at the 5% level, by the usual tests, for most of the populations of firms considered."

Whittington (1971) however states (p47), discussing his aggregate sample, "we cannot reject the hypothesis that companies of different size classes form a homogeneous population with respect to average profitability". And as regards individual industry analysis (p49): "with the

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[1] See for example Samuels (1965), and Singh and Whittington (1968, chapters 4-8 and 1975) for an analysis of the relationship between size and growth and growth and profitability. Their arguments will not be pursued further here except to note that in an initial principal component analysis of our data, both growth and return measures were highly weighted with the same sign on the first factor - ie they appeared synonymous. This is probably not surprising considering company growth is usually internally financed by retained earnings which are a function of profit.

possible exception of Metal Manufacturing, there is no systematic relationship between size and profitability within the broad industrial groups studied here."

The four studies mentioned all worked with size classes and average profitability ratios for each class. It is possible although not very likely that disaggregation of the data would produce different results.

In terms of the work of more relevance to our purposes, Gupta working with 18 ratios classified into four classes as discussed above (p56) indicates (table 1 p519) that on the basis of his data 5 out of 6 of the activity ratios fall as company size increases (the other one rises), 4 out of 5 of the leverage ratios fall (the fifth rises) and the two liquidity ratios rise as do three out of 5 of the profitability measures (the other two having "no significant movement"). However since he does not discuss the actual statistical results and appears content with a qualitative discussion of why these movements are to be expected from a priori economic reasoning, we do not gain much insight. He does in fact show (in table 3 p521) apparently very statistically significant relationships between certain ratio variables and "size" but the table defies interpretation and is nowhere referred to directly in the text.

In their more helpful study, Singh and Whittington reproduce in Chapter 3 simple correlation matrices for their 14 variables considering all their firms together separately across the three time periods. They suggest (p67) "The tables show an apparent lack of any correlation between the two size measures [opening net assets and closing net assets] and any of the other variables."

Thus we are forced to conclude that what little empirical evidence there is, (see also Bates, 1967), does not appear to indicate (at least with British publicly quoted company data) that the size of a firm has a large effect on its

financial characteristics, although the converse cannot necessarily be held to be true either. (It is interesting to note that the measure of size of the continuing companies we utilised in this study, log net assets, was only significantly loaded on the seventeenth principal component in the initial factor analyses of our data!)

6. Summary and Conclusions

This chapter has been concerned with the conceptual framework within which such empirical work as that constituted by this research has to be evaluated together with the nature and amenability to statistical analysis of the financial ratio data employed. After an introductory section the criterion of 'predictive-ability', often invoked in empirical accounting studies, was discussed from both logical and operational viewpoints and a revised criterion suggested. In section three an examination of the 'materiality' concept in accounting as currently expressed was undertaken, the problems associated with its application in practice were spelled out and a more restricted concept suggested to take account of these. Additionally some of the empirical evidence relating to the 'materiality' of published accounting data was reviewed. It was pointed out that 'predictive-ability' and 'materiality' are concerned with one and the same question and in effect are largely synonymous.

The second part of the chapter commenced in section 4 with a detailed discussion of the nature and extent of use of financial ratios and followed with a description of the criticisms sometimes levelled against these measures, largely on the basis of imagined or real problems with the underlying accounting data from which they are constructed. Their use was defended in the final paragraphs. In the following section the amenability to statistical analysis of such financial ratio data was discussed at length from four angles: firstly whether ratio

distributions are normally distributed and therefore whether parametric statistical tests can be applied, then whether ratio values differ significantly between industries, in which case arguments for the need to stratify companies by industry can be made out, next whether the size of a company affects its ratios and finally whether cyclical trends in the economy are reflected in a company's ratios.

It was concluded that we would appear to be fully justified in using financial ratios in our study as basic measurements of the underlying economic dimensions of the companies in our various samples and that many of the theoretical reasons adduced to suggest that such data may not be useful are in fact not valid in practice.

We view the accounting numbers we use in a similar way to Ijiri (1967:6) viz:-

> "The products of an accounting system are always surrogates, they are useful only because they represent principals, ie the economic events of an entity. This point can never be overemphasised."

Only by examining the results of the decision models we adopt here taken in conjunction with the data to which they are applied can the utility of the ratios employed be appraised and then only for the particular purpose in question.

CHAPTER III: SURVEY OF THE RELEVANT LITERATURE

1. Introduction

Associated with and possibly part of the explanation for the revival of interest in financial ratio analysis particularly amongst academics and the acknowledgement of the 'material' value of ratio data in certain situations for describing underlying micro-economic characteristics of a firm, has been the recent adoption of the techniques and approaches of the psychometrician and statistician by researchers in industrial economics, finance and investment management generally.

These predominantly multivariate techniques such as multiple regression analysis, principal component and factor analysis, multiple discriminant analysis, cluster analysis and the like (see Johnston, 1972, Cooley and Lohnes, 1971, Harman, 1967, Everitt, 1974 etc) together with the recent development of simple to use computer packages and suites of programs such as SPSS (Hadlai Hull et al, 1975) BMD (Dixon, 1973) and Statistical Analysis MKII, (ICL ,1971) have enabled researchers to build formal models and investigate hypotheses about financial and economic systems which otherwise would have been completely infeasible. To a certain extent as well this process has been aided by the ready availability of individual company accounting and stockmarket data in standardised form particularly in the States[1] and the various company card services and investment manuals available on both sides of the Atlantic.

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[1] The Compustat tapes prepared by Standard & Poor's contain accounting data for about 900 corporations for a 20 year period to date and the CRSP data tapes, compiled by the Centre for Research into Stock Prices, University of Chicago, monthly security prices. In the UK SCAN owned by Cybernetic Research Consultants, 83, Clerkenwell Road, London EC1 runs a service allowing subscribers to access datafiles containing many accounting items and ratios for the previous 5 years of accounts of publicly quoted UK companies by terminal and FOCUS owned by Exchange Telegraph is a similar service dealing with stock market prices.

Such studies are those, for example, by Melicher and Hempel (1971) who used a 2-group multiple discriminant analysis (MDA) approach to investigate whether there were significant differences between the financial characteristics of conglomerate merger groups and those of horizontal and vertical merger groups, and Simkovitz and Monroe (1971) who used stepwise 2-group MDA to examine whether firms taken over by conglomerates had significantly different financial characteristics to unabsorbed firms. Singh (1971 and 1975) and Stevens (1973) employed univariate statistical anslysis and 2-group MDA and factor analysis and 2-group MDA respectively to compare the characteristics of taken-over and non-taken-over firms and Tzoannos and Samuels (1972) used an analagous multiple regression approach to examine similar questions. Walter (1959) found it was possible to use certain financial variables in association with a 2-group discriminant function approach to distinguish fairly effectively between firms with low and high earnings - price ratios, and he suggested the use of the model as a means for determining whether an equity was under or overpriced. Other studies using similar methodology have been used to predict good and bad credit risks in the hire purchase situation (Myers and Forgy, 1963, and Apilado et al, 1974) and to predict whether firms will convert part or all of their convertible debentures in the next period (Frank and Weygandt, 1971) and so on.

In this chapter we will first review the literature on the empirical work undertaken examining the extent to which financial ratio measures considered on a univariate basis differ between companies which subsequently fail or do not fail. In section 3 the discussion is expanded and a critical look is taken at the multivariate study (Altman, 1968) which follows the approach taken here to the greatest degree and in the next section a more general review of the other multivariate studies into manufacturing industry insolvency is undertaken. In section 5 the

literature in the related area of commercial loan evaluation is examined and 'prediction' studies for railroads and financial institutions commented upon. Penultimately a detailed look at US bond rating studies will be taken as they address themselves to very similar issues to those we are interested in here in this study.

Finally two alternative approaches are examined which attempt to provide explicit probability estimates for a firm's failure.

2. Unvariate Ratio Studies of Financial Failure

Most American studies into the 'prediction' of company insolvency and related subjects using financial ratio data (such as those of Horrigan, 1965:565/6, Beaver, 1966:82/83, Altman, 1968:590 and Elam, 1975:27/8) acknowledge the studies by Fitzpatrick (1931 and 1932), Winakor and Smith (1935) and Merwin (1942) as being the earliest work in this area to indicate that failing firms have very different ratio patterns to continuing entities. However since the original sources were not available in the UK, the joint discussion of the above recent authors will be followed here. Fitzpatrick analyzed the trends of thirteen ratios for 3-5 years prior to the failure of a sample of 19 successful firms and found that although all his ratios 'predicted' failure through declining trends, the best predictors were net profit/net worth and net worth/total debt.

Winakor and Smith examined the prior ten-year trends of the mean values of 21 ratios for a sample of 183 firms which had failed by 1931 and concluded that the ratio of working capital/total assets where decline began 10 years before the occurence of financial difficulties, was the best indicator of impending failure, although as Horrigan points out the long-term solvency ratios were equally good indicators.

As regards methodology, Fitzpatrick's sample was probably

too small and selective and Winakor and Smith's lacked a matched sample of continuing firms, however Merwin's study, which consisted of a sample of 939 mainly small corporations examined over the period 1926-36 divided into "continuing" and "discontinuing" classes, did not suffer from such problems. He analyzed the trends in the average industry ratios of his "failed" sample for six years before failure for a large number of measures and compared these with the equivalent average industry ratio trends for his continuing companies.

On this basis he concluded that his three "best" ratios, working capital/total assets, net worth/total debt and the current ratio, could indicate discontinuance as early as six years before the fact in some instances. However the results with regard to the other ratios analyzed were not given nor were all his discontinuing firms necessarily failures in a strict sense. Nevertheless as with the other two studies quoted it does appear that even forty years ago it was believed that financial ratios could be used to indicate potential company insolvency.

The more interesting univariate studies for our purposes are those of Beaver (1966, 1968), Deakin (1972) and Dascher (1972). Working with 2 samples of 79 failed[1] and 79 non-failed firms matched in pairs by industry and asset size although not completely by fiscal year[2], Beaver (1966) computed values of 30 ratios for each firm sub-divided arbitrarily into 6 groups (cash flow, net income, debt to total asset, liquid asset to total asset, liquid asset to current debt and turnover) from the financial statements for 5 years before failure (where available). The ratios chosen were those frequently mentioned in the literature:

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[1] Operationally defined (1966:71) as "bankruptcy, bond default, an overdrawn bank account or nonpayment of a preferred stock dividend", (59,3,1,16 firms respectively).

[2] Beaver suggests (1966:74, f.6) that since the ratio behaviour of the non-failed firms was quite stable and apparently independent of age this latter point would not be very important.

he apparently used 36 sources dealing with financial ratios - 25 text books, 8 articles and 3 government studies (1968:116 f.13), they had performed well in previous studies or could be defined in terms of a "cash flow" concept.

He then carried out dichotomous classification tests[1] on his ratio data using both his samples together and then sub-divided into two groups so that the cut-off points obtained from one could be used to classify the firms in the other.

In the 1966 study the results for the single best discriminators from each of the 6 groups (cash flow/total debt, net income/total assets, total debt/total assets, working capital/total assets, current ratio and no-credit interval [quick assets - current liabilities/operating costs - depreciation]) were reported upon for each of the two tests and for each of the 5 financial years prior to failure and the results (misclassification percentages) compared with random prediction (50% correct classification according to Beaver).

The best ratios were cash flow/total debt and net income/total assets with the first producing a 13% misclassification (cross-classified samples) in the first year before failure while in the fifth the error percentage was 22%. The second ratio produced very similar results (which is not surprising given the very high correlation to be expected between these two measures and which Beaver only mentions in passing), whereas the other four ratios were all much inferior particularly the last three and particularly for more than one or two statements before failure. Beaver also produced contingency tables for the cash flow/total debt ratio for each of the five years before failure to indicate the type I and type II errors and the type I

[1] The dichotomous classification test consists of ranking the values of all firms for a particular ratio and then determining the cut-off point which minimizes the total number of misclassifications, ie failed as non-failed and vice versa.

errors are seen to be significantly greater, ie non-failed firms can be classified more 'correctly' than failed firms. This also applied to his other ratios and is clearly potentially more serious to the user than the reverse situation.

Beaver also attempted a crude measure of an industry effect by comparing the results for tests with samples containing different industry compositions and concluded that nothing had been observed to suggest that industry effects were of any magnitude particularly with the 'better prediction' ratios. He also investigated the effect of asset size on the financial ratios of the companies in his samples, but observed no strong correlations.

He finally suggested a Bayesian likelihood ratio approach as a framework of analysis but did not attempt to apply it to his data.

In his 1968 paper Beaver essentially reported on other aspects of the same study in discussing in detail whether liquid asset ratios perform better (as suggested in the literature) than non-liquid asset ratios[1] by considering the results for three non-liquid asset ratios (the first three of the 6 examined in detail in the first study) over the five year period compared with eleven liquid asset ratios divided into three common denominator groups (total asset, current debt and net sales or turnover). The significantly superior performance of the non-liquid asset ratios even in the short term was explained by the hypothesis that their components represented fundamental aspects of a firm that could not be readily altered whereas

[1] It was not clear from either of his papers what distinguished liquid asset from non-liquid asset measures. He states (1968:114): "The non-liquid asset ratios are generally regarded as measures of long-term solvency, while the liquid asset ratios are generally regarded as short term predictors". However he classed his current liabilities to total assets ratio in his 1966 study as non-liquid but current assets/total assets, working capital (CA-CL)/total assets and 'no-credit interval' containing current liabilities in the numerator, all to liquid asset status.

the other ratios indicated liquidity problems which could be overcome by borrowings etc given the underlying financial structure of the company was sound.

He also compared the 11 liquid asset ratios and found the more popular ones (current and quick asset ratios) were significantly worse 'predictors' than the less common (working capital and cash ratios) possibly indicating "window-dressing", however an analysis of the individual ratio components (financial statement items) suggested that these ratios could be bad predictors since although failed firms had less cash and surprisingly lower inventory they had more debtors on average. Using similar arguments he suggested that as non-failed firms had higher current assets and lower current liabilities, working capital measures could be expected to be better predictors than either type of current measure alone.

Although the two studies are important contributions a number of criticisms must be made. Firstly the lack of any correlation analysis is serious because of the high multicollinearity to be expected in his ratio data as discussed in Chapter II §5 above. Secondly out of his 79 pairs of companies 15 were drawn from non-manufacturing industries and this could possibly explain why he had such poor results with certain of his ratios (which presumably are the ones which differ between industries), a priori his best two should be largely industry independent. The results of his not very rigorous tests to detect an industry effect are consistent with the discussions in the previous chapter that within the manufacturing sector industry effects are not necessarily very significant. (Since he selected his subsamples at random there is not a high probability of a great majority of his non-manufacturing companies being assigned to the same sample.) It would have been interesting for him to have used the cut-offs derived from analysis of the non-manufacturing sample to classify the manufacturing companies. Beaver also did not restrict his samples as we have done to companies which had been in existence for at least five

years; since as was suggested in chapter I young firms might fail more frequently than better established ones and they most certainly have a different financial structure, it is dangerous to compare samples of mixed age firms. (This point was also made by the 1966 paper's discussant Neter, 1966; in fact we are not told how old his firms were.) Also the definition of failure used can be questioned from the point of view of the homogeneity of the resulting firms and as Deakin points out (1972:168) it necessitates really a matching of samples by debt structure. Other problems also arise in the treatment of the intertemporal aspects of his data.

However of far more importance is Beaver's claim that he is evaluating the 'predictive-ability' of financial statement items in the case of company failure. He states (1968:114):

> "The purpose [of the 1966 study] was to discover how well financial ratios could predict failure relative to random prediction... [and the] findings of the study were: based solely on a knowledge of the financial ratios, the failure status of firms can be correctly predicted to a much greater extent than would be expected from random prediction.... [In addition the evidence] suggested that financial ratios can be useful in the prediction [this author's italics] of failure for at least five years prior to the event."

Quite clearly this is not so. Prediction means to foretell the future, what Beaver has done is to attempt to classify companies into one of two groups on the basis of their financial ratio values considered one at a time. His study is one of ex post discrimination not ex ante prediction; although he claimed predictive success, he could only have claimed ex post discrimination success on the basis of the way his study was constructed. (see Joy and Tollefson, 1975:727/8, although they discuss the Altman, 1968 study.) Only by examining for each ratio what subsequently happens to a large sample of companies with values currently below the cut-off, ie how many companies subsequently fail, how many recover and how many continue over time exhibiting 'failure' characteristics can he

consider his study to be predictive in nature. This point is also relevant with regard to the interpretation of his results for financial years prior to the last before failure.

In addition by effectively ignoring the prior probability of firms in practice belonging to each of his two classes the classification probabilities on a random prediction basis which Beaver compares his results with are not the 50% he supposes. His discussant, Neter, points this out in detail and suggests that when this is done Beaver's results are far more modest and in certain cases in fact may be less successful than random prediction or even a pure strategy eg: accept all firms as non-failed. (See also the very detailed examination of these points in Joy and Tollefson, pp727-739.)

Also Beaver does not take into account the differential misclassification costs of a type I against a type II error. This again Neter points out. Apart from anything else for a decision maker the type I error is the significant one and considering only the total misclassification percentages obscures this. When these are considered separately the classificatory power of his ratios no longer appear so strong. In fact examining his 'best' ratio the type I percentage errors (with total percentage errors in brackets) for the 5 years before failure (1-5) are 22(13), 34(21), 37(23), 47(24) and 43(22) percent.

It is surprising that these points have not been commented upon before in any of the numerous studies which have taken his work as their starting point.

In the first part of his study Deakin attempted to replicate the Beaver study (1968) using data from a later period with firms failing between 1964-1970. However he used a more restricted definition of failure namely "those firms which experienced bankruptcy, insolvency, or were otherwise liquidated for the benefit of creditors" (p168) and 32 failed firms were selected and matched with non-failed firms as in the Beaver studies but also by financial

statement year. His results were very similar with Spearman rank order correlation coefficients indicating the relative 'predictive-ability' of the same 14 ratios in his study and in Beaver's 1968 one for the 5 years before failure (1-5) being .88, .82, .56, .80 and .76. Deakin suggests that the comparatively low coefficient for the middle year of the data was because his failed firms unlike those in the Beaver study tended to expand rapidly in the third and fourth years prior to failure and this was financed by additional debt and preference capital that could not be serviced. Also the 'predictive-ability' of his cash/sales ratio differed significantly from that in the Beaver study which he suggests was because firms tended to invest more of their cash in the late 1960's because of the high interest rates. This part of his paper suffers from many of the same problems discussed above with regard to Beaver's studies except possibly the one concerning the time span of his samples. However Deakin then adopted a multivariate discriminant analysis approach in an attempt to improve on the classifications and the results of this will be reported below.

The other paper mentioned, that of Dascher, is of interest in that by analyzing the 14 ratios mentioned in Beaver's 1968 paper for Penn Central and comparing them to industry average values computed from a sample made up of the largest 10 railway companies including Penn Central, he showed that its failure should not have been unexpected. In fact in 9 out of the 14 and 10 out of the 14 ratios in 1968 and 1969 it was ranked worst of all the 10 companies.

From what has been said so far it cannot necessarily be concluded that individual ratio values are good indicators of potential insolvency. However this does not mean that a number of ratios taken together, ie ratios representing the multidimensional nature of financial data expressed in terms of a multivariate model, would also not be successful and in the next sections the literature in which this approach is taken is discussed.

3. Multivariate Models for the Identification of Company Failure Potential, Pt 1: The Altman (1968) Study

Several multivariate studies using financial ratio data and a discriminant analysis approach[1] have been reported upon in the literature dealing with the forecasting of failure for manufacturing companies (Tamari, 1966, Altman, 1968 and Blum 1974), companies generally (Deakin, 1972, second part of paper), small firms (Edmister, 1972), railroads (Altman, 1973), insurance companies (Trieschmann and Pinches, 1973 and Pinches and Trieschmann, 1974) and banks (Meyer and Pifer, 1971).

Related studies of interest include Elam (1975) in which the effect of the capitalisation of leases on the ability of financial ratios to 'predict' insolvency is examined, the studies by Horrigan (1966), Pogue and Soldofsky (1969), West (1970), Pinches and Mingo (1973a) and Ang and Patel (1975) on the'prediction' of US corporate bond ratings and that of Carleton and Lerner (1969) for municipal bonds. Papers on commercial loan evaluation (Altman, 1970a, Orgler, 1970 and Altman et al 1974), have been published and the evaluation of companies as going concerns (Altman and McGough, 1974) has also been discussed.

The only relevant British study of this nature is the report on the prediction of company failure completed by Lis (1972) as part requirements of the City University MSc. in Administrative Sciences and this was reported upon in the Investors Chronicle (Bolitho, 1973).

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[1] Multiple discriminant analysis (MDA) in the 2-group case reduces to multiple regression analysis with the dependent variable either 0 or 1, when the discriminant function is known as a linear probability function. However the necessary assumptions about the data distributions for an application of regression analysis are unlikely to be valid in many situations making interpretation and significance testing difficult. See Singh (1971:93-94), Ladd (1966) and Chapter V of this study §2 for a discussion of this point.

In this section we will focus primarily on the 1968 Altman study which proved to be the starting point for many of the later studies and provides a first class structure upon which a critique of the approach generally taken can be hung.

The first study chronologically, however, of direct interest to us, that of Tamari (1966) contains an analysis of the distributions of a number of financial ratios for a sample of 28 Israeli industrial firms failing in 1958-60 compared with the 'all industry' distributions, together with a brief discussion of certain trends over time. Of more actual relevance here was his attempt at a multivariate approach by developing a model in which a risk index (likelihood of failure measure) for a company was derived by allocating points to each of six variables separately according to their values and summing the results[1]. The measures appeared to be chosen fairly aribitrarily and each ratio was (p19) "given a weight according to its importance in the eyes of financial analysts, economists, and credit men in Israel and abroad". The distribution of total weights for his failed sample was compared with that for 'all industry' and whereas 75% of the former sample had scores below 35 points, 75% of the latter had scores above 46 points.

Tamari finally proceeded to examine the scores for 130 industrial companies operating in 1958 and found that of the 21 with less than 30 points, 11 (52%) had failed by 1960, of the 50 with 30 - 60 points, 3 (6%) had and of the 59 with a score of more than 60, only 2 (3%) failed.

[1] These six measures with the maximum points possible given in the brackets were (i) equity capital & reserves/ total liabilities (25), (ii) profit trend measure (25), (iii) current ratio (20), (iv) value of production/working capital (10), (v) sales/debtors (10), (vi) value of production/working capital (10). For the third variable for example firms with a ratio over 2 would be allocated 20 points, between 1.5 and 2, 15 points and so on.

This study is important, not necessarily in terms of its methodology which although interesting clearly suffers from a number of drawbacks, but firstly in its recognition that we are unable to predict failure but only crudely measure a propensity for failure and its attempt to explictly do this, which most of the other later studies with similar objectives have not. And secondly by laying out the transition matrix reproduced below in table 3.1, Tamari pointed attention in the direction of examining the extent to which companies in a poor position recover over time instead of fail which is vital information for practical application of such approaches.

Index Values in 1958	Index Values in 1960 (percentages) High	Medium	Low	Ceased operating by 1960	Total Firms
High (60 points)	76	21	0	3	59
Medium (31-60 points)	32	50	12	6	50
Low (< 30 points)	10	14	24	52	21
					130

Table 3.1: Percentage Distribution of the Movement of 130 Israeli Industrial Companies Between Different Risk Classes from 1958-1960

(Source: Tamari, 1966:20, table 5, corrected)

The first multivariate approach in this area conventionally recognised in the literature as such is the study by Altman (1968) the importance of which was spelled out above. Altman describes the purpose of his paper (p589) as an attempt to assess "the quality of ratio analysis as an analytical technique. The prediction of corporate bankruptcy is used an an illustrative case."

His initial sample consisted of 33 manufacturing firms filing a bankruptcy petition in the years 1946-65; he acknowledges that since average ratios move over time a 20 year span is not ideal but states that nothing else could have been done because of data limitations. These companies ranged in asset size from $0.7m to $25.9m and the mean lead time of their accounts prior to bankruptcy was 7½ months. Altman also utilised 33 firms still in existence in 1966 matched with the first set by industry, size and financial year and selected on a stratified random basis.

22 ratios were computed from the financial statements of the failed and non-failed groups. These, Altman states, were chosen on the basis of their popularity in the literature and potential relevancy to the study and also incorporated some "new" measures; they were classified into five groups, liquidity, profitability, leverage, solvency and activity.

A large number of computer runs then took place to determine the combination of variables which together produced the best discriminant function, which was of the form:

$$Z = .012X_1 + .014X_2 + .033X_3 + .006X_4 + .00999X_5$$

where

Z = overall index

X_1 = working capital/total assets

X_2 = retained earnings/total assets

X_3 = earnings before interest and taxes/total assets

X_4 = market value of equity/book value of total debt

X_5 = sales/total assets[1]

with the classification table arrived at from application of this discriminant function to the data from which it was derived given in table 3.2 below:

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1 The coefficient of this ratio differs from that given in the paper by a factor of a hundred to make the measurement scale for that ratio compatible with the other four. (See Altman, 1970b:1172.)

Actual	'Predicted' failed	non-failed
failed	31	2
non-failed	1	32

(entries denote number of companies)

Table 3.2: Classification Matrix for the Results of Altman's Discriminant Function Applied to the Sample from which it was Calculated

(Source: Altman, 1968:599)

The F value computed to test for significant differences between the two groups was 20.7 ($F_{5,60}(.01)=3.34$). The cut-off point employed in the computer package utilised by Altman was half way between the group centroids and table 3.2 is derived on this basis. However he appeared tc believe that the point which minimised the total number of misclassifications was more useful (pp606/7). The area of the scale in which the two samples overlapped (7 companies) he termed the "zone of ignorance" or "grey area".

Two of the variables in the function need elaboration. X_2 was a "new" ratio and according to Altman, an attempt to include firm age explicitly (since younger firms are supposed to have a higher probability of failure than older ones), and the fourth measure, the reciprocal of the conventional debt/equity ratio was an attempt to include a market value dimension. However the retained earnings ratio (X_2) would appear to be a very difficult one to compute, at least using UK data, requiring the inclusion of all the previous scrip issues over the life of the company to allow for the capitalisation of reserves and also be difficult to interpret conceptually reflecting accurately neither the firm's age nor its past earnings. The inclusion of the equity/debt ratio likewise is open to criticism on a number of counts, including problems

associated with the question of when a company's equity price is to be measured and also whether it should be adjusted for short term fluctuations in the aggregate stock-market indices. (See the problems Argenti, 1976a ch4, met when trying to fit the function in practice to UK data.) Whereas the first four ratios were all very highly significant discriminators taken alone and the fifth poor, when the variables were taken together into a single function Altman argued sales/total assets contributed second most (after the profitability ratio) to group separation because of its interactions with the other variables and this, he maintained, illustrated some of the relevance of a multivariate approach. However Joy and Tollefson (1975:729-30) point out that using the correct measure of relative discriminating power, sales/total assets is in fact the least important variable explaining only 8% of the average discriminant score separation between the groups.

Two years prior to failure 83% of his original firms were 'correctly' classified although as in the Beaver study the type I error (classifying failed as non-failed and potentially the more serious) was much greater than the type II error at 28%. However the 'accuracy' of the model fell off substantially after that as indicated in table 3.3 below:

Years prior to failure	Number of firms	Misclassifications (Type I errors)	Percentage correct classification
1	33	2	95
2	32	9	72
3	29	15	48
4	28	20	29
5	25	16	36

Table 3.3: Five Year Predictive Accuracy of the Altman MDA Model (initial sample)

(Source: Altman, 1968:604)

The reduced sample over time was mainly because several of the firms were in existence for less than 5 years.

Altman finally set out to test his derived function more rigorously, pointing out that when the discriminant function derived from a set of data is used to classify that data the results are likely to be biased upward by (a) sampling errors in the original sample and (b) search bias. To avoid these problems he first adopted a procedure, the 'split sample approach', suggested by Frank et al (1965)- described in chapter VI §6 here, to examine the extent of search bias by dividing the original sample of 66 firms into two groups in different ways and using the discriminant function derived from one group to classify the firms in the other. An average misclassification of 6.5% resulted indicating negligible search bias in the function. He then also compiled two secondary samples, one of 25 failed firms similar in asset size to those of the initial sample and the second of 33 firms making losses in 1958 and another 33 making losses in 1961, and tested his derived discriminant function on these. Only one failed firm was misclassified in the first sample whereas in the second the type II error was 14 or 21% with 10 of these lying in the area of his scale (the "zone of ignorance" or "grey area") in which failed and non-failed scores for the firms in his original sample overlapped.

This first class piece of research as pointed out above was of considerable importance in stimulating quite a number of studies in related areas, however these seem to have frequently suffered from similar misunderstandings to those of Altman's and without decrying the value and importance of his work in any way it is instructive to examine ways in which his approach could be improved so similar mistakes can be avoided in our work.

Apart from the obvious problems inherent in an analysis in which the sample data spans a twenty year period and an uncritical acceptance (which is implied by his paper) of the basic data, Altman does not refer to the statistical assumptions underlying the use of a multiple discriminant model, namely that the variance-covariance

matrices of the two samples from which his function was derived should be equal and that the joint ratio distributions should be separately multinormal. It is not possible to know whether his paired sample design ensures that these conditions are met, he does not for example examine the possibility of using transformed ratios.

However, probably of far more importance in terms of the operational utility of his function is his lack of explicit consideration, as with Beaver, of differential prior probabilities in the population to which his function is to be applied. Joy and Tollefson in fact point out that if the prior probability of bankruptcy is .01, then the results from classification of the two secondary samples of 25 failed and 66 non-failed firms would not indicate that his linear discriminant function (LDF) was performing significantly better than chance, although this is based on the assumption that the cut-off is not altered to incorporate the prior probability information. In addition, again as with Beaver, Altman does not explicitly include mention of differential misclassification costs in his model which is necessary if it is to be used as an applied decision-making tool. Joy and Tollefson (pp735-738) go into this in some detail and discuss the Bayesian approach to classification incorporating such differential costs. They in fact conclude that on the assumption of a prior probability of failure of .01 and given Altman's secondary sample results then (p737)

> "his LDF would be superior to proportional chance classification using the expected cost criterion.... if and only if the cost of misclassifying a bankrupt is more than about 21 times as great as the cost of misclassifying a nonbankrupt....and to classifying all firms as non-bankrupts if and only if... [it] is more than about 22 times as great"

It should of course be pointed out that the figures Joy and Tollefson used were for demonstration purposes only and that in any case Altman's results for his 66 secondary sample continuing firms are biased downwards by virtue of his selection of poor performers. However

they do vividly point out the need for incorporating prior probabilities and differential misclassification costs into a discriminant model, which we explicitly do in our study here.

Of equal importance to the above is the more philosophical question of what is actually being measured by Altman, who clearly views his LDF as a "bankruptcy prediction model". Strictly speaking, however, as Joy and Tollefson make clear (pp727/8), he has only demonstrated ex post discrimination success not ex ante prediction. "Prediction...requires inter-temporal validation whereas explanation requires only cross validation."

What he has done on an ex post basis, as Beaver did to a less convincing degree on an univariate basis, is to show that firms which have gone bankrupt differ from non-failed firms in terms of their financial ratios considered in a multivariate context. In testing his secondary samples he is not 'predicting' bankruptcy but simply saying that certain firms resemble in terms of their financial characteristics firms which have already failed more than those which have not and others conversely.

It is probably too strong to claim that all Altman is doing is being tautologous (as Johnson, 1970 does) but it must be recognised that he is not predicting failure (although one would expect a priori a high probability of failure to be associated with a low Z-score below the cut-off); none of the results of his study allow him to do this explicitly.

Only an inter-temporal study in which the behaviour of the Z-scores of a very large number of companies is monitored over several years, and the proportion of firms with 'failed' Z-scores at some stage which recover (or stay in existence for several years) is compared to those that actually fail (or adopt an alternative to failure

such as merger, government aid etc), can indicate whether this approach is truly 'predictive'.

Nevertheless until this is feasible there is very good circumstantial evidence that a discriminant function computed in a well conducted multiple discriminant analysis study similar to that of Altman's but incorporating prior probability and differential misclassification cost information is likely to be useful for the manager to examine the degree to which his firm resembles those which have failed in the past or for the government to have a simple and quick screening device to determine those companies which deserve more detailed examination and potential aid. (We ignore for the moment the question of self-fulfilling prophesies.)

Thus if a discriminant model is used to produce an operational definition of 'insolvency' in terms of whether a company resembles financially firms which have previously failed or are sound and is then utilised to investigate certain economic events in a descriptive sense the approach is being correctly used although its general utility is probably being understated.

In this study we explicitly recognise the above arguments and make no attempt to claim that what we are doing is to 'predict' failure (although implicitly recognising that a well conducted study is likely to be able to clearly indicate companies at high risk).

Altman himself (1970b) does not necessarily accept these points. In his reply to Johnson's criticisms he sidesteps and confuses companies which are technically insolvent (negative working capital) or bankrupt insolvent (negative retained earnings) with those with Z-scores below the cut-off. He claims that because at least 82% of the 129 companies out of the 2000 whose financial statements for 1964 he examined, which were technical or bankrupt insolvents, were still in existence in 1970, the definitional quality of financial ratios is not demonstrated.

In the light of this discussion then we can examine some of his results from a new perspective. Of particular interest are his interpretation of the results of his investigation of the 'non-failed' secondary sample and his discussion of the 'long-range predictive accuracy' of the model. In the first case he interprets the fact that the discriminant model (p602) "correctly classified 79 per cent of the sample firms" as non-bankrupt as a test of the significance of the model and in the second that (p604) "the bankruptcy prediction model is an accurate forecaster of failure up to two years prior to bankruptcy".

If we interpret the Z-score as a one-dimensional analogue of multidimensional data that measures the degree to which a firm financially resembles those which have failed in the past or have not, then what Altman has done in the first case is to describe the 21% and 79% groups of his sample as possessing substantially the financial characteristics of previously failed and non-failed companies. It is not possible to go further with the smaller number of firms and predict they will fail subsequently. Another set of decisional and probably behavioural models would have to be developed to do this. It is virtually certain, however, on a face value basis that they have a very much higher propensity of failure than the firms in the other group. However, it is certainly not a test of the predictive value of the model. In fact his results (14 out of the 66 firms "misclassified") point up the definitional nature of his model.

As regards the predictive value of the model over time, considering it in its definitional capacity, all that can be said is that 36 per cent of his failed firms (see table 3.3 on page 81 above) had five years prior to bankruptcy similar financial characteristics to those they exhibited in their last financial statements before failure. It is clearly wrong to interpret these results as indicating that failure could be predicted five years in

advance for the 36% of the 25 firms for which data was available.

The debate on the meaning of materiality and the predictive ability criterion, discussed in the last chapter is of considerable relevance here. Altman's results do not reflect on the "quality of ratio analysis as an analytical technique" (p589) as he claims but on the value of a particular statistical model taken in conjunction with the data (certain financial ratios) from which it was developed which allows for ready transformation of similar data into a more comprehensible form relevant to specific decision-makers for certain specific purposes.

We must strictly speaking agree with Johnson (p1168) when he says "Evidence of the ability of ratios to predict failure has not been presented".

The justification for discussing the Altman study in such detail and for the extended debate about the predictive value criterion and the materiality of accounting data at the beginning of the second chapter of this study is that virtually all the American studies in this area conceptually follow a similar approach and are open to the same criticisms. In this research we hope to have perceived the dangers and to have produced results which can be defended statistically. In addition we acknowledge explicitly the <u>definitional nature of the approach adopted</u> and consequently believe our models can be used to test certain economic and financial hypotheses in a meaningful way.

4. <u>Multivariate Models for the Identification of Company Failure Potential, Pt 2: Other Studies</u>

The other studies mentioned at the beginning of §3 will not be considered in such detail although certain of these do contribute to our understanding despite an apparent lack of statistical rigour. A discussion of their constituent variable measures contrasted with the

ones that were included in our final model will be undertaken in Chapter VI §3.

Blum (1974) constructed his model to be used as a defence in antitrust cases under the "Failing Company Doctrine"[1]. The samples with which he worked consisted of the 115 medium sized industrial companies which had failed between 1954-1968 for which 3 years financial statement data was available and 115 non-failed firms paired by industry, size and financial year. Data was collected for a maximum of 8 years before failure where possible.

The 12 measures selected by Blum contained both financial statement and stockmarket items and their selection was based on application of a similar cash flow model of the firm to that mentioned by Beaver which explains why in an attempt to measure variability (or risk) explicitly, the standard deviations, trend breaks (0-1) and slope of the trend lines of net income and the ratio net quick assets/inventory were employed as variables. Two of the other 6 variables made use of stockmarket data. Using a conventional discriminant analysis approach with 12-variable functions in most cases he developed a large number of models from half the sample for different range intervals (for the variability measures) and different "most recent year before failure". These Blum tested on the other half producing results in the form of matrices with the number of years before failure for which the prediction was made on one axis and the range interval (3-8 years) on the other and "correct" classification percentages as entries. The results indicated a steady falling off in 'predictive-ability' over time

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1 "The rationale of the Doctrine is that the likely harm to communities, employees, creditors, and owners associated with a failing business that might be forced into a liquidation proceeding, outweighs harm to competition caused by allowing a failing and presumably weak but still intact firm to merge with a competitor." (p2)

with the accuracy of the functions for his best range being 95%, 80%, 70%, 80%, and 69% for the 1-5 years before failure on the validation sample taking type I and type II errors together.

However the application of the statistical methodology employed is questionable, many of his ratios are multicollinear and the variability measures used could be expected to invalidate the multinormality assumptions underlying the approach. Blum also did not test for equality of dispersion matrices. In addition the use of a large number of variables is likely to bias the results of his primary sample upwards compared to the validation sample particularly with the smaller number of firms included because of lack of data as the range interval is increased. This was in fact very clearly shown in his matrices of results. Also a naive model using non-ratio financial data and stockmarket items alone (8 numerators and denominators in his measures) appeared to be able to discriminate just as effectively, although Blum suggests this may be a result of inexact size pairing and consequently not a fair test of the utility of financial ratios.

Nevertheless Blum did appear to realise the 'definitional' nature of the approach, and this was the basis of his legal arguments. He also pointed out the logical inconsistencies and assumptions of the constituent discriminant coeffecients being invariant to time implicit in Altman's use of the same model to 'predict' failure on data for different years before failure. And he did discuss the differential costs associated with the two possible types of error in determining a cut-off, although he did not incorporate these explicitly in his model. It is interesting to note that for his purposes the type II error (misclassification of 'non-failed' as 'failed') may very well be more important than the type I error.

The second part of the Deakin 1972 study consisted of calculating discriminant functions for each of the 5 years

before failure from the ratios computed for his paired samples of 32 failed and non-failed companies. He found not surprisingly, given the large number of ratios compared to number of observations (firms), that the misclassification errors for the first three years (taking type I and type II errors together) were 3%, 4½% and 4½% for firms used in deriving the discriminant functions but 22%, 6% and 12% on the cross-validation sample of 11 failed and 23 non-failed firms, and he was unable to explain these poorer results particularly for the first year before failure. He comments (p173):

> "it is often possible to decrease the number of the variables included in the function without reducing the discriminating value of the matrix. However, when this was done in the present study, the number of classification errors increased substantially. This would tend to support the use of many of the variables considered important in the literature for the prediction of business failure."

The presence of "sampling error bias", which arises from the computation of a function to maximise the proportion of correct classifications for the sample from which it was derived not for the underlying population(s), would appear to be the reason for this. (See the discussion in chapter VI §6.)

He also showed that the discriminant function calculated from the 14 ratios of firms 2 years prior to failure and non-failed firms matched by financial statement date was the most effective and correctly classified 90% of all firms that did or did not fail over the next 1-3 years.

Finally in the appendix he examined the empirical classifications of 1260 firms and compared the observed error rates with those expected from distribution theory and concluded that (p179) "the discriminant classification is sufficiently robust to be used for distributions of financial data". Deakin did pay lip service to the underlying statistical assumptions of the method, however this did not appear to affect his analysis. He also terms

his study 'a predictive' one (p167): "The purpose of this paper is to propose an alternative model for predicting failure." It also suffers from other problems similar to those of Altman's study, such as lack of incorporation of prior probability information or differential misclassification cost data and probably like Beaver includes a number of non-manufacturing firms which may have affected his results substantially.

Edmister (1972) applied a discriminant analysis approach using a regression model with 0-1 dependant variable (p1477) "to test the usefulness of financial ratio analysis for predicting small business failure". He tried two samples, one of 562 firms (half 'failed', half non-failed) in which only data from one financial statement was used and a much smaller one of 21 failed and 21 non-failed companies for which financial statements for 3 years were available.

He worked with 19 conventional ratios, both in absolute and industry relative terms (2 measures employed), for both samples and added to these for consideration, in the case of the smaller size sample, various 0-1 trend measures and 3 year average values computed from both the absolute and industry relative ratios. Additionally 4 trend-level joint condition variables for each of his industry adjusted ratios (152 measures) were calculated. Such an interactive trend and level measure is variable X_5 of his computed discriminant function which is 1 if the industry adjusted inventory/sales ratio shows an up-trend and is still less than .04, otherwise it is 0.

It is not clear from Edmister's paper whether all variables he considered were in 0-1 form, however the seven variable discriminant function (strictly speaking a linear probability function) derived by stepwise regression analysis with correlation restrictions on variables entering for the tri-annual samples contained only 0-1 variables. Certain of these were industry adjusted, others not, some

straight trend and others trend-level interactive measures. R^2 was .74 and the computed F-ratio at 14.02 was significant at $\alpha = .01$, 3 out of the 42 cases (7%) were misclassified. He did not test this function on a validation sample instead he applied the test suggested by Frank et al (1965), termed by them the "synthetic sample approach" to investigate "sampling bias". In this a discriminant function is computed and resultant classification table produced on the basis of the observation data reassigned into two groups at random and the results compared with the original using a t-test. He reported a statistically significant difference. (The approach is described in more detail in chapter VI § 6.) Edmister also explicitly examined the choice of a cut-off z-score in the light of differential type I and type II error costs and suggested a grey area of uncertainty as did Altman.

No details of the results for the larger sample were given except that they were not statistically significant and Edmister concludes that small firm analysis of this nature requires the provision of at least three consecutive financial statements.

The discussant of the paper, Dake (1972), questions the effect of using 0-1 independent variables on the statistical assumptions underlying the methodology employed and points out that the large number of variables used relative to the sample size really requires a validation test on an hold-out sample before Edmister's conclusions can be fully justified. In fact it may very well be that although significant "sample bias" is not present, "search bias" is. Given the very large number of measures Edmister considers for selection in his model and its size relative to the number of firms, there must be very strong grounds for supposing such bias to be explaining much of the discriminating power. In addition although the use of dichotomous variables is interesting one wonders whether the use of continuous variables would

not have produced a better result especially in the mono-annual sample case. Edmister does not justify his use of the 0-1 measures.

There are problems also in the selection of his samples. Edmister suggests that certain of the more obvious potential firm failures would never have entered his data set in the first place since he only had access to the records of companies which had been granted Small Business Administration loans and this could be a reason for the lack of discriminating power of his mono-annual function, ie some potential failures had already been rejected by SBA credit analysts. Joy and Tollefson (p725) point out that strictly speaking as a result of this his conclusions only pertain to firms granted loans.

An additional reason for the problems he experienced with the mono-annual sample may be that firms which have been in existence only a short time are different in financial structure from those which have been in existence longer and consequently his sample of 282 failed firms may have been too heterogeneous for analytical purposes.

One point of interest in the study, however, is the use of industry relative data which was new in the recent literature. Since he did not appear to restrict his data to say one relatively homogeneous sector (manufacturing for example) a priori adjustment of certain ratios might be considered necessary.

Nevertheless, the reader must conclude that on the basis of the results reported it is not at all clear that his conclusions (p1491) viz:- "The discriminant function demonstrates an ability as great as those functions recently estimated for much larger firms" are justified in any operational sense.

The only British study published in this area at all is the one by Lis (1972) which was completed as a 3 month project as part of the City University Msc in Administrative Sciences. It stimulated a lot of interest in the City when the results were published in the Investors' Chronicle (Bolitho, 1973). The particular issue of this magazine in fact referred to article on its cover with as background a picture of Carey Street.

Lis took 30 listed companies failing between 1964 and 1972 (24 manufacturing, 4 contracting and construction and 2 retail) and 30 non-failed companies matched by industry, size and year and computed four ratios from their last 3 sets of accounts, these ratios being drawn from an analysis of certain of the previous literature particularly Altman's 1968 study.

A two group linear discriminant analysis was carried out using the last available financial statements as the data source and the following function resulted:

$$Z = .06289 \text{ X } (WC/TA) + .09241 \text{ X } (EBIT/TA) + .05739 \text{ X } (RE/TA) + .00143 \text{ X } (NW/TD)$$

where Z = overall index
WC/TA = working capital/total assets
EBIT/TA = earnings before interest and tax/total assets
RE/TA = total retained earnings over the company's life/total assets
and NW/TD = net worth/total debt (current and long term)

The computed F-value for the null hypothesis of no difference between the two groups was 13.52 where $F_{4,55}$ (0.001) = 5.4. This function when applied to the data from which it was computed correctly classified 90% - 54 out of the 60 companies with 1 type I error and 5 type II errors with the cut-off set to minimise the total number of misclassifications. The failed firm incorrectly misclassifed, on investigation, proved to have failed for strictly non-financial reasons and should not have been included in the first place.

Other discriminant analyses were carried out using statement data for 2 and 3 years before failure resulting in 81.7% and 76.7% discriminative accuracy respectively. The function derived from the accounts for the last year before failure was not 'tested' on data for the two preceding years.

A careful examination of the report, however, calls into question its value for decision-making purposes on a number of counts. Firstly in terms of the variables used a number of companies had zero debt and an arbitrary figure of 20 was substituted for the ratio. The selection of ratios itself was haphazard and was not helped by the lack of turnover data for many of the companies (only after the 1967 Companies Act were firms required to publish turnover data).

No statistical examination was carried out to test that the underlying data distributions met the statistical assumptions of the model. Most of the 'Lis' failed companies entered into the data used in this study and our experience would suggest that these assumptions were not met with unadjusted data.

The actual function itself for the last year data prior to failure produced a 'grey area' or area of overlap between the two samples of 15 companies or 25% of the data (excluding the company mentioned above) and this is far too great for most purposes. In any case using a cut-

off to minimise the total number of misclassifications rather than the mean of the distance between the two group centroids, which would have resulted in 2 more misclassifications, is suspect. In addition no consideration of differential prior probabilities or misclassification costs was taken. However of most importance probably was the absence of any validation tests, only in this way can the model's discriminative power be really tested; it is unlikely that equivalent results would be obtained in such a test.

Lis also falls into the trap of seeing the type of approach as predictive not definitional. Nevertheless the study was an excellent piece of work by a student with little statistical knowledge and took under three months to complete. Apart from anything else the study is of note in that it showed that the type of approach used - ratio analysis and multiple discriminant analysis - can be employed outside the American environment (compare the French experience of Altman discussed in the next section).

5. Related Multivariate Studies: A Survey

Of the other studies of direct relevance, those dealing with commercial loan evaluation (which is effectively what Edmister was concerned with) have very similar goals in operational terms and can contribute to our study here.

The paper by Altman (1970a) is a simplified version of his 1968 article and consequently need not concern us here. Orgler (1970) used a similar approach to Edmister (1972) and certain of the comments pertaining to Edmister's work are also relevant to this study. His final regression function of 6 variables only contained one conventional financial ratio; certain of the other measures, such as whether the proposed loan was secured or not, were specific to a loan situation. The results were disappointing although probably partly explainable by an examination of his data and methodology, however his attempt at a 3-way, bad, marginal and good classification was interesting.

Altman et al (1974a) however is a more interesting study despite its very poor operational results and cavalier approach to the statistical techniques employed, in terms of the question it indirectly addresses itself to, namely the 'materiality' of the French accounting data used in conjunction with the multivariate models constructed.

The study consisted of an analysis of commercial loan applicants from the French textile industry and the financial statements for one and two years before loan nonrepayment of 35 problem firms (classified as such through default on loan repayment, bankruptcy or liquidation) and 99 good firms matched by size and year, were analysed. All told 41 ratios were computed and divided arbitrarily into liquidity, indebtedness, profitability, turnover, coverage and value added groupings. The last group is a new one to the literature.

A principal component analysis was undertaken for all the 134 firm data taken together and an unconvincing attempt to interpret the first two components (accounting for 26 + 14 = 40% of the variation) made. The component loadings were not given in the paper separately so the reader was unable to attempt his own explanation. A scatter diagram of the scores for the 134 firms (on these two components) was provided but only indicated a distinct lack of discrimination between the two groups.

A multiple discriminant analysis was then carried out using all 41 variables and not surprisingly (p205) "the statistical discriminant power is very high". The type I error based on the data from which the function was calculated was 14% (5 misclassifications) and the type II was 1% (1 misclassification). For a function calculated from data two sets of accounts prior to difficulties the type I error was 22% and the type II, 2%.

A qualitative analysis of the principal component structure and the 41 ratio model resulted in the choice of 10 ratios for inclusion in a final discriminant model with

aggregate minimum misclassification errors (depending on the cut-off) of 13% when type I errors were 43%.

The authors were conscious however that their results were mediocre and the paper gives all the signs of being unfinished, in a footnote (p208) they state "time and resources were running out as our project's deadline approached".

Apart from problems in the statistical methodology employed in the study such as, ignoring the non-consideration of differential prior probabilities and misclassification costs, attempting to construct a discriminant function of 41 variables from two sets of companies, one numbering only 35 firms, the interested reader must ask whether firstly the two groups were each homogeneous (particularly whether the loan interest defaulters resembled the 'failed' firms - bankrupt or in liquidation - in the problem sample) and secondly whether the apparent poor quality of the accounting data in spite of the French standardised system is due to the lack of effective auditing as practised in the States or UK unless it is primarily the methodology at fault. (See the discussant Dufay, 1974.) One wonders if the same results would hold true with a study of French companies similar to those in the UK quoted sector.

The other studies mentioned above at the beginning of §3 are not of such direct interest except in a few cases for suggesting accounting measures etc which might prove useful here. Elam (1975) was interested in the effect of the capitalisation of lease data on the 'predictive-ability' of financial statements in the case of company bankruptcy. His investigations were made up of both univariate and multivariate analyses, the latter consisting of comparing the results of two discriminant analyses, with the relevant constituent ratios in the functions incorporating and not incorporating capitalised lease data, with a view to examining their differential discriminating ability between bankrupt and non-failed firms.

His sample sizes were each from 48 down to 25 and his discriminant functions contained 25 ratios, no real validation tests were conducted. Although the paper was one of the winners in the 1974 American Accounting Association Manuscript Contest and it treats the actual capitalisation of lease data in an ingenious manner, it must be considered methodologically suspect to a certain degree. However there is no need to discuss this here but only to note Elam's conclusions which would appear on the basis of his results to be very convincing. He concludes (p41): "Evidence gathered by this research does not support the hypothesis that: Addition of capitalized lease data to a firm's financial statements will increase the power of affected financial ratios for predicting firm bankruptcy." These empirical results would seem to suggest that at least in certain situations capitalisation or non-capitalisation of leases, which the literature seems to consider important on a priori grounds, does not in fact appear to be very 'material' in practice.

This study is incidentally one of the very few which explicitly recognises the need to view the predictive-ability of accounting data in terms of the purpose to which it is put and the associated decision models.

Another paper of interest is that by Altman and McGough (1974) who sought to examine whether the discriminant function (Altman, 1968) would help the auditor to recognise going-concern problems in the companies he was auditing. A comparison of the extent to which the model would have 'predicted' bankruptcy for 34 firms failing between 1970 and 1973 was compared with the number of qualifications due to going-concern problems made to the accounts by the auditors. For the last available report, the model correctly 'predicted' 28 failures (which can also be taken as another ex post test of the model on data several years after the sets of accounts from which the function was derived - 28/34 = 82% success rate) whereas only 15 firms' accounts were qualified in this way.

A comparative analysis was also carried out using the model to examine the financial state of 21 companies in which the accounts had been qualified for going-concern reasons and mixed results were reported. The small number of cases analysed however do indicate that some companies are able to pull themselves out of trouble. Neverthelss the probability of this relative to the probability of actual failure cannot be appraised. It is interesting that the approach is being used here in more of a definitional than predictive sense.

Of the papers discussing the prediction of failure in specific non-manufacturing industries, the study of American railroads by Altman (1973) is of interest because of its timeliness in the light of the demise of Penn Central and its demonstration of the value of a discriminant analysis approach using financial ratio data in a non-manufacturing environment. In fact with the data from which the 7 variable discriminant function was derived only one company was misclassified out of the 42 (21 failed, 21 'non-failed') for both 2 and 1 years before failure although industry averages 'matched' for different years were used as the 'non-failed' group. The F-value was 20.1 with $F_{7,34}(.01) = 3.21$.

Using a matched sample of non-failed companies however in place of the industry averages the F-value fell to 13.1 and 3 companies were misclassified (including 2 type II errors) by the function using the data sample from which it was derived and a cut-off which minimised the total number of misclassifications not the mean of the two groups centroids. This was not surprising as it would probably have been impossible for any industry mean values to be misclassified as failed in the first case.

Altman tested for the presence of 'search bias' in his first sample using the same approach as in his 1968 paper but did not find it significant. In addition using his first model he examined the Z-scores of 50 railroads selected at random for years between 1946 and 1969, six

of which scored below the cut-off point. Two subsequently failed, one discontinued all railroad operations, two were merged into larger systems which themselves went bankrupt and the sixth was owned by a Canadian railway system. The paper concluded by classifying the 55 existing companies (in 1970) into solvent railroads and potential bankrupts (14, 5 of which had in fact failed by the time of writing). This would have resulted in a prosecution for libel in the UK as the 'potential bankrupts' were named.

The insurance industry study (Trieschmann and Pinches, 1973 and Pinches and Trieschmann, 1974 - both discuss the same piece of research) again is similar in methodology and achieves a similar degree of classification success in a non-manufacturing area with 49 out of the 52 firms making up the samples being correctly classified by the discriminant function derived from them. The computed F-value was 12.559 where $F_{6,45}$ (.001) = 4.75. The authors however found that the financial ratio data computed for the failed companies from the last statement before failure were completely non-normal and the actual accounting items exhibited signs of "window-dressing", hence they used data computed from the second to last financial statement. A comparison of the multivariate model results with those from using univariate data showed its superiority over the best single ratios. The potential dangers of "window-dressing" was also stressed. Although no hold-out sample was tested, validation through the use of a "simulated sample" approach indicated the lack of significant "sample bias".

The bank study (Meyer and Pifer, 1971) however was comparatively unsuccessful. It employed ratios and other measures very dissimilar to those commonly used in the analysis of manufacturing industry and a 0-1 regression (linear probability function) approach. Classification errors, when the derived equation was applied to the

original 60 bank sample, of between 12% and 25% with 9 down to 5 dependent variables resulted. No validation tests were undertaken. The authors suggest that defalcation (embezzlement) explains a substantial proportion of bank failures and this could be one of the reasons why the approach does not appear particularly effective - are the financial ratios and other measures used likely to pick it up?

6. Bond Rating Systems: A Survey

The numerous empirical studies examining the feasibility of replicating the US bond rating systems of Moody's Investors Services and Standard & Poor's Corporation using statistical models apply themselves to similar problems to those we are interested in here in that the ratings are expected to bear some relationship to the risk of default.

Horrigan (1966) in an "evaluation of the predictive power of accounting data in regard to corporate bond ratings" attempted to predict the top six ratings assigned by the companies by using a multiple regression approach. In this the independent variables consisted of 17 accounting ratios computed from a single set of accounts and divided into six classes (short term liquidity, long-term solvency, short-term capital turnover, long-term capital turnover, profit margin and return on investment) and expressed in unadjusted, industry-adjusted and parabolic industry adjusted (!industry adjusted!) form, together with a size of firm measure (net assets) and dummy 0-1 variable to indicate the subordinate nature of the bond. The dependent variable consisted of an integer in the range 9 to 1 to correspond to the 9 principal bond ratings.

He found that his best model, consisting of 6 independent variables in which the subordination dummy and size measure were the most significant statistically, was able to correctly predict in his hold-out sample about 58% of the Moody's new ratings and 52% Standard & Poor's with

most of the remaining predictions within one rating.

Little discussion of the effect of industry-adjustment to the ratios was presented, however Horrigan's table 5 (p53) indicates that the parabolic industry-adjusted measures were more highly correlated with the dependent variable than the unadjusted ratios in 8 out of the 17 cases. The straight industry-adjusted measures were less significant than the other two classes in virtually all situations. What this may tell us is that since all the parabolic measures in the table are negatively correlated with bond rating, bond raters implicitly look unfavourably on deviations from the "industry average" irrespective of their direction - better or worse. In addition in the regression equation the coeffecients of both the parabolic variables included were negative.

The reader of this important study which clearly challenged the remark of Moody's chief rater who was quoted as saying (p48): "It is a judgement of analysts. No computer can come up with a rating", however, is forced to question the assumptions underlying the use of a 1 to 9 scale for the dependent variable and its effect on the linear model. The results produced really seem to argue for classification of bonds to 3 groups, however what the dependent variable should be in this case is debatable. It would appear that a multigroup discriminant analysis might overcome these problems. (See the discussion of Pinches and Mingo's study, 1973a, below.)

West (1966), the discussant of Horrigan's paper, criticised the study on the basis of the fact that an R^2 value of .5 in his model was accounted for by just one variable - net assets and the general lack of theory underlying his hypotheses. In his 1970 article he suggested an alternative approach relating risk premiums on bonds to their default risk and marketability. His independent variables were log (earnings variability), period of solvency, equity/debt and used bonds outstanding and the dependent variable log (coded rating) and a linear regression

approach was undertaken. The results he obtained in 'predictive' tests were similar to those of Horrigan.

Pogue and Soldofsky (1969) adopted a far more complicated procedure with separate discriminant (linear probability) functions computed for each pair of successive ratings from Aaa to Baa, as shown in fig 3.1 below:

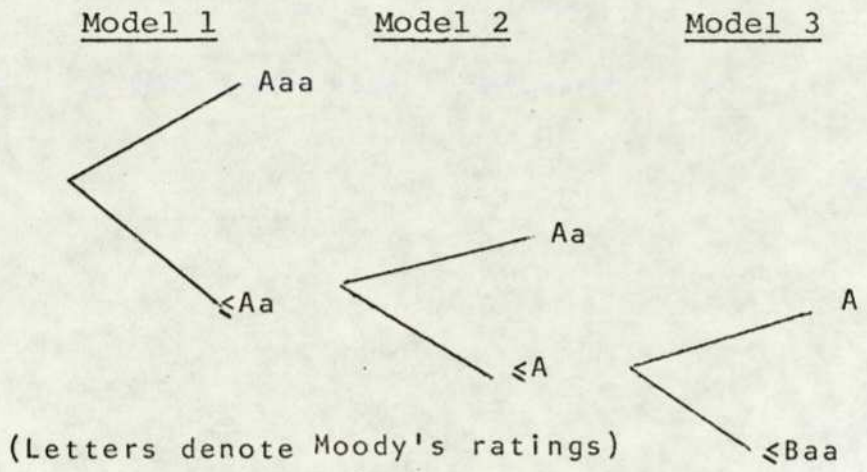


Fig 3.1: The Separate Sequential Discriminant Model Approach of Pogue and Soldofsky (1969)

Their independent variables consisted of 6 year means of a leverage-squared measure, a profitability ratio and net total assets together with the coeffecient of variation of net income/net total assets and their data was drawn separately for industrials, utilities and railroads for years from 1961-1966. Using this approach 8 out of the 10 industrial bonds in their hold-out sample were correctly classified. Considering all their 53 Aaa and Baa bonds together with dummy variables to distinguish industry effects, only 3 were incorrectly classified between the two bond classes when a separate linear probability function was computed.

In a fourth study Pinches and Mingo (1973a) employed a multigroup discriminant analysis approach, with the groups representing bond classes, to examine the same question. Financial data of four types making a total

of 35 variables were calculated, these were information relating to the bond issue itself, one year financial ratios, five year average ratio values and coeffecients of variation measures and were standardised and transformed for each bond class separately to improve normality and reduce the heteroscedasticity of the distributions. The data was then factor analysed and the first seven factors - size, financial leverage, long-term capital intensiveness, return on investment, short-term capital intensiveness,earnings stability and debt and debt coverage stability explained 63% of the variation in the data matrix. Six variables made up the final discriminant function: subordination (0-1) and one variable from 5 out of the 7 factors - $\log_{10}$ (years of consecutive dividends), $\log_{10}$ (issue size), $\log_{10}$ (5 year mean of {1 + net income/interest}, 5 year mean of long term debt/total assets and net income/total assets. The computed F value for the null hypothesis of the bonds coming from the same population was 17.225 with $F_{24,\infty}$ (.001) = 2.13.

An analysis of the different discriminant functions followed and it appeared that (p5) "bond raters are very concerned about specific provisions of the bond issue and the stability of the firm, while the financial performance of the firm is of lesser importance".

An analysis of the predictive ability of the model on a hold-out sample indicated that the model correctly classified 65% of the 48 bonds and rated the others within one rating of their actual score. A second sample of 48 newly rated bonds was then tested to examine the true ex ante predictive ability of the model and similar results obtained, ie the approach possessed future predictive ability not just cross-sectional discriminative ability.

A rigorous statistical analysis was finally carried out to discover why the model consistently misclassified bonds of a particular grade and the conclusions appeared

to be that there was no real difference in the data for these compared to those rated either side.

This study is important not only in terms of its results but also because of its intelligent use of multiple discriminant analysis by authors who clearly understood the underlying statistical models and truly demonstrated the ex ante predictive power of their approach. Joy and Tollefson (1975:728) state that this is the only study to their knowledge to explicitly do this.

These four methodological approaches were separately tested by Ang and Patel (1975) who fitted the appropriate functions etc on data for 5 different years between 1928 and 1938 and it appeared that the Pogue and Soldofsky and Pinches and Mingo studies performed better than the other two or the two naive models they set up, in emulating the appropriate Moody's ratings for the cross-sectional hold-out samples.

However as Ang and Patel point out (p636):

> "The only test of any bond rating method's usefulness is its ability to predict actual financial distress [and] since the accuracy of Moody's rating is also in question, its ex post financial loss experience could not be used as a standard of comparison."

Two approaches were used to compare the ex post 'predictive' accuracy of each method - the sum of the "squared difference between the financial distress experience of bonds assigned by each rating method including Moody's and the average of the reference group with the same rating" (p637) and the loss rate "which was the difference between the realised yield and the promised yield" (p638). They comment (p639)

> "Thus, various bond rating methods were only able to perform better than the random selection methods when the lead time was short. [and]...A mild surprise was the ability of most statistical rating methods using only published information to do as well as Moody's."

These results reinforce the need to view a company within

a dynamic environment and to perceive such 'predictive' models as we have discussed above as being primarily definitional in nature.

The only arguments that can probably be used by Moody's in defence of their rating system on the evidence of this study would appear to be that their methods have improved considerably since 1938 and that in any case the nature of the bond market is now very different. (According to Ang and Patel the percentage of bond defaults in the 9 years before the Second World War was in fact 20 times greater than in the post-war years.) However the results of the above studies in rating the recent data from which they were derived or their validation samples would seem to indicate that things are not necessarily very different now as regards Moody's coming up with different ratings to those 'predicted' by the various statistical models. Ang and Patel clearly point out (p640) "the danger of overemphasizing the importance of agencies ratings and especially their effect on the pricing of new issues, since their ability to predict long term financial loss probabilities is in question". They conclude: "Thus it seems that the role of bond rating in long-term bond pricing must be re-evaluated".

The study by Carleton and Lerner (1969) into municipal bond ratings adopted a similar approach to Pinches and Mingo, however the variables used do not relate to the financial ratios we are interested in here so it will not be discussed further.

7. Alternative Approaches to the Prediction of Company Failure

The studies examined in this chapter have been predominantly classificatory in nature by virtue of the statistical methodologies employed and although the majority have claimed 'predictive-ability' explicitly, as pointed out they should more accurately be classed as definitional.

Two alternative approaches to the prediction of company

insolvency which explicitly recognise the stochastic nature of actual failure are those of Wilcox (1971a, 1971b and 1973) and White and Turnbull (1974).

Wilcox's first two articles are virtually identical and develop the theory of his approach which the 1973 article puts into an operational context and seeks to test in practice. He adopted an intuitively appealing classical gambler's ruin (Markov chain) approach to develop an explicit stochastic cash flow model for the computation of the probability of ultimate failure P(UF) of a company and his formula reduced to the form:

$$P(UF) = \left(\frac{1-x}{1+x}\right)^N \quad \text{if } x, N>0$$

and if $x<0$ and $N>0$, the mean time to failure is $-N/x$ etc

where

x = mean adjusted cash flow/σ

N = adjusted cash position/σ

and $\sigma = \sqrt{(\text{mean adjusted cash flow})^2 + (\text{statistical variance of adjusted cash flow})}$

The terms are defined in detail in Wilcox (1973:165) and are made up of combinations of conventional accounting numbers from the balance sheet and funds flow statement. They require the availability of 6 years of balance sheet and 5 years of earnings data to compute.

The empirical tests consisted of paired comparisons of 52 companies failing between 1949 and 1971 matched by industry, firm size and years of data availability. He found that 94%, 90%, 88%, 90% and 76% of the comparisons made from 1 to 5 years before failure were 'correct' and these figures were all statistically significant.

Wilcox viewed his results as being a substantial improvement over those for Beaver's best ratio - cash flow/total debt, however the study was severely criticised by the two discussants, Benishay (1973) and Kinney (1973), on theoretical grounds with respect to the construction of the model and also as regards the tests of its predictive ability. Benishay (p180) suggests in fact that the paper really only "represents an autopsy of deceased

firms". Effectively the discussants point out that showing a company which eventually fails has a higher probability of failure than a matched continuing firm does not constitute a test of the prediction of its failure.

Nevertheless although the approach appears to produce far inferior results for decision-making purposes to a more conventional discriminatory descriptive approach it has considerable value as a conceptual model and this will be taken up again in a later chapter.

The other study, that of White and Turnbull, postulates an alternative model for computing the probability of a firm going bankrupt which depends "not only upon the firm's future cash flow net of all fixed charges, but also upon its ability to utilise alternative sources of funds: borrowing, issuance of equity, reduction of planned outflows being possible examples" (Synopsis). The final models that were derived using probit and logit analyses (which are alternative approaches to the conventional multiple regression linear probability function) consisted of terms which measured the firm's future cash flow net of all fixed charges, credit rationing in the economy in conjunction with the debt capacity of the firm and its financial risk. R^2's were 0.53 and 0.54 respectively and methods for computing a critical cut-off taking into account differential misclassification costs and prior probabilities were discussed. However ignoring these and employing a cut-off half way between the samples' centroids together with their cumulative distributions White and Turnbull estimated the probability of a type I error as 47% and a type II error 0.6%.

They finally tested their model on 8 firms which failed in 1970 (subsequent to the period for which their model parameters were compiled) and found that using their computed cut-off 5 out of the 8 firms could be classified as bankrupt on the basis of the 3 sets of accounts up till and including the last available and of these 5, 2 also could

be so classified on the basis of the 3 sets of accounts up till and including their prior to last published.

Although the approach is of considerable theoretical interest particularly in its explicit use of forecasts about the future for values of certain of the firm's measures by use of regression, it does not appear to demonstrate as the authors claim (p26): "good classification and predictive ability" on the basis of the results they present. In the present state of the model's development it would appear to be very unwieldy to apply and again as with Wilcox, to offer no advantage for decision-making purposes over the application of a more conventional approach.

8. Summary and Conclusions

In this chapter a detailed examination of the existing literature that has explicitly dealt with issues of relevance here was undertaken and the different methodological approaches that have been adopted for the 'prediction' of corporate insolvency were commented upon in the context of the revised 'predictive-ability' criterion discussed in the previous chapter.

The first sets of studies to be considered were of an univariate nature and indicated that companies which subsequently fail not surprisingly have different values for certain of their ratios, considered separately, to those for companies which continue. It was pointed out that this does not constitute a test of the predictive-ability of the underlying accounting data as was claimed in the papers.

In section 3 the multivariate study of most interest because of its adoption of a related methodology to that used here (Altman, 1968) was examined in detail from both the theoretical and statistical points of view and the results commented upon. It was pointed out again that the study, although maintained to be of a predictive

nature, can only in fact be termed ex post classificatory or at best 'definitional'.

In the following section the other studies addressing themselves to related issues and employing similar methodology, although with inferior results, were described and commented on from the point of view of what could be learnt of relevance here. The papers discussed included a study into the prediction of small business failure and the only UK work; the latter indicating that the generic approach adopted in the US could be applied in the UK environment.

In section 5 other papers of interest, including those examining the prediction of insolvency in non-manufacturing industries, were discussed and in section 6 a detailed review of the US bond rating studies was undertaken with the purpose of firstly examining their potential contribution to our work, as they are effectively concerned with similar issues to those raised here, but also as to whether the formal statistical models constructed were as efficient as the rating systems applied by the US bond rating agencies using 'fundamental' analysis. Similar results were achieved by 2 of the studies and the agencies, however the ability of both these studies and the agencies to predict more than a short period ahead was considerably in question.

In the final section before this one the two alternative approaches to discriminant analysis for the examination of company failure potential which have appeared in the literature were analysed to examine whether they produced as good results as the more conventional approaches and also whether attempting to explicitly measure the probability of failure, which they both did, could yield operational results and justify adoption of a similar methodology here. Both studies, however,although having considerable conceptual relevance, on examination appeared to be quite unwieldly to apply and in any case provided

very inferior results to the more conventional approaches.

Most of the studies reviewed in this chapter, leaving aside the methodological weaknesses in many cases, explicitly claim to be predicting insolvency when in fact all they are doing is classifying firms which have failed or not on an ex post basis. In many cases as well the ex post classificatory ability of a function is considered a test of the 'predictive-ability' of the accounting data used. However, ex ante prediction is very different to ex post classification and to conduct a true test of the predictive power of a model it is necessary to explicitly monitor what happens to companies currently exhibiting 'failure' characteristics into the future - do they fail, recover, or continue in a similar state for a number of years? These studies can, in fact, only really be considered to be'definitional' and that is the starting point explicitly adopted here in deriving models for the examination of the economic issues of interest to us in this research.

CHAPTER IV: THE DATA

1. Introduction

The primary data used in this study consists of financial ratio measures calculated from the accounting items present in the published balance sheets and profit and loss accounts of quoted UK industrial companies.

In this chapter we will first examine the procedures employed for selecting companies for inclusion in our different samples, then the actual accounting data utilised in detail. Next the selection of ratios and other measures used will be discussed, followed finally by an examination of their amenability to statistical analysis and the results of the transformations and adjustments applied to improve the marginal distributions.

Lists of the actual companies and the data used in different stages of statistical processing described in the next chapter will also be provided.

2. Companies Considered

The approach taken in this research for derivation of the classification function subsequently used as a tool of economic analysis, was to consider essentially two groups of companies -'failed' and 'good' (although a third - 'poor' firms was also utilised in one set of computer runs) and examine the differences in the financial ratio characteristics of different subsets in a multivariate context.

The first group of firms was made up of all those which had failed between 1.1.1967 and 31.12.1973, had published their last accounts prior to failure between these dates and met certain other criteria for inclusion. The 'good' firms were companies for which data of the form required was readily available, could be classified as financially sound or 'well-solvent' by people knowledgeable about their operations and again which met certain

criteria to be described below.

All companies we considered (apart from one or two) are or were public industrials with shares (ordinary or preference or both) quoted on a UK stock exchange and principal operations based in the UK and the accounts used were consolidated.

The reasons for working with public quoted companies exclusively were:-

(i) Since public companies are considerably larger on average than private firms - although representing only about 5% of registered companies they account for around 65% of total paid up capital and 75% of total profits (see Bates, 1969), any individual failure is likely to have a far greater impact on the economy.

(ii) The nature and financial structure of private companies differ considerably from those of the quoted sector and company characteristics within each industry are far less homogeneous. These factors may make analysis more difficult (see Bates, 1969).

(iii) Most other empirical studies using financial ratio data both here and in the States have worked with public quoted companies and it was intended to compare our results with related work.

(iv) Information about public quoted companies is more readily available and the financial data more reliable and much more up to date.

The industrial sector was chosen for examination because of its importance in the economy and intrinsic interest, the comparative homogeneity of its financial data (see chII §5) and the presence of related studies with which to compare our results. Companies predominantly in retailing and distribution, property, rentals, finance and insurance etc were consequently excluded. The

problem of industrial classification is a complex one and will not be discussed in detail here, however in terms of selecting companies for inclusion in this study the Stock Exchange Securities Classification System prepared by the Institute of Actuaries and Faculty of Actuaries (see Plyman,1971) was employed and companies assigned to broadly the manufacturing sectors of the Capital Goods, Consumer Goods (durable), Consumer Goods (non-durable) and Other Groups were considered acceptable for inclusion. Certain problems however arose with the classification 'industrial holding company'.

3. Selection of Failed Companies

The definition of failure adopted in this study is that of insolvency. Only those situations are of interest here in which firms are unable to continue in business through inability to meet outstanding financial obligations as a result of factors under the control of the company[1] and where loss to creditors and shareholders consequently results or would have resulted without action by the government.

In Company Law two types of liquidation procedure are known[2]

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[1] John Feaver for example was excluded because its failure was a direct result of a move to new premises in a development area where insufficient labour was obtainable and E J Austin and S Collier on the grounds of fraud in some sense.

[2] The terms winding-up and liquidation are used synonymously. No distinction is made between the concepts of bankruptcy and liquidation in US company law although in the UK only an individual can be declared a 'bankrupt'. Nevertheless because virtually all the literature of relevance to this study originates in the States and the term applied to companies incorporated under the Companies Acts appears to be entering common usage on this side of the Atlantic, however strictly incorrect in a legal sense, the expression 'company bankruptcy' will be used in this study at times as an alternative to 'company failure'.

3.1 Compulsory winding-up under an Order of the Court.

3.2 Voluntary

3.2.1 Members' voluntary

3.2.2 Creditors' voluntary

3.1 Compulsory Liquidation

This is done by Order of the Court and is initiated on a petition either by the company, any creditor or any member on any of the grounds specified in Section 222 of the Companies' Act 1948, the most common one being an inability of the company to pay its debts. The liquidator is appointed by the Court and must act under its supervision. (Gower, 1969:649/50.)

3.2 Voluntary Liquidation

This is initiated by appropriate resolutions of the company to the effect that it is unable to continue in business by reason of its liabilities and that liquidation is advisable. The liquidator appointed takes steps to realise the assets, to ascertain claims against the company and finally to distribute funds left over (if any) to the members by way of return of capital[1]. (Gower, pp650/51)

3.2.1 Members' Voluntary Winding-Up

In this case the appropriate resolutions are preceded by the majority of the directors making a statutory declaration that the company will be able to pay its debts in full within a specified period not exceeding twelve months and the liquidator is appointed by and is responsible to the members.

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[1] The Court, on the application of the company or any creditor, may direct that the winding-up shall continue subject to its supervision (Section 311, Companies' Act 1948), although this is very rare - only 14 cases in the UK between 1964 and 1974.

3.2.2 Creditors' Voluntary Winding-Up

Here a Declaration of Solvency is not made and the creditors appoint the liquidator and if they wish a committee of inspection to assist and supervise him.

As far as we are concerned voluntary liquidations (members) do not indicate insolvency (although liquidity problems may be present) as no material loss occurs to creditors of debenture holders etc and all debts can be met in full. In fact an examination of the accounts of the public quoted companies which entered into Members' Voluntary Liquidation showed them resembling the 'good' firms more than the 'failed' firms and in general to be low in profitability but to have considerable liquid assets.

However another indication of insolvency is that of receivership (Gower, pp434-8).

3.3 Receivership

The appointment of a receiver by the debenture holders, made either out of or by the Court, results when the money due to them is not paid or where there is default in the payment of interest. His function is to collect the rents and profits and to exercise the debenture holders' powers of realisation to meet the payments due; however in most cases he is additionally appointed as manager with power to carry on the business.

The appointment of a receiver does not necessarily mean that the company will be wound-up although this does happen quite often. Nevertheless since he is responsible to the debenture holders who are a class of creditor and it is very infrequent for a company to continue subsequently in its original form, such an action for our purposes is regarded as an additional

indicator of insolvency.

3.4 Government Action as an Alternative to Failure

A number of other companies can be identified as having been clearly insolvent although no winding-up procedure was initiated or receiver appointed; direct government action being the alternative. Such companies are BSA, British Leyland, Ferranti and Alfred Herbert etc. BSA failed prior to 31.12.1973 and was used as data for the derivation of the various classification functions.

As in the US no records are specifically kept of the names of quoted failed companies and consequently identification of firms for inclusion in our 'failed' group of firms proved initially to be a serious problem. However certain Stock Exchange publications together with an examination of historic Moodie and Extel cards (Moodies, a subsidiary of Dun & Bradstreet has itself since failed), the press cuttings service of McCarthy[1] and company files held at Companies House, eventually provided what is hopefully a virtually complete list of the publicly quoted industrial companies failing according to our definitions, with last available sets of accounts for the financial year ending some time in 1967, until the present - for our purposes 21.7.1976. (The companies failing subsequent to 31.12.1973 were used to test the derived final classification function.)

The Stock Exchange Official Year Book lists all companies with current or suspended quotations together with certain financial information and identifies most of those in receivership or liquidation and its sister publication Register of Defunct and Other Companies lists the names of all firms with cancelled quotations usually with reasons for cancellation. The third publication employed was the Stock Exchange Fact Book which is currently being issued on a quarterly basis and lists all the cancellations, suspensions and liftings of

[1] McCarthy Information Ltd., 1a Floral Street, London WC2B 9DS

suspension of securities traded occuring during the quarter.

When data collection commenced the latest available Stock Exchange Official Yearbook was for 1972 and contained relevant information until September of that year and the commercial and industrial sections, together with the late additions section, were examined in detail to identify failed firms. All told details of about 2,300 companies were examined. In a number of situations the class of voluntary liquidation - members' or creditors' - was not specified and recourse had to be made either to historic Moodie or Extel cards supplied upon request by the companies or to Companies House as a final resort. However, it was finally possible to identify all the companies appropriately. Likewise problems arose with companies for which the date of last available set of accounts was not specified in the Yearbook and similar recourse had to be made to determine whether it was before 1967. One or two companies were registered in Edinburgh and this also created some problems.

The list of companies resulting was also augmented by a small number with quotations cancelled prior to 1972, their names being obtained from the Register of Defunct and Other Companies and similar procedures to those described above were adopted in cases of doubt with additional recourse to old editions of the Official Year Book.

The names of companies failing subsequent to September 1972 to the present were obtained from examining the lists of cancelled and temporarily suspended quotations in the Stock Exchange Fact Books covering the period and the most recent ones from an examination of records kindly supplied by the Statistics Section of the Public Relations Department of the Stock Exchange.
(A Stock Exchange listing is suspended if the company's

books are closed so no trading in its securities can take place or it is felt that insufficient true information about its affairs are available for a fair market to exist. Consequently, although suspension of quotation is normally consequent upon liquidation this is not necessarily so, hence it is possible that some failed firms have been missed from inclusion.)

Industrial classification for all companies was determined from the classified lists published in the Stock Exchange Official Yearbooks and Daily Lists, where available, and for earlier years classification on the basis of the description of activities given in the Moodie or Extel cards was attempted. One or two firms caused some problems. Where the Stock Exchange classification coding system was different from the subgroup code valid at 31.12.1973, this was substituted. The classification at time of failure was employed. The classification system was changed in 1970 and earlier year classifications were changed to the current coding.

4. The Failed Firm Subgroups

All valid failed companies were then divided into one of the following three subgroups:

4.1 Prime Failed Group

This was the prime failed group used in the analysis. Firms were included if they met the following conditions:

4.1.1 They had failed before 31st December 1973 - the cut-off date for inclusion in the analysis.

4.1.2 At least five years of consolidated accounts were available and the company had been quoted for that period. (This condition was imposed because the use of trend variables in the analysis required 5 years of data and it could be used as a crude proxy to indicate a measure of continuity and comparative stability in company operations for a reasonable length of time and therefore hopefully reasonably robust

accounting data. Its relaxation would only have resulted in the addition of 4 or 5 companies to the set.)

4.1.3 There had been no year end change in the last year covered by the accounts. (This was not true for Bydand when the accounts for the year to 31.3.1971 were used instead of the 9 months of accounts to 31.12.1971.)

4.1.4 At least one year of turnover data was available.

Twenty three companies satisfied all these criteria and made up the first group and their names, industrial classification, date of last accounts and time between this and the first sign of trouble are given in table 4.1 below.

4.2 No-turnover Failed Group

This group consisted of 8 companies meeting all the conditions for inclusion in the first group except 4.1.4. Relevant details for this group are given in table 4.2.

4.3 Members' Voluntary Liquidation Group

This group consisted of 11 firms which were excluded from inclusion from the first two sets on the grounds of non-insolvency in the terminology employed here, although they had apparently strictly speaking failed in an economic sense. The firms were all relatively small and unprofitable.

Relevant details for the firms in this group, which were only used in the initial stages of analysis, are given in table 4.3.

Company	Date of last accounts prior to failure	Months from date of last accounts to first indication of failure[3]	Industry	
			Description	Stock Exchange subgroup code number
Amalgamated Transport Services[1]	31. 3.70	19	Motor Components	41
BSA	31. 7.72	7	Miscellaneous Engineering	27
Byard Manufacturing	31.12.67	30	Miscellaneous Textiles	62
Bydand	31. 3.71[2]	24	Industrial Holding Company	73
Dansette	31.12.68	10	Electronics, Radio and TV	35
Dickson and Mann Ltd	31. 3.68	12	Mechanical Handling	23
John Galloway	30. 9.70	15	Packaging and Paper	54
Hartley Crosland Group	31. 3.70	23	Industrial Holding Company	73
Headquarters & General Supplies Ltd[4]	31. 3.67	16	Mail Order	57
Hupfield Bros	31.12.69	13	Industrial Plant, Engines and Compressors	22
Lawes Chemical	30. 9.68	10	General Chemicals	68
Lines Bros	31.12.69	20	Toys and Games	65
Mansell Thorpe	31.12.69	7	Contracting & Construction	18
Mitchell Construtution	31.12.71	13	Contracting & Construction	18
Pearson & Foster (Bradford) Ltd	31. 3.70	6	Wool	61
Robert Pickles	31. 3.69	10	Miscellaneous Textiles	62
Rippingilles	31. 3.69	24	Household Appliances	39
Rolls Royce	31.12.69	13	Aircraft and Components	11
W & J Sagar Holdings Ltd	30. 6.68	22	Footwear	64
United Match Industries	31. 3.69	11	Industrial Holding Company	73
Wardle and Davenport	28. 2.69	16	Miscellaneous Textiles	62
Wilson Lovatt and Sons Ltd	31.12.69	14	Contracting & Construction	18
Wilson Mandleburg Ltd	31.12.69	18	Clothing	59

Table 4.1: Constituent Companies of the Prime Failed Group

Notes (continued overleaf):

[1] This company was in fact classified 'industrial holding company' - 73 at time of failure however it was originally classified prior to 1970 to 'motor components' - 41 with the major part of its activities in the area of motor part factoring ie wholesaling. In June 1969 it acquired Allison Freightliners, a large haulage company in poor financial state, mainly financed by fixed interest capital and large bank loans and an examination of the detailed accounts indicated this purchase was the reason for failure.

[2] The accounts for the 9 months to 31.12.1971 were not used in the analysis.

[3] The definition used for this is the earliest of the date of liquidation or receivership or suspension of Stock Exchange listing. The mean value is 15.4 and the standard deviation 6.3 months. If the accounting date of 31.12.1971 is used for Bydand then the mean is 15.0 and standard deviation 6.0 months.

[4] This company was included to increase the sample size in spite of its main activity; it should probably have been left out although inclusion, because of adjustments for outlier ratio values (see §8 below), probably made little difference to the derived models.

Company	Date of last accounts prior to failure	Industry	
		Description	Stock Exchange subgroup code number
British Celilynd	31. 5.67	Packaging and Paper	54
James Brown	31. 3.67	Packaging and Paper	54
Gorringes[1]	31. 1.67	Department Stores	55
Handley Page	31.12.67	Aircraft and Components	11
Cyril Lord	30. 5.67	Cotton and Synthetic	60
A J Main	31.12.66	Contracting and Construction[2]	18
Mersey Mills (1919) Ltd	21. 1.68	Cotton and Synthetic	60
Royston Industries	31. 3.67	Electricals (Ex. Light Electronics, Radio and TV)	19

Table 4.2: Constituent Companies of the No-Turnover Failed Group

Notes:

[1] This company arguably should not have been included for analysis - see note 4 to table 4.1.

[2] It was difficult to classify this company exactly because no industrial classification was available from the Stock Exchange publications. In fact they were engaged in structural and general engineering and fence manufacturing.

Company	Date of last accounts prior to failure	Industry	
		Description	Stock Exchange subgroup code number
Bee Hive Spinning	31. 3.67	Cotton and Synthetic	60
Cozens Sutcliffe	30. 6.67	Contracting and Construction	18
J & CH Evans & Co Ltd	31. 8.69	Breweries	45
John Feaver Ltd	31.10.67	Packaging and Paper	54
William Fison Ltd	31.12.67	Wool	61
Oldham Twist Co	31. 3.69	Cotton and Synthetic	60
Robey & Co Ltd	31.12.67	Industrial Plant, Engines & Compressors	22
Sarum Fine Woollen Mills	31. 3.69	Wool	61
Waterloo Feed Mills & Cake Co	30. 6.67	General Food Manufacturing	49
Joseph Westwood & Co	31.12.70	Contracting and Construction	18
Edward Wood	31. 8.68	Contracting and Construction	18

Table 4.3: Constituent Companies of the Members' Voluntary Liquidation Group

5. The Selection of Continuing Companies

In almost all of the related studies examined (see Chapter III) a matched sample technique was used to select non-failed firms for inclusion in the analysis with individual firm matching in most cases taking place on the basis of industry, size and financial year although usually no justification was given for the approach. This however is not necessary for our purposes and because of the absence of any UK databank equivalent to the US Standard and Poor's Compustat tapes (see the footnote to p66) would have resulted in an even more considerable data collection task.

The underlying statistical assumptions of the multiple linear discriminant model are only that the populations are individually multivariate normal and their convariance

matrices equal, there is no necessity for the number of observations in each group to be equal. In chapter II §5 we discussed the available literature which seemed to suggest that within the general manufacturing sector, at least, industry did not appear to have a large effect on financial ratios, that size was uncorrelated with these measures (at least for the size of firm examined here) and that over the time span this study is concerned with any intertemporal changes in ratios are likely to be very small.

Thus there would appear to be no a priori argument, providing the necessary statistical assumptions are valid for the data employed, for adopting the matched sample approach and a fair number of sets of accounts for any reasonably mixed group of successful industrial companies for financial years within the time span of the 'failed' firm data, would be perfectly satisfactory for the purposes of this study. In addition if in fact the derived models using data for firms selected on this basis perform well, then invoking our amended 'predictive-ability' criterion (see Chapter II §2) this would suggest that the underlying data in conjunction with the decision model employed (in our case the particular statistical technique) are valid for our purposes and success in this sense is a sufficient test of the validity of the approach used to select the firms and data employed.

A firm of London stockbrokers, Laurence, Prust & Co of Basildon House, 7-11 Moorgate, London EC2, have developed a computerised databank of company accounts in standardised format containing the balance sheets, profit and loss accounts and funds flow statements together with certain other information for in most cases at least the 5 most recent years of operations of the companies they specifically follow and this currently holds the accounts for around 160 firms.

The constituent firms of our non-failed groups were selec-

ted from within this databank which offered the advantages of (i) data compiled in a homogeneous way and available in a form that could be directly processed and (ii) companies which experienced financial analysts had been following in detail for some years and which consequently could be assessed on fundamental grounds.

5.1 The Well-Solvent Group

This was the prime non-failed group in the analysis. Firms from within the databank were included if they met the following conditions (around 100 companies were on file at the time of firm selection):

5.1.1 At least five years of accounts were available on tape and the firm had been publicly quoted for all that period.

5.1.2 The company was primarily engaged in a manufacturing activity.

5.1.3 There had been no year end change during the period.

5.1.4 No large growth had taken place during the period; this was indicated for our purposes by an increase in net capital employed of 25% from one year to the next (the rate of inflation was considerably lower than this figure for the whole time period covered by the data).

5.1.5 The last set of accounts was available for the financial year ending in the calendar years 1972 or 1973.

5.1.6 The Laurence Prust analyst following the company indicated that it was in a healthy financial state on fundamental grounds.

The first and second conditions were made for the same reasons as with the 'failed' group and since there were enough companies available the third was set to avoid problems associated with change in year end. A similar objective explains the fourth criterion which was included

in an attempt to avoid problems associated with the use of such financial ratios as earnings before interest and tax/opening total assets where a large change in the denominator over a year would invalidate their effective power of measurement; additionally it is possible to avoid companies in this way which have potentially changed their nature through large acquisitions. The fifth condition was set to ensure that the financial analysts were commenting on up to date financial information and the final one because of the normative nature of this research. The US studies discussed in the previous chapter effectively accepted that there is an absolute difference between all failed and all continuing companies. This is patently not so although the processes by which those continuing firms resembling failed firms as regards their financial characteristics manage to continue in operation for a period and either recover or are tipped over into 'failure' in the sense of the term employed here are not known and are the realm of the behavioral investigator not the economist or statistician. We explicitly recognise that there are many continuing firms which are similar to firms that have already failed in financial terms and in fact examine the issue in detail empirically in Chapter VII.

To ensure the selection of 'well-solvent' companies the respective analysts were requested to rate each of the companies they followed on a 4-point scale in terms of a notional 'long-term credit rating' and those firms assigned to the best two ratings (3 and 4) were considered 'well-solvent' for our purposes. Not surprisingly the analysts found the concept of long-term solvency unfamiliar initially so a verbal translation into the investment terms they were more familiar with was supplied. The only objective of this procedure was to select firms on a fairly crude basis the majority of which were in a reasonably sound financial state. No formal absolute classification was being attempted and so considerations of the capital asset pricing model and tests of the homegeneity of the

underlying decision models used by the different analysts were not necessary. However an examination of the results of various of the discriminant analyses which included the 16 firms classified to the other two ratings (see §5.2 below) to be discussed in the next Chapter together with the results of classifying these 16 firms using the best derived discriminant model (Chapter VI §7) can be used to judge the effectiveness of this crude classification system.

The financial analysts on the basis of their knowledge were also able to indicate companies for which the Stock Exchange industrial classification code was not a good guide to their activities. Such companies were J Lyons & Co Ltd which is really more of a property company than a general food manufacturer and a number of other firms which were effectively retail or leasing/rental operations. 45 firms were available and their names, date of last accounts, LP 'long-term credit rating' and industrial classification are given in table 4.4 below[1].

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[1] Data for two additional firms, Fine Art Developments Ltd and Thorn Electrical Industries, were included in the intial analyses, however they were rejected subsequently as Fine Art had increased its size by 50% (in terms of net capital employed) over the accounting year to 31.3.73 and Thorn Electrical was considered to have sufficiently large rental/leasing activities to make its financial ratio measures potentially dissimilar to those of manufacturing firms in general.

Table 4.4: Constituent Companies of the Well-Solvent Group (continued overleaf)

Company	Date of last accounts	LP 'long term credit rating' (1=low, 4=high)	Industry Description	Stock Exchange subgroup code number
Aberthaw & Bristol Channel Port Cement Co Ltd	31.12.72	3	Cement and Concrete	15
Acrow (Engineers) Ltd	31. 3.72	4	Mechanical Handling	23
Amalgamated Power Engineering	31.12.72	3	Pumps and Valves	24
Associated Biscuit Manufacturers Ltd	31.12.72	4	Milling and Flour Confectionery	50
Associated British Foods Ltd	31. 3.73	3	Milling and Flour Confectionery	50
Associated Portland Cement Co Ltd	31.12.72	3	Cement and Concrete	15
Beecham Group Ltd	31. 3.73	4	Drugs and Pharmacy	67
Bristol Insulated Callender's Cables Ltd (BICC)	31.12.72	3	Electricals (Ex Light Electronics, Radio and TV)	19
Brotherhood (Peter) Ltd	31. 3.72	4	Industrial Plant, Engines and Compressors	22
Courtney Pope (Holdings) ltd	31. 5.73	3	Contracting and Construction	18
Doncaster (Daniel) & Sons Ltd	31. 3.73	3	Founders and Stampers	21
Ductile Steels Ltd	30. 6.73	3	Special Steels	33
Dunford & Elliott	31. 7.72	3	Special Steels	33
J B Eastwood Ltd	31. 3.73	4	General Food Manufacturing	49
EMI	30. 6.73	3	Electronics, Radio and TV	35
Fine Arts Developments Ltd[1]	31. 3.73	4	Tobacco	63
General Electric Co Ltd	31. 3.73	4	Electricals (Ex Light Electronics, Radio and TV)	19
Glaxo Holdings Ltd	30. 6.73	4	Drugs and Pharmacy	67
Hawker Siddeley Group Ltd	31.12.72	3	Miscellaneous Engineering	27
Hopkinsons Holdings Ltd	31. 1.73	4	Pumps and Valves	24
Howden Group Ltd	30. 4.72	3	Industrial Plant, Engines and Compressors	22
Kitson's Insulations Ltd	31. 3.73	3	Heating and Ventilating	30
Lamson Industries Ltd	31.12.72	3	Office Equipment	69
London Brick	31.12.72	4	Bricks and Roofing Tiles	12

1 These were only included in the initial analyses (see footnote p127)

Table 4.4 continued

Company	Date of last accounts	LP 'long term credit rating' (1=low, 4=high)	Industry Description	Stock Exchange subgroup code number
Martin-Black Ltd	31.12.72	3	Wires and Ropes	26
Mather & Platt Ltd	31.12.72	3	Industrial Plant, Engines and Compressors	22
Muirhead Ltd	30. 9.73	3	Electricals (Ex Light Electronics, Radio and TV)	19
Norcros Ltd	30.11.72	4	Industrial Holding Company	73
Pegler-Hattersley Ltd	31. 3.73	4	Pumps and Valves	24
Plessey Co Ltd	30. 6.73	3	Electricals (Ex Light Electronics, Radio and TV)	19
Ranks Hovis McDougall Ltd	31. 8.73	3	Milling and Flour Confectionery	50
Reckitt & Coleman Ltd	31.12.72	4	Drugs and Pharmacy	67
Rugby Portland Cement Co Ltd	31.12.72	3	Cement and Concrete	15
Scapa Group Ltd	31. 3.73	3	Miscellaneous Textiles	62
Scotcros Ltd	31. 3.73	3	General Food Manufacturing	49
Serck Ltd	30. 9.72	3	Miscellaneous Engineering	27
SGB Group Ltd	30. 9.72	3	Contracting and Construction	18
Sheffield Twist Drill & Steel Co Ltd	31.12.72	3	Machine Tools	28
Smiths Industries Ltd	31. 7.73	3	Instruments	31
Stone Platt Ltd	31.12.72	4	Industrial Plant, Engines and Compressors	22
Thorn Electrical Industries[1]	31. 3.73	3	Electronics, Radio and TV	35
Tunnel Cement Ltd	31. 3.73	3	Cement and Concrete	15
Turner & Newall Ltd	30. 9.72	3	Building Materials/Quarry Products/ Asbestos	14
United Buscuits Ltd	31.12.72	3	Milling and Flour Confectionery	50
Weir Group Ltd	31.12.72	3	Miscellaneous Engineering	27
Westinghouse Brake & Signal Co Ltd	30. 9.72	3	Electricals (Ex Light Electronics, Radio and TV)	19
Yorkshire Chemicals Ltd	31. 3.73	4	General Chemicals	68

[1]See footnote on page 128

5.2 The Poor Group

16 other companies in the Laurence Prust databank at the time of company selection met all the requirements for inclusion in the 'well-solvent' group except for condition 5.1.6 above, ie they were not considered by the appropriate Laurence Prust financial analyst to be financially very sound (Assigned ratings 1 and 2). Similar details to those given for the 'well-solvent' set of firms are provided for these companies in table 4.5 below. They were included in some of the discriminant runs to be described in the next Chapter.

Company	Date of last accounts	LP 'long term credit rating' (1=low 4=high)	Industry	
			Description	Stock Exchange subgroup code number
Associated Engineering Ltd	30. 9.72	1	Motor Components	41
Avon Rubber Co Ltd	30. 9.73	2	Motor Components	41
British Oxygen Co Ltd	30. 9.72	2	General Chemicals	68
Brooke Bond Liebig	30. 6.73	2	General Food Manufacturing	49
Brown (John) & Co Ltd	31. 3.73	2	Machine Tools	28
Dowty Group Ltd	31. 3.73	2	Aircraft and Components	11
The Ever Ready Co (GB) Ltd	28. 2.73	2	Electronics, Radio and TV	35
Flight Refuelling (Holdings) Ltd	31.12.72	2	Aircraft and Components	11
Kent (George) Ltd	31. 3.73	!	Instruments	31
Lucas (Joseph) Industries Ltd	31. 7.73	2	Motor Components	41
MK Electric Holdings Ltd	31. 3.73	2	Electricals (Ex Light Electronics, Radio and TV)	19
Morgan Crucible Co Ltd	31.12.72	2	Miscellaneous Engineering	27
Reyrolle Parsons Ltd	31.12.72	!	Electricals (Ex Light Electronics, Radio and TV)	19
Royal Worcester Ltd	31.12.72	2	Industrial Holding Company	73
Strong & Fisher (Holdings) Ltd	31. 5.72	2	Clothing	59
Wilmot-Breeden (Holdings) Ltd	31.12.72	2	Motor Components	41

Table 4.5: Constituent Companies of the Poor Group

In table 4.6 the industrial classifications of the firms in the failed and two continuing groups are given and in table 4.7 the distribution of their last accounting dates.

Stock Exchange subgroup code number	Industrial classification	'Failed' Groups			Continuing Groups	
		Prime (23)	No-turnover (8)	Members' voluntary (11)	Well-Solvent[1] (47)	Poor (16)
	CAPITAL GOODS	7	3	3	31	7
11	Aircraft and Components	1	1			2
12-17	Building Materials				6	
18	Contracting & Construction	3	1	3	2	
19	Electricals (Ex Electronics, Radio and TV		1		5	2
20-27	Engineering (Non-electrical)	3		1	13	1
28	Machine Tools				1	1
30-33	Miscellaneous				4	1
	CONSUMER GOODS (DURABLE)	3			2	5
35	Electronics, Radio and TV	1			2	1
37-40	Household Goods	1				
41-43	Motors (and Distributors)	1				4
	CONSUMER GOODS (NON-DURABLE)	9	5	7	8	2
45	Breweries			1		
49-50	Food Manufacturing			1	6	1
54	Packaging and Paper	1	2	1		
55-58	Stores	1	1			
59-62	Textiles	5	2	4	1	1
63	Tobacco				1	
63-65	Miscellaneous	2				
	OTHER GROUPS	4			6	2
66-68	Chemicals	1			4	1
69	Office Equipment				1	
72-75	Miscellaneous	3			1	1

[1] Including Fine Art (63) and Thorn Electrical (35)

Table 4.6: Industrial Distribution of Firms in the Study

Calendar year of most recent accounts	1967	1968	1969	1970	1971	1972	1973
'Failed' groups							
Prime	2	4	10	4	2	1	
No-turnover	7[1]	1					
Members' voluntary	6	1	3	1			
Continuing groups							
Well-solvent						25	22[2]
Poor						8	8

[1] A J Main is included here although its last set of accounts were for the financial year to 31.12.1966.

[2] Fine Art and Thorn Electrical are included here.

Table 4.7: Distribution of Most Recent Accounting Dates of the Study Data

In table 4.8 a comparison of the number of companies used as data in the present study compared with recent strictly related studies is provided.

Study	Area of Analysis	Size of analysis groups	Distribution of dates of firm failure	Size of validation groups
Present	Industrial failure	68	1967-1973	several hundred
Altman (1968)	Industrial failure	66	1946-1965	91
Altman (1973)	Railroad failure	42	1939-1970	50
Altman et al (1974)	French commercial loan evaluation	134	1968-1971	-
Beaver (1966)	Business failure	158	1954-1964	-
Blum (1974)	Industrial failure	230	1954-1968	-
Deakin (1972)	Business failure	64	1964-1970	34
Elam (1975)	Effect of lease data/industrial failure	96	1966-1972	-
Edmister (1972)	Small business failure	42	1959-1969	-
Lis (1972)	Business failure	60	1964-1972	-
Meyer and Pifer (1971)	Bank failure	60	1948-1965	18
Orgler (1970)	Bank loan evaluation	300	Not specified	120
Tamari (1966)	Not strictly comparable			
Trieschmann and Pinches (1973)	Insurance company failure	52	1966-1971	-

Table 4.8: Comparison of Data Employed in Related Studies

6. Financial Data collection for the Analysis Groups

6.1 The Failed Groups

An initial consideration of the types of financial measure required for the study (of both straight ratio and trend nature) indicated the need for the collection of data on each firm sufficient to reconstruct summary standardised profit and loss, balance sheet and funds flow statements for a five year period of the form given in appendix 4.1 for Rolls Royce and in appendix 4.5a for Dowty Group.

To this end the required financial statement items were laboriously abstracted from historic Moodie and Extel cards supplied on application and where they were not available, from the company accounts filed in Companies House and a computer input form for each company containing 40 data items for each of 5 years was completed for each firm. The data items are listed in appendix 4.2. A computer program was written to convert the data into summary account format (appendix 4.1 or 4.5a) for visually verifying the input against the original data sources and to carry out certain subtotaling checks. Definitions used for the individual items on the coding form were comparable with those employed in the Laurence Prust & Co databank and considerable detective work sometimes had to be undertaken to rearrange the data available from the company card services into a form suitable for the analysis. A list of definitions used for each of the data items is also given in appendix 4.2 which should be read in conjunction with appendix 4.3 which contains the list of financial statement items present for a company in the Laurence Prust and Co databank together with their descriptions.

The 1967 Companies Act required disclosures of additional items of information over and above those required by the previous 1948 Act, of specific

interest here were figures for turnover, wages and interest on overdraft and loans. Due to the lack of turnover and wages data for the earlier years of most of the firms no trend measures employing these items could be computed and in fact although by virtue of its construction all the firms in the 'prime failed' group published turnover data in the last year before failure, wages data was not supplied by three of them. However in the case of the interest item (item 28 in appendix 4.2) it was possible to approximately estimate the missing figures for the last and all earlier years by averaging the opening and closing balance sheet loans etc items and calculating interest payable at 1% above the ruling bank rate.

Some companies treated investment grants as a capital item in the balance sheet whereas others deducted them directly from gross fixed assets. To standardise their treatment and the computation of ratios any accounts with investment grants shown as a capital item were amended and the net asset figure reduced by the amount of the grant.

Certain firms changed their year end during the five year period and pro-rata adjustments were made to the profit and loss items. (Changes to the income statement items also affected the funds flow statement, however as will be pointed out below variables derived from it were found at an early stage to be too unstable for use in the study and were consequently rejected from inclusion in any of the discriminant runs.) In the case of Bydand when the last available set of results only covered a nine month period it was ignored for analysis purposes, however for all the other companies the changes took place in prior years to the last and consequently only the trend variables were affected. (These were removed from later stages of the analyses

because of their lack of effectiveness - see chapter V §3.) In appendix 4.4 the companies and the adjustments made to their accounts for year end changes are listed.

Changes were also made to the profit and loss account items of Wilson Mandleberg for the financial year to 31.12.1966 since the published figures for that year included the operations of both Wilson, Smith and Sutcliffe and J Mandleberg & Co prior to their merger whereas the closing balance sheet for 1965 was for Wilson Smith and Sutcliffe only. The relevant accounting items were reduced 50%.

Rolls Royce and Handley Page had both capitalised some of their research and development expenditures and this was written back into the profit and loss accounts and appropriate changes made to the balance sheets. Specifically Handley Page had capitalised £550,000 in 1966 and £2,529,000 in 1967 of the research and development costs of their Jetstream aircraft and Rolls Royce £200,000 in 1966, £4,400,000 in 1967, £7,700,000 in 1968 and £4,100,000 in 1969 with respect to the RB211 project.

6.2 The Continuing Company Groups

The data for these firms were taken directly from the Laurence Prust & Co databank and a computer program was written to convert the data into the form it was required for this study. Appendix 4.5b contains the standardised accounts for the 5 years to 31.3.72 for Dowty Group produced by Laurence Prust & Co from the data items (listed in appendix 4.3) held in their databank and appendix 4.5a the equivalent standardised sets of accounts in the format required in this study.

The same adjustments to the balance sheet to standardise the treatment of investment grants were made as with the 'failed' firms.

7. The Financial Measures Used in the Analysis

As discussed in Chapter II despite their widespread use there has been little theoretical framework developed to explain the utility of financial ratios or to suggest which ratios may be relevant for which purposes. Most investigators in the present area appear to have ignored the problem and to have used an amalgam of the more familiar measures culled from a variety of sources, popularity, which is self-perpetuating, appearing to be a principal criterion for selection.

Nevertheless some help is available from the literature although translating the theoretical models into operational terms is frequently difficult and the attempt is apparently avoided by most empirical researchers.

The most coherent conceptual model of the firm for our purposes appears to be that of Beaver (1966) adapted from Walter (1957) who views a firm as a reservoir of liquid assets supplied by inflows and drained by outflows. Walter convincingly argues that the static approach to technical solvency determination which stresses the availability of current assets to meet current liabilities is not useful as it does not recognise the true function of current liabilities which is that of a funding source for changes in the volume of sales. He consequently stresses the importance of looking at net cash flows (changes in working capital). Beaver develops these concepts (although he does not appear to use them directly in arriving at his ratio set) and views failure in terms of an exhaustion of the liquid asset reservoir which effectively is a cushion against variations in the different flows.

Essentially, other things being equal, the probability of failure is higher

(i) the smaller the size of the reservoir
(ii) the smaller the funds flow from operations
(iii) the larger the claims on the resources by

creditors (ie debt)

(iv) the greater the funds flow for operations of the business

and (v) the more highly variable are the inflows, outflows and claims on the business

Nevertheless following Walter's argument the size of the reservoir should not be of as much importance as the actual cash flows because of the self-liquidating nature of the current liabilities.

Wilcox (1971a or 1971b), adopting a classical gambler's ruin (Markov chain) approach (see chapter III §7), appears to be able to explain on theoretical grounds certain of Beaver's empirical results with cash flow/total debt, cash flow/total assets and total debt/total assets being certain of the ratios his model suggests are likely to be good 'predictors' of failure.

Bierman (1960) points out the relationship between funds flow measures and changes in liquidity and argues that although the company's cash statement is more useful for internal management purposes it is more open to manipulation by for example deferring the payment of creditors and so for the external analyst funds flow (changes in working capital) is more relevant. Since static measures such as the current ratio and long term liabilities/net capital employed do not take into account the rate at which funds are generated, he suggests various measures relating the time the firm would take to generate funds through its operations to pay off different measures of its net liabilities, or alternatively if its operations are unprofitable to be faced with serious liquidity problems.

However Fess (1966) questions the value of the concept of working capital per se, at least in a static sense, and argues for a "renovated balance sheet".

Lemke (1970) is an excellent paper, explains on theoretical grounds why the current ratio is unlikely to

prove a useful measure for most purposes by analysing the behaviour of its individual components with changes in the level of sales. However the liquidity flow-indices he suggests in its place require for computation information not available to individuals external to the company.

Staubus (1966) discusses four related funds flow concepts concerned with recurring operations: earnings (net change in net assets), working flow (net change in working capital), quick flow (net change in net quick assets) and literal cash flow (net change in cash). He examines the comparative advantages and disadvantages of working with each type of measure and finishes by discussing which type of concept is likely to be of most use for different types of statement user (decision maker). As far as we are concerned all four concepts appear relevant.

Finally Sorter and Benston (1960) and Davidson et al (1964) suggest the use of ratios that describe the ability of the firm to pay its debts in the short term, however again for the external financial statement user certain of the required information items are not directly available although they can be approximately estimated. Nevertheless their concept of defensive assets is useful. (Also see Samuels and Wilkes, 1971 §10.3.)

To summarise then, the existing literature appears to stress the importance of funds flow measures in the examination of company liquidity and solvency and this is taken into account in this study, although earnings and working flow concepts are given more emphasis than literal cash flow as being less amenable to manipulation and because certain information necessary for the preparation of full literal cash flow statements was not available for many of the failed firms. Lee (1972:28) quotes Hendriksen (1970:237): "In the final analysis, cash flows into and out of the business enterprise are the <u>most fundamental events</u> upon which accounting measurements are based and upon which investors and

creditors base their decisions."

Lee further argues (p30) that: "Cash flow information... is perhaps the most objective information possible, avoiding most of the subjectiveness which enters into the technical adjustments involved in the traditional accrual accounting."

Nevertheless, despite the theoretical arguments to the contrary, it will be recollected from §2 of the last chapter that Beaver (1968) found that the non-liquid asset ratios appeared to be far better 'predictors' than liquid asset ratios and hypothesised that this was because their components represented fundamental aspects of a company which could not be readily altered.

Van Horne (1968 Ch.25) gives a good account of funds flow analysis as regards the sources and uses of funds statement both on a cash and on a working capital basis. Samuels and Wilkes (1971) in their chapter on the management of working capital (Ch.10) discuss a number of the issues raised above and point out the vital importance of getting its level right and their Chapter 12, particularly the sections on the 'Cash cycle' and 'Cash flow' and 'Funds flow' statements, is also very relevant to the discussion.

In addition in seeking to descriminate between failed and non-failed firms, theory would also seem to suggest that trend and variability information both for individual accounting items and ratios would contribute to our understanding. Such measures were employed in a number of the previous studies.

To arrive at an initial set of measures with which to work, an analysis of ratios employed in previous studies which were found effective and which were likely to be relevant on the basis of the arguments in the literature was made and additional measures arrived at from an analysis of the existing theory and discussions with

financial analysts based on their experiences. However because of the nature of the multivariate approach used here and the fact that most of the literature appears to be concerned with ratio measures taken one at a time rather than in a multivariate context it was not possible to reject those ratios which on a face value basis might have had little relevance individually because of their potential interaction with other measures. However it was expected that the stepwise multiple linear discriminant approach employed would be helpful in determining effective combinations of measures.

Three classes of broad measure were computed:

7.1 simple ratios computed from profit and loss and balance sheet items

7.2 4 year ratio trend and variability measures

7.3 ratios computed from the sources and uses (funds flow) statement of appendices 4.1 and 4.5a.

The process of determining the best set from which the statistical package would select the final satisfycing combination of measures took several months and additions and deletions and changes in definition took place throughout the time period.

The procedures used to arrive at the final list of 50, which turned out all to be straight ratios, included the development of a suite of computer programs to plot distributions of the measures both non-transformed and transformed in various ways for the different groups and to count and adjust for outliers. The multiple linear discriminant package was run a number of times in addition with different sets of independent variables as well as companies before a final choice of data was made. The comments of the experienced financial analysts consulted were of considerable use.

There is little point in describing here in detail the different steps in the selection of the

final data set except for noting the salient features of the stages in the analysis. All the measures considered and the reasons for their inclusion or rejection are listed in the appendices.

7.1 The Conventional Financial Ratios

The works of Beaver (1966 and 1968), Altman (1968), Horrigan (1966), Edmister (1972), O'Connor (1973) Jaedicke and Sprouse (1965, ChVII) and Miller (1966) were found to be of particular help in chosing ratios in general usage and these were supplemented by ratios used by Laurence Prust & Co financial analysts and other suggested to the author by the theoretical models discussed above.

All told 80 ratio measures computed from income statement and balance sheet data were considered at different stages in the study and a list of these together with definitions is given in appendices 4.6a and 4.6b.

7.2 4 Year Trend Measures

The literature indicated that ratio trend variables might be important discriminators. To investigate this in the initial stages of the study trend measures were calculated for the first seventy one of the ratios in the list in appendix 4.6a (these constituted the original set which was added to as the study progressed) where there was sufficient data available, although the definitions used for a small number of the ratios differed slightly being changed subsequently.

The two groups of companies for which these measures were separately calculated consisted of the 'well-solvent' set including Fine Art and Thorn Electrical - 47 firms, and all the 3 'failed' sets taken together (including the 11 companies which had gone into members' voluntary liquidation [1]) - 42 firms.

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[1] Originally the intention was to examine failure in more general terms with the hypothesis that firms in members' voluntary liquidation would be reacting to similar types of situation to firms classified previously as failed through insolvency and thus they could all be examined together as one group. As the study progressed, however, the characteristics of these firms proved to be very different from both the 'failed insolvent' and the 'well-solvent' companies and they were omitted from the later stages of the analysis.

The trend measures employed were measures of the percentage change in each ratio over the four year period. The variables consisted of:

$$\frac{\text{the difference in the predicted values of the ratios for the most recent and first years derived from the calculated trend line}}{\text{the predicted values in the first year}}$$

A positive sign was assigned for a positive gradient and a negative one for a negative gradient.

The trend line $pr_t = a + bt$, where pr_t is the predicted value of the ratio r_t for year t ($t=1,2,3,4$ with 4 the most recent year), was fitted by the least squares method with

$$b = \frac{4\Sigma tr_t - \Sigma t \Sigma r_t}{4\Sigma t^2 - (\Sigma t)^2}$$

and $$a = \bar{r}_t - b\bar{t}.$$

The percentage change measure used was then given by

$$\frac{pr_4 - pr_1}{pr_1} = \frac{3b}{pr_1},$$ which is made positive if $b>0$ or negative if $b<0$ [1].

For many of the ratios not all companies in the 'failed' set of 42 provided sufficient data enabling computation of the trend measures; in fact only 4 firms provided wages information over the necessary period and 8 sales data. In addition 11 firms had no long term liabilities in the last

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[1] As pointed out above the literature argued that a variability measure might also be important and such a measure was also computed here viz:-
the value for the estimate of the standard error of the line of best fit:

$$SE = \sqrt{\frac{\Sigma r_t^2 - a\Sigma r_t - b\Sigma tr_t}{2}}$$

However on four years data the resulting figures, of course, were not meaningful and were not used in the analysis.

year and another 4 none in at least one of the previous 3 years (these were predominantly those companies which had gone into members' voluntary liquidation). Similar figures for the debt item were 5 and 3 and for the cash item 4 and 3 firms. Any measure which could not be computed was flagged by the program utilised in the computations.

7.3 Funds Flow Ratio Measures

Arguments in the literature suggested that this class of ratio, measuring changes in working capital, should be of utility in the analysis and to this end values for the 48 ratios listed in appendix 4.7 were computed for each of 4 years separately in the initial stages of the analysis for all the firms. However these measures were all without a single exception highly volatile from one year to the next and as a result not amenable to any form of statistical analysis. They were consequently not included in any of the analyses of the study.

Redefinition, particularly by taking changes over a 4 year period rather than over a single year, may have improved matters although various problems not only connected with the amount of data necessary to be collected but with inflation etc would then enter into account.

Additionally since the conventional measures in themselves appeared more than sufficiently 'material', further analysis using this class of measure appropriately redefined was not pursued.

8. Data Transformation

To investigate the amenability to statistical analysis of the measures finally considered, a suite of computer programs and subroutines were written which did the following (with names in brackets):

8.1 Calculated for each input measure and for each company the number of negative items, zero items

and the number of outliers in three ways (outside 2, 2.5 and 3 standard deviations of the mean values) and produced the results in tabular form for easy inspection (EXAMIN),

8.2 plotted data in histogram form excluding invalid items (PLOT),

8.3 produced reciprocal transforms (RECIP),

8.4 produced logarithmic transforms (LOG),

8.5 replaced items which could not be calculated, where appropriate, with mean values (REPLAC),

8.6 adjusted data for outliers - those values outside 4 standard deviations of the mean being replaced by the mean of the other values, and those between 2.5σ and 4σ by the appropriate 2.5σ value calculated from the other values (ADJUST),

8.7 replaced items which could not be calculated with values randomly sampled from a normal distribution with mean and standard deviation derived from the other data (SAMPLE)

and 8.8 calculated mean and standard deviation values for data with items outside of 2.5σ of the mean excluded (STATS).

This latter program employed the iterative procedure given in fig 4.1 below to determine the outlier companies for each measure (excluding of course values which could not be computed due to lack of data items).

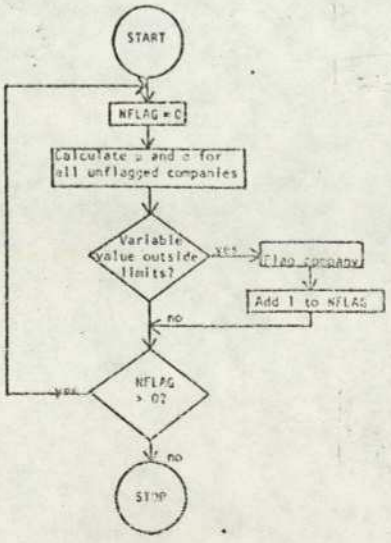


Fig 4.1: Broad Flowchart of Subrouting STATS

These programs and subroutines were used to carry out appropriate transformations etc to improve the normality of the marginal distributions and to impute values for missing data items.

The initial part of the statistical analysis (discussed in Chapter V §3) consisted of an attempt only to examine whether it would be worthwhile to continue to work with trend information and whether such variables were likely to contribute sufficiently significantly to the power of a discriminant function to outweigh the increased work and data collection task necessitated in employing them. In addition it was not forgotten that the inclusion of such measures in the final function would make more difficult and less readily interpretable the results of any analysis of the movement in the financial state of companies over time.

Out of the 71 trend variables potentially calculable, the 13 requiring 4 years of turnover data were not considered nor were any involving long term liabilities (7), cash (6 including the trend of cash to LTL) or interest (2 variables).

Similarly out of the equivalent 71 ratios based on 'final year' data, initial examination indicated that distributions of the ratios with the item 'cash and other liquid assets' as numerator, apart from its absence for some of the failed companies, appeared to have no coherent form for either the 'failed' or 'well-solvent' groups with large numbers of outliers however the ratios were transformed, and thus they were dropped from further analysis. It would in fact appear on this basis that the level of cash held by a company at the end of the financial year is an arbitrary figure not necessarily reflecting any underlying economic reality contrary to the theoretical arguments in the literature[1]. In addition ratios involving long term

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[1] This is also borne out in the factor analysis studies of Pinches et al (1973b and 1974) into the dimensionality of financial ratio data where their 'cash position' ratios were all highly loaded on a separate distinct factor. Similar results appear in our investigation of related issues in Chapter VI §2.

liabilities were dropped from further analysis due to lack of the item in many of the 42 failed firms. Thus an additional 13 ratios were left out from further analysis.

The distributions for all the remaining 102 measures were then examined in detail for the two groups to arrive at a maximum list of 80 which could be handled by the stepwise discriminant analysis computer package, BMD07M (Dixon, 1973), employed.

Using the suite of computer programs and subroutines described above the normality of the marginal distributions for the remaining 102 variables transformed in different ways for the 'well-solvent 47 and 'failed' 42 groups were separately examined and the number of outliers (outside of 2.5σ of the mean of the other variable values) using the best transformation in each case was observed.

Although a priori argument suggests that for most ratios with non-negative values a logarithimic transformation would improve normality (compare the experience of Deakin, 1976, and see the discussion in Chapter II §5 above), this was not found with the data employed here except with certain of the turnover and a few other ratios. Where there was little difference between transformed and non-transformed distributions no transformation was employed since direct interpretation of log ratios is more difficult than for the equivalent untransformed measures. The 78 variables left after removal of those grossly non-amenable to statistical analysis are listed in appendix 4.8 together with their respective transformations and outliers for the two groups.

From Chapter V §3 it will be seen that the addition of trend measures to the data set did not improve the discriminatory power of the model and consequently the increase in the data collection and associated computational work necessitated plus the problems of analysing intertemporal aggregate company financial trends could not be justified.

Analysis was thus finally concentrated on the 'final' year

ratio variables and 50 out of the list in appendix 4.6a constituted the data variables employed in the main analysis. These variables are given in appendix 4.9 together with their transformations and outliers for three groups: the 45 'good' companies (the GOOD-45 set) and two failed groups, the 23 firms with turnover data available (the FAILED23 companies) and an augmented set of 31 (the FAILED31 set) including the second failed group providing no turnover data. This latter group was included in the analysis and only the 41 variables without turnover data were calculated for it. The objective was to examine whether any better results would be obtained through increasing the size of the failed group in the analysis at the expense of absence of ratios requiring turnover data for computation.

The list of 50 was arrived at by carrying out a similar analysis to that discussed above using the same suite of programs but working with the set of 80 ratios given in appendix 4.6a which contained additional ratios (72-80) and changes in the definition of certain of the measures employed previously. Certain of the ratios were additionally rejected from consideration on the advice of financial analysts as being industry dependent, specifically the majority of the turnover ratios. In this way it was hoped that the resulting discriminant model would be fairly robust as regards differences within the broad manufacturing sector. 3 of the 23 failed firms did not supply wages data so 'SAMPLE' was used to provide values for days creditors (variable 45) in these cases. Additionally odd firms had zero denominators for one or two ratios and 'REPLAC' was used to provide appropriate mean values. The outlier observations were adjusted as before.

The use of opening balance sheet items as denominators in the 'profitability' ratios 1-18 will be noted. This was an attempt to measure the true profitability of a company relative to its position at the beginning of the year since the equivalent closing figures would have

reflected the retained proportion of those profits thus distorting the measures.

9. Summary and Conclusion

In the first main section of this chapter the two basic groups of companies - 'failed' and 'good' - used in the analyses were introduced and the reasons for working with quoted industrial firms discussed.

In section 3 the definition of company failure adopted here was given and the procedures for arriving at the names of appropriate failed firms were described. In the following section the constituent members of the three subsets of failed firms employed in different of the statistical analyses together with their characteristics were provided. In section 5 the source of the continuing companies employed, split into 'well-solvent' and 'poor' subsets, was discussed and the names and characteristics of these firms provided. A comparison of the numbers of companies used in this study compared with related works was also given. In the next section the actual accounting items collected for the different companies were examined and the adjustments made to various of these for such things as changes in year end and capitalisation of research and development expenditures laid out.

Section 7 analysed the relevant literature and discussed the reasons for the selection of the variables computed from these accounting items which were subsequently in the analyses. Essentially three classes were computed - conventional ratio, trend and funds flow measures.

Finally the steps taken to arrive at the final data sets potentially amenable to statistical analysis through the use of computer programs to examine marginal distribution normality, compute appropriate transformations and adjust for outliers etc were laid out.

This chapter, in its discussion of the data employed here,it should be noted explicitly points out why a matched sample approach, as adopted in virtually all the other related studies, was not considered necessary, and why the subset of financially sound firms was distinguished from the set of all continuing firms.

An examination of the results of the statistical analyses to be laid out in subsequent chapters will indicate the superior performance of our final discriminant function compared to those in related studies with virtually a 100% classification success on the validation samples and part of the explanation would appear to lie in the way the data was selected as described here. The number of companies used in the derivation of the final model (68) ranked this study as 6th out of the 13 studies (including this one) related in some way and listed in table 4.8 on page 132 above.

CHAPTER V: THE STATISTICAL ANALYSES

1. Introduction

The research study discussed here is essentially an examination of the degree to which firms which have failed differ in their financial characteristics from those which are in a sound financial state. Multivariate statistical analysis techniques are employed to derive discriminating models which can be used to classify firms on the basis of the extent to which their financial characteristics resemble those of firms which have been forced into liquidation or receivership for solvency reasons or other firms which are "well-solvent". These models can then be used in an attempt to explain various economic events in terms of a solvency or multivariate measure of financial "soundness" concept. Unlike related American studies no claim is made that the model is able to predict actual failure. Although on a face value basis the results described below and in the next chapter seem to indicate that a derived score for a company that would classify it as resembling in terms of its financial characteristics previously failed firms is a necessary but not necessarily sufficient condition for actual failure in the sense of company bankruptcy.

In this chapter the various multivariate analyses undertaken using the data of chapter IV to derive the final classificatory model used subsequently are discussed together with the results of the statistical and other tests carried out to determine

(i) whether the underlying data was amenable to the types of analyses conducted and
(ii) whether the derived models were statistically significant.

The results of tests on replication and validation sets of firms will be left for discussion in chapters VI and VII.

In the appendices to this chapter the theory underlying the

statistical models employed is given and certain of the statistical tests discussed.

2. Regression v Discriminant Analysis

The calculation of the appropriate classification function from the data discussed in chapter IV which can be used to classify firms into one of two classes, can be approached using multiple linear regression analysis with a dichotomous 0-1 dependent variable (when the model is known as a linear probability function) or two group linear discriminant analysis. And although the results from employing the two approaches are the same, their distributional assumptions and derivations differ substantially.

In the literature, Edmister (1972), Meyer and Pifer (1971) and Orgler (1970) used a linear probability function approach whereas the other authors conducting related multivariate studies (listed in table 4.8) employed 2-group linear discriminant analysis.

Ladd (1966) discusses the two models in some detail and demonstrates their mathematical equivalence. However for our purposes the linear probability approach suffers from certain important drawbacks which outweigh any of the computational advantages from using the better developed multiple regression programs available. These are briefly

(i) the variance of the error varies with the values of the independent variables, ie the assumption of homoscedasticity is not valid when the dependent variable is dichotomous[1] and

(ii) the value of the dependent variable calculated

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[1] Goldberger (1964:249-255) discusses an approach for overcoming this problem although the two stage procedure suggested has the disadvantage of using the same set of data twice.

from the linear regression equation in practice may be outside the range 0-1, whereas the model can only be interpreted as a linear probability function if the calculated value lies between 0 and 1[1].

The use of discriminant analysis overcomes these problems, although requiring in turn that the two observation populations are each separately multinormal with common variance-covariance matrices, however no assumptions need to be made about the distribution of the error terms.

The computer package employed for the discriminant analysis was BMD07M (Dixon, 1973:233-254) which is stepwise and able to handle multiple groups. The particular program used was available at the University of London Computer Centre on its CDC 7600/6600/6400 complex and is essentially a 1968 implementation partially updated. As the maximum number of variables it could handle was restricted to 70 certain modifications had to be made to the program to increase the number to 80.

Investigations with different sets of data took place over an extended period and a very large number of runs were made. The results discussed below relate to:

(i) the initial analysis to investigate whether trend data was of sufficient additional utility for our purposes to outweigh the disadvantages of additional data collection and more complex calculations

(ii) a three group analysis to determine whether the 16 continuing firms not classified by the Laurence Prust investment analysts as "well-solvent" were a separate and distinct entity in terms of their financial characteristics

(iii) the runs to derive the final model in which

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[1] Probit analysis can be employed to overcome this although non-linear normal equations result; see Goldberger (1964: 250/51). Kuehn (1975:Chs.3-5) in his empirical study into takeovers derives a series of linear probability functions and equivalent probit models and compares the results.

(a) all the 31 strictly failed firms ('prime failed' and 'no-turnover' groups of tables 4.1 and 4.2) were included but with ratios requiring turnover data for computation left out from the variable set

and (b) the no-turnover group of failed firms was excluded allowing for inclusion of the turnover ratios in the variable set from which the discriminant function was derived

and (iv) the analysis undertaken to investigate whether using all the available continuing firms ("well-solvent" and those not classified as such by investment analysts - termed here "poor") produced a significantly different model from the one finally arrived at in the set of runs under (iiib) above.

Good accounts of the theory and mathematics of multiple linear discriminant analysis are given in Cooley and Lohnes (1971), Tatsuoka (1971) and other standard works on multivariate analysis; a brief description of the technique is given in appendix 5.1. Essentially the approach in the two group case is aimed at deriving a function which is a linear combination of variables that will best enable classification of observed items to each of the two classes. In the multigroup case (n-1) functions are derived (where n is the number of groups), however not all of them are necessarily statistically significant or have useful discriminating ability. Cooley and Lhones (1971:244) suggest that even for situations in which a very large number of groups are under study, three or even two discriminant functions usually suffice.

3. Discriminant Analysis of the FAILED42 and GOOD47 Groups of Firms

In the initial stages of the empirical analyses all the firms failing according to the definitions employed here plus those in voluntary liquidation (members) were treated as one group - the 'FAILED42' set, and a two-group step-

wise discriminant analysis was carried out with these constituting one of the groups and the 47 'well-solvent' companies - the GOOD47 set the other. The list in appendix 4.8 describes the 78 variables employed in this analysis. It will be remembered that 14 of the FAILED 42 firms provided no turnover data so the appropriate variable values were sampled (chapter IV §8). (The constituent firm names are provided in tables 4.1, -4.4, ppl21-3 and 128-9.) As pointed out in Chapter IV (footnote to §7.2 pl41) the results of these first runs together with other data analyses indicated that firms in voluntary liquidation (members) were very different from other failed firms in terms of their financial characteristics, and consequently only firms which had strictly failed were used in subsequent analyses. Nevertheless these runs which included trend variable data did show that such measures added very little to the discriminant model and consequently could be left out from consideration in following runs.

The 'best' discriminating function (see appendix 5.1.2) with minimised multicollinearity and all included variables statistically significant resulted after 6 steps and was of the following form:-

$$z = 12.2 \times EBIT/TA_{t-1} + 10.2 \times CF/S - .469 \times TL/NW - 1.82 \times \Delta(Dr./Cr.) + .145 \times S/av.inv. + .0142 \times \text{days debtors}$$

and this classified all but three firms correctly (the classification method employed is described in appendix 5.1.5) - Amalgamated Transport, Joseph Westwood and Waterloo Feed Mills. In chapter IV pl21 in the note to table 4.1) it will be recollected it was suggested that Amalgamated Transport, in fact, belonged to an invalid industrial classification for inclusion. The other two firms were in members' voluntary liquidation.

The simple within groups correlation matrix and included variable F-values are given in table 5.1 below:-

Variable	F-value						
12.	44.3	1.00					
21.	11.1	.44	1.00				
34.	7.6	.12	.09	1.00			
69.	17.8	.45	.21	-.25	1.00		
77.	5.4	.06	.07	.10	-.09	1.00	
78.	10.8	-.26	-.10	-.21	.08	-.38	1.00
		$EBIT/TA_{t-1}$ 12.	CF/S 21.	TL/NW 34.	Δ(Dr./Cr.) 69.	S/av. inv. 77.	days debtors 78.

Note: $F_{1,82} \simeq 5.24$ for $\alpha = 0.025$. (See appendix 5.1.4 §iii)

Table 5.1: Simple Within Groups Correlation Matrix and Associated Information for Included Variables: GOOD47 - FAILED42 Discriminant Function

$$r_{ij} = \frac{\text{Covar}\ (x_i,\ x_j)}{\sqrt{\text{Var}\ (x_i)\ \text{Var}\ (x_j)}}$$

where $\text{Covar}\ (x_i, x_j) = \frac{1}{n-g} w_{ij}$

$$\text{var}\ (x_i) = \frac{1}{n-g} w_{ij},$$

W = within groups cross-product matrix

with $w_{ij} = \sum_{m=1}^{g} \sum_{k=1}^{n_m} (x_{mki} - \bar{x}_{mi})(x_{mkj} - \bar{x}_{mj})$

where n_m = no.of observations in group m

$n = n_1 + n_2$

g = no of groups (here $g = 2$)

The computed F statistic to test for significant group differences was 47.59 but $F_{6,82}$ ($\alpha = .001$) $\simeq 4.26$, hence the null hypothesis of no significant difference is strongly rejected. Similarly each of the individual variables included is significant at $\alpha = .025$ ($F_{1,82} \simeq 5.24$ for $\alpha = .025$).

The only trend variable included was the percentage change in the Debtors/Creditors variable over four years and it

bears a negative sign which was to be expected - as firms face liquidity problems they are likely to attempt to accelerate the collection of debts but delay paying creditors for as long as possible. It appeared that the addition of no other trend variable would have improved the model further. It was also interesting to observe that the Δ(Dr./Cr.) measure had no discriminating ability whatsoever on a univariate basis (judged by its initial F-value for inclusion in the model given by the package - see appendix 5.1.4 §iii, in fact when the 78 variables were arrayed in descending order on the basis of their univariate discriminating power (F-value) Δ(Dr./Cr.) was ranked last! (The rankings are given in appendix 5.2.) However the measure was the third to enter the multivariate model and this confirms the value of adopting a multivariate approach.

The inclusion of the first variable $EBIT/TA_{t-1}$ left only three trend variables [Δ(QA/TA), Δ(QA/NW) and Δ(Dr./Cr.)] with significant F-values to enter at the second step.

Despite a priori arguments, then, on the basis of the results of the initial runs omitting trend variables from subsequent analyses would appear justified. The lack of their significance however was surprising especially as the mean values of most of the ratios for the failed group fell steadily as actual failure approached. (This is discussed in more detail in chapter VI §8.) It may be partially explained by the larger variances for the trend measures than for the straight ratio variables and particularly for the FAILED42 set compared to the GOOD47 group. Trend measures appear considerably more volatile and thus less amenable to statistical analysis.

Apart from the inclusion of 11 non-insolvent firms in the FAILED42 population - the voluntary liquidation (member) companies - and the inclusion of a trend variable, requiring additional data and computation effort, in the function, other drawbacks related to the operational use of the model, specifically that three of the six variables required turn-

over data and 14 of the FAILED42 firms did not supply the information. Thus clearly, in spite of its high classificatory ability on the firms which made up the original populations from which the discriminant function was derived this model was not completely satisfactory.

4. Three Group Discriminant Analysis

An additional set of runs was carried out using the same two groups - GOOD47 and FAILED42 as in the previous section and the 78 measures of appendix 4.8, but including a third set of firms in the analysis. This consisted of the 16 companies not classified to the best two ratings by the Laurence Prust financial analysts (see chapter IV §5) - ie continuing companies meeting all the criteria for inclusion in the 'well-solvent' group except that they were not considered to be financially very sound. These were termed the 'POOR16' group (table 4.5 p130). The main objective was to investigate the extent to which it could be meaningful to think in terms of three distinct populations of firms each with different financial characteristics.

N-group discriminant analysis for n>2 cannot be directly interpreted in the same way as in the two-group case. N-1 uncorrelated discriminant functions are derived and can be separately tested for significance. (See Tatsuoka, 1971:164/5.) A brief description of the statistical model is given in appendix 5.1.3.

For the three group analysis of concern here table 5.2 lists the variables found to be the best discriminating set together with their F-values. The high correlations between certain of the variables should be noted. The size of $r_{16,28}$ is to be expected given identical denominators and related numerators for the two ratios.

Two trend variables are now included in the model and two of the same variables employed in the two group analysis model described above are also present in this case, while

a third $EBIT/CL_{t-1}$ is highly correlated (.79) with $EBIT/TA_{t-1}$.

Variable	F-value						
1.	8.7	1.00					
16.	4.2	.48	1.00				
28.	8.4	.27	.73	1.00			
40.	4.2	-.01	.30	-.18	1.00		
69.	10.6	.25	.43	.28	-.55	1.00	
78.	5.0	-.06	-.29	-.26	-.03	.06	1.00
		FF/S	$EBIT/CL_{t-1}$	CF/CL_{t-1}	$\Delta(TL/CA)$	Δ(Dr/Cr.)	days debtors
		1.	16.	28.	40.	69.	78.

Note: $F_{2,97} \simeq 3.85$ for $\alpha = .025$. (See appendix 5.1.4 §iii)

Table 5.2: Simple Within Groups Correlation Matrix and Associated Information for Variables Included in the 3-group Discriminant Model

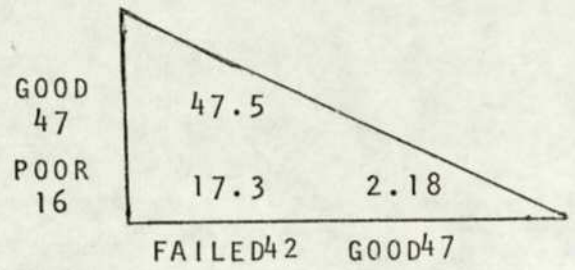
In table 5.3 the classification matrix is laid out with firms assigned to the group for which the square of their Mahalanobis D^2 distance to that group is a minimum. (This measure may also be used as a chi-square variable with degrees of freedom equal to the number of variables in the model to test the degree of confidence with which the classification is made. See appendix 5.1.5.)

		FAILED 42	GOOD 47	POOR 16	TOTAL
Actual Group Membership	FAILED 42	37	0	5	42
	GOOD 47	0	31	16	47
	POOR 16	1	4	11	16

Table 5.3: 3-way Classification Table

Wilks' Λ statistic to test the significance of the overall difference among the group centroids = .227 with degrees of freedom 6, 2 and 102. As shown in appendix 5.1.4 §i this is approximately equivalent to the F statistic 17.78 with 12 and 194 degrees of freedom. But $F_{12,194} \simeq 2.50$ for $\alpha = .005$ hence the discriminant analysis has a high degree of statistical significance[1].

The matrix of F-statistics to test for significant differences between group centroids taken in pairs (see appendix 5.1.4 §i) is given in table 5.4.



Note: $F_{6,97} \simeq 2.22$ for $\alpha = .05$

Table 5.4: The F-Values for Testing Differences Between Each Pair of Groups

The equations of the two discriminant functions are

$z_1 = 6.88 \times FF/S + 1.05 \times EBIT/CL_{t-1} + 3.91 \times CF/CL_{t-1} - .913 \times \Delta(TL/CA) - 2.00 \times \Delta(Dr./Cr.) + .0125 \times$ days debtors.

$z_2 = -8.62 \times FF/S + 6.72 \times EBIT/CL_{t-1} - 6.17 \times CF/CL_{t-1} + .520 \times \Delta(TL/CA) - 1.54 \times \Delta(Dr./Cr.) + .00040 \times$ days debtors.

with associated eigenvalues λ_1 and λ_2 = 3.078 and .082. The first discriminant function is significant at $\alpha = .01$ (Bartlett's $\gamma = 139.83$ with $\chi^2_{7df} = 18.475$ for $\alpha = .01$), but the second is not significant even at $\alpha = 0.1$. (Bartlett's $\gamma = 7.85$ with $\chi^2_{5df} = 9.236$ for $\alpha = 0.1$.) In fact the first functio

[1] Alternatively as shown in appendix 5.1.4 §ii, Bartlett's γ statistic calculated from Wilks' Λ is distributed approximately as a χ^2 - statistic with $p(g-1)$ degrees of freedom where p = number of variables included in the model and g is the number of groups. Here Bartlett's γ is 147.7 But $\chi^2_{12df} = 26.217$ for $\alpha = .01$, hence again the discriminant analysis is statistically significant.

accounts for 97.4% of the discriminating information available[1].

The five 'failed' companies classified as 'poor' consist of the three firms misclassified in the previous model plus Lines Bros. and Rolls Royce. The 'poor' firm classified as 'failed' was John Brown.

As regards discrimination between the groups taken in pairs however, it would appear from table 5.4 and examination of the classification table 5.3 that the GOOD47 and POOR16 companies cannot necessarily be thought of as coming from different populations. An examination of table 5.5 highlights this. Here the 63 GOOD47 and POOR16 firms are distributed according to original classification by the financial analysts on the basis of the four-point 'long term credit-rating' scale (1 = bad, 4 = good) - the individual company ratings are given in tables 4.4 and 4.5 - and according to the model. There appears to be no clear differentiation between the two groups. (This point is brought out even more clearly when the final two-group model is used to classify the 'poor' firms - see the next chapter §7.)

			Classified by Model		
		'Long term credit-rating'	Good	Poor	Failed
Classified by financial analysts	POOR16	(1	0	3	0
		(2	4	8	1
	GOOD47	(3	19	13	0
		(4	12	3	0

Table 5.5: Classification of GOOD47 and POOR16 firms by Laurence Prust Financial Analysts and the Three-group Discriminant Model

[1] Calculated by $\frac{\lambda_1}{\lambda_1+\lambda_2}$. Effectively the model collapses into one dimension (along z_1) with the z_2 coefficients being the result of residual errors.

On the basis of these results, however, it is not possible to argue that fundamental analysis as carried out by investment analysts is not very useful.

Firstly, although a company's z-value calculated using the discriminant model can be thought of as a measure of its performance, and this will be pursued in more depth in chapter VIII, the measure may or may not relate to the different concepts of performance employed by individual investment analysts in appraising companies for investment purposes (and of course these differ between analysts) and only relates to whether firms resemble financially more those which have failed or not.

Secondly, although a serious attempt was made to explain what was required of the analysts and to direct their attention for evaluation purposes onto a solvency criteria and historic information, the concept of a long-term financial soundness measure appeared to be alien to certain of the analysts who were used to thinking in more conventional investment, price/earnings ratios, growth in earnings/share or recovery potential terms etc.

Finally, unless the analysts and the model are used to classify other firms and these are then observed as to whether they fail or not, there is no reason to believe on the basis of its classification of the data from which it was derived that the model is necessarily a better 'predictor' than fundamental analysis. In addition, in the situation we are concerned with here directly where a concept of poor financial state has been introduced, there is no way on absolute grounds to test the classificatory ability using such a model compared with ill-defined 'fundamental' criteria ie mental models used by financial analysts.

Nonetheless, there does appear to be a clear distinction between 'failed' and 'continuing' firms as regards their financial measures in spite of the lack of clear lines of demarcation between the GOOD47 and POOR16 firms. On

this latter basis only a marginally less powerful discriminatory model would be expected if the 'poor' and 'well-solvent' firms were taken together as one group - 'continuing firms' (which is in fact done in §5.3). The previous researchers (see chapter III) mainly attempted to build their 'predictive' models using non-failed firms matched by industry and size criteria to those 'failed' irrespective of their 'solvency' and this may partly explain the lack of equivalent results to those obtained in this study.

5. The Final Runs

The runs in which the final decisional model was derived utilised the GOOD45 group, excluding Fine Art and Thorn Electrical (table 4.4), the 'prime' group of failed firms FAILED23 and the 'no-turnover' failed group - eight in number (see tables 4.1 and 4.2).

Two sets of runs took place, the first using the full 50 variables (including ratios 40-48 requiring turnover data for computation) listed in appendix 4.9 in which case the two populations employed consisted of the GOOD45 and FAILED23 firms. The other runs were to investigate whether increasing the failed set by including the 8 firms (making up the FAILED31 group) for which sales data was not available more than outweighed the disadvantages of having to work with the restricted set of 41 variables (excluding turnover ratios). In fact it did not.

Only the runs with sales variables will be discussed in detail.

5.1 The 'No-turnover' Runs

A large number of functions all with similar discriminatory power were produced by different runs of the BMD07M package but all of those containing more than four variables suffered from very serious multicollinearity either because the package selected more than one profitability measure or if only one was allowed to enter the

function the program selected a second working capital ratio. Consequently the 'best' discriminant function was restricted to 4 variables. In fact a detailed examination of the runs seemed to indicate that there was only marginal benefit in moving from a three to four variable model.

The model $z = -0.344 + 3.26 \times EBIT/CL_{t-1} - 1.65 \times TL/NCE + 4.08 \times QA/TA + 1.07 \times WC/NW.$

resulted after six steps with $EBIT/CL_{t-1}$ the only profitability ratio allowed to enter the model. Although it was not the four variable model with maximal discriminatory power as measured by the computed F-statistic to test for significant group differences[1], it was the only four variable function that was arrived at in the runs with all variables individually significant and with comparatively low multicollinearity. The computed F-statistic was 61.23 ($F_{4,71} \simeq 5.25$ for $\alpha = 0.001$). All but two firms, Rolls Royce and Cyril Lord were correctly classified when firms were assigned to the group from which their Mahalanobis D^2 distance was the smaller.

In table 5.6 the individual F-values for the four variables in the model together with the within groups simple correlation matrix are laid out.

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[1] The model $z = 3.58 + 39.0 \times EBIT/TA_{t-1} - 4.78 \times TL/NCE + 9.90 \times \log_{10} (QA/CL)^{t-1} + 3.13 \times WC/NW$ had a marginally greater computed F statistic (63.42) but the ratio WC/NW was not statistically significant for inclusion (its individual F-value being 2.66). However multicollinearity appeared lower.

Variable	F-value				
10. $EBIT/CL_{t-1}$	66.29	1.00			
25. TL/NCE	33.84	.06	1.00		
29. QA/TA	6.30	-.10	.30	1.00	
34. WC/NW	4.76	-.11	.24	.40	1.00
		$EBIT/CL_{t-1}$	TL/NCE	QA/TA	WC/NW

Note: $F_{1,71} \simeq 3.98$ for $\alpha = 0.05$. (See appendix 5.1.4 §iii)

Table 5.6: Simple Within Groups Correlation Matrix and Associated Information for Variables Included in the GOOD45 - FAILED31 Discriminant Model

5.2 The Final Runs with Turnover Data

The model used in all subsequent analyses reported here was arrived at by working with the full set of 50 variables listed in appendix 4.9 and the GOOD45 and FAILED23 companies. The means and standard deviations for the two groups over the fifty ratios are given in appendix 5.3.1 and the within groups correlation matrix in appendix 5.3.2.

Although a number of functions provided identical classification matrices, the model described below had one of the highest computed F-values for the 5-variable case, multicollinearity was not too great and all variables were individually significant[1].

[1] The model $z=-7.32 + 54.8 \times EBIT/TA_{t-1} - 9.99 \times TL/NCE + 8.94 \times WC/NW + 1.45 \times S/av.inv. + 0.0674 \times$ days debtors, arrived at by allowing two additional steps in the same run, had a marginally greater computed F statistic (64.47) and all ratios were individually significant. However it was not employed in preference because of the inclusion of the days debtors variable which it was felt was a behavioural rather than a financial measure. Compare the inclusion of the trend variable Δ(Dr./Cr.) in the model with trend data variables in §2 above p154.

The resultant function was arrived at after 7 steps and was of the form:

$$z = -3.20 + 47.7 \times EBIT/TA_{t-1} - 11.2 \times TL/NCE + 16.3 \times QA/TA + 8.27 \times WC/NW + 1.10 \times S/av.inv.$$[1]

In appendix 5.3.3 the steps in the discriminant analysis are laid out in extenso and in appendix 5.3.4 the classification of companies to the two groups on the basis of minimum Mahalanobis D^2 distance is provided (see appendix 5.1.5). Only Rolls Royce is misclassified.

The computed F-statistic for the function to test for significant group differences was 62.5 which is significant at $\alpha = .001$ ($F_{5,62}$ for $\alpha = 0.001$ ≈4.76). It will be noted that this is fractionally greater than the value for the 'no-turnover' 4-variable function (61.23) in spite of the additional variable in the model. Although the number of observations is reduced here by eight, because of the magnitude of the degrees of freedom, this makes little difference. Thus the model derived using sales data would appear to discriminate better among the observations used to derive it than the model derived using the 31 variable data set.

This is not, of course, to say that when attempting to classify firms outside of the original sets the five variable model will be more accurate than the four variable one nor that the provision of turnover data is necessarily very 'material' for our purposes. The 5 variable model may only perform better because of greater sample or search bias (see Chapter VI §6) or because Cyril Lord was included in the FAILED31 set but not the FAILED23

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[1] To five decimal places: $z = -3.20104 + 47.67561 \times EBIT/TA_{t-1} - 11.20357 \times TL/NCE + 16.29335 \times QA/TA + 8.26707 \times WC/NW + 1.10174 \times S/av.inv.$

group. Nevertheless we are probably justified in using the 5 variable model in place of the 4 variable one particularly as 3 out of the five variables are common to both and a fourth is highly correlated ($r_{7,10}$ = 0.75 with 68 firms). In addition since the stockturn measure entered at the fourth step and the 5-variable model with marginally higher F-statistic replaced QA/TA with another turnover ratio - days debtors, there would be face value evidence for believing turnover data to be material for classifying firms on the basis of their financial state when taken in conjunction with the appropriate statistical models and other measures. This may or may not have been emphasised if the turnover ratios omitted from the final analyses because of potential inter-industry differences had been added to the 50 variable set (see chapter IV §8).

The individual F-values for the five variables in the model together with the within groups simple correlation matrix are laid out in table 5.7 and the z-scores and the mean and standard deviations for the 5 variables for each group separately and for all observations taken together in table 5.8.

Variable	F-value					
7. EBIT/TA$_{t-1}$	40.5	1.00				
25. TL/NCE	68.1	.24	1.00			
29. QA/TA	4.45	.01	.35	1.00		
34. WC/NW	8.97	.04	.26	.30	1.00	
41. S/av.inv.	11.9	.07	.17	-.10	-.46	1.00
		EBIT/TA$_{t-1}$	TL/NCE	QA/TA	WC/NW	S/av.inv.

Note: $F_{1,62} \simeq 4.45$ for $\alpha = 0.05$. (See appendix 5.1.4 §iii)

Table 5.7: Within Groups Simple Correlation Matrix and Associated Information for the Variables included in the Final Model

Ratio	FAILED23 μ	FAILED23 σ	GOOD45 μ	GOOD45 σ	ALL(68) μ	ALL(68) σ
7. $EBIT/TA_{t-1}$	-.0309	.0968	.1477	.0511	.0873	.1089
25. TL/NCE	1.5500	.5718	.7776	.2461	1.0388	.5277
29. QA/TA	.2591	.1074	.3226	.0835	.3012	.0956
34. WC/NW	.3371	.3690	.5606	.2223	.4850	.2953
41. S/av.inv.	3.7233	1.4236	5.3634	2.5312	4.8087	2.3245
Z	-10.929	5.92	10.929	3.900	0.00	11.404

Table 5.8: Mean and Standard Deviations of the FAILED23 and GOOD45 Companies

(67 degrees of freedom are used in the computations of the σ's)

In figure 5.1 the scores of the GOOD45 and FAILED23 firms are laid out along a linear 'Z-scale' according to their z-scores and these scores are also listed separately in table 5.9.

A visual examination does appear to confirm a distinct cut-off at around Z=0 with Rolls Royce just being assigned to the 'well-solvent' group.

This misclassification is probably not as surprising as it may at first appear. Rolls Royce had not been financially healthy for a number of years previously and this is brought out also in its prior year z-scores ($z_{1966} = -1.30$ adjusted for the merger with Bristol Siddley, $z_{1967} = 1.18$, $z_{1968} = 4.27$, $z_{1969} = 2.91$), however as the report of the inspectors appointed by the Department of Trade and Industry (McCrindle and Godfrey, 1973) indicates the effective cause of the crash was the drain upon the company's finances brought about by the RB211 project (p357):

> "To be sure the company was not without other problems, for example the merger with Bristol Siddeley some years earlier had increased its liquidity troubles. But in the event this was of relative unimportance. The RB211 venture apart, none of the problems facing

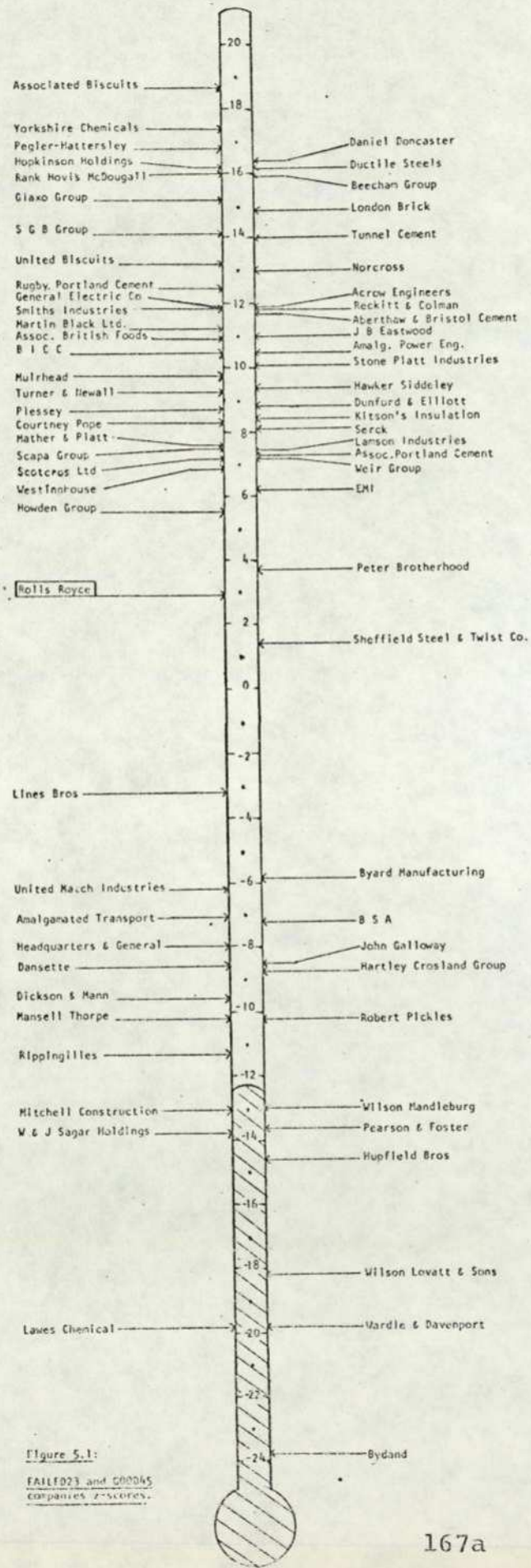


Figure 5.1:

FAILF023 and G00045 companies z-scores.

GOOD45			FAILED23		
No.	Company	Z-Score	No.	Company	Z-Score
1.	London Brick	14.78	1.	Bydand	-23.87
2.	Aberthaw & Bristol Cement	11.71	2.	John Galloway	- 8.51
3.	Associated Portland Cement	7.28	3.	Hartley Crosland Group	- 8.69
4.	Rugby Portland Cement	12.41	4.	Hupfield Bros.	-14.57
5.	Tunnel Cement	14.01	5.	Mansell Thorpe	-10.16
6.	S.G.B. Group	14.10	6.	Mitchell Construction	-13.07
7.	General Electric Co.	11.82	7.	Rippingilles	-11.27
8.	Plessey	8.69	8.	Rolls Royce	2.91
9.	Westinghouse	6.88	9.	Lines Bros.	- 3.17
10.	Daniel Doncaster	16.40	10.	Wilson Mandleburg	-12.97
11.	Brotherhood (Peter)	3.71	11.	Wilson Lovatt & Sons	-18.20
12.	Howden Group	5.43	12.	B.S.A.	- 7.22
13.	Acrow Engineers	11.91	13.	Dansette	- 8.59
14.	Hopkinsons Holdings	16.24	14.	United Match Industries	- 6.19
15.	Serck	8.07	15.	Headquarters & Gen Supplies	- 8.02
16.	Weir Group	7.16	16.	W & J Sagar Holdings	-13.84
17.	Sheffield Steel & Twist Co.	1.39	17.	Wardle & Davenport	-19.83
18.	Dunford & Elliott	8.78	18.	Lawes Chemical	-19.89
19	Associated Biscuits	18.68	19.	Amalgamated Transport	- 7.06
20.	United Biscuits	13.20	20.	Robert Pickles	-10.15
21.	Scapa Group	7.46	21.	Byard Manufacturing	- 5.91
22.	Yorkshire Chemicals	17.40	22.	Pearson & Foster (Bradford) Ltd.	-13.59
23.	Lamson Industries	7.44	23.	Dickson & Mann	- 9.51
24.	Reckitt & Coleman	11.81			
25.	Scotcros Limited	7.14			
26.	Norcros Limited	12.99			
27.	Glaxo Group	15.21			
28.	Associated British Foods	10.87			
29.	Beecham Group	15.94			
30.	E.M.I.	6.23			
31.	Martin-Black Ltd.	11.24			
32.	Rank Hovis McDougall	15.96			
33.	Turner & Newall	9.26			
34.	Courtney Pope	8.31			
35.	Muirhead	9.72			
36.	Kitson's Insulations	8.40			
37.	Smiths Industries	11.80			
38.	Ductile Steels	16.20			
39.	Hawker Siddeley	9.35			
40.	Amalgamated Power Eng.	10.52			
41.	Mather & Platt	7.59			
42.	J. B. Eastwood	10.99			
43.	Stone Platt Industries	10.08			
44.	BICC	10.46			
45.	Pegler-Hattersley	16.82			

Note: The company numbers refer to the sequence in which the company data was submitted to the computer package BMD07M.

Table 5.9: Z-Scores for the GOOD45 and FAILED23 Groups Calculated Using the Final Model and the Ratio Data from which the Discriminant Function was Derived.

> Rolls-Royce would have given rise, immediately or remotely, to the burdens which submerged the company in February 1971."

The last available published accounts were for the financial year to 31.12.1969, 13 months before the actual date of 'failure' and thus did not reflect the large cash outflows during this period. It can also be argued that the failure of Rolls Royce was not directly attributable to the cash outflows on the RB211 project before February 1971 but because of the vast sums required subsequently to complete the project, as indicated by the revised launch estimates, which could not have been recovered from sales of the engines. The estimated launch costs by February 1971 had increased to 2.19 times the £89.3m figure of September 1968 (McCrindle and Godfrey: appendix 9), and in the unconsolidated accounts compiled on a 'going-concern' basis for the year to 31.12.1970 for the company only given as appendix 1 to the report of the inspectors, a special provision for future production losses of £78.8m was made.

Z_{1970} derived from these accounts ignoring the provisions figure and the RB211 R & D capitalisation in 1970 was -5.72, however this is probably an overstatement of the groups true state of affairs since its subsidiaries and such things as its 20% stake in BAC were excluded from the accounts.

It could in fact probably be plausibly argued that Rolls Royce went into receivership as the only way to break the ruinous RB211 contract.

That Rolls Royce was not strictly insolvent at time of failure, if future commitments are excluded, is also brought out by the fact that all creditors including debenture holders have

since been repaid in full by the official receiver together with all accrued interest and the shareholders at the time of the crash have received back 50p/share -2.7 times the value of their original stake as valued by the Stock-market (18½p/share) when dealings were finally suspended on the 26.2.1971 with a further substantial distribution expected shortly.

Thus there would appear to be good reasons why Rolls Royce has a small positive z-score based on the last published set of accounts prior to failure.

5.3 The Grouped GOOD45 and POOR16 Runs for All Continuing Firms

As indicated above an additional investigation was carried out in an attempt to discover whether substituting continuing companies (ALL61 = GOOD45 + POOR16) for 'well-solvent' firms would make much difference to the analyses. The results of this are discussed below.

It will be recollected that no such distinction had been made in any of the previous related studies which were principally straight attempts to distinguish for 'predictive purposes' between 'continuing' and 'failed' companies considering these as belonging to two quite distinct groups. However here we acknowledge a continuum and view 'insolvency' in a definitional sense in terms of a combination of financial dimensions rather than as whether a firm has had initiated against it a set of legal proceedings. The results of the ALL61 model and the analyses of chapter VI confirm the validity of this approach.

In the ALL61 runs, the 61 continuing firms were considered together and the FAILED23 firms again made up the second group. All the 50 variables

of appendix 4.9 were included as data for the runs.

Although the classification matrix was identical to that of the 'final' model above (ie only Rolls Royce was misclassified), the best derived models were not as satisfactory being less statistically significant overall and with only a maximum of four variables individually significant at $\alpha = 0.05$.

Initially all variables were allowed to enter the derived discriminant function however in the seventh step variable 38 - WC/NCE entered as a fifth ratio although it was very highly correlated ($r_{34,38} = 0.86$) with the fourth entered, variable 34 - WC/NW[1]. When variable 38 was prevented from entering variable 41 - S/av.inv. entered making variable 29 - QA/TA no longer individually statistically significant at $\alpha = 0.05$ although the resulting 5 variable model

$z = 0.43 + 19.8 \times EBIT/NW_{t-1} - 10.4 \times TL/NCE + 12.4 \times QA/TA + 7.26 \times WC/NW + .869 \times S/av.inv.$ only misclassified Rolls Royce.

The associated F-statistic to test for significant differences between the groups was 55.14 ($F_{5,78} \simeq 4.68$ for $\alpha = 0.001$).

It will be noted that four out of the five included variables are identical to those in the 'final' model of §5.2 and the fifth is very highly correlated with $EBIT/TA_{t-1}$ (0.906).

Consequently a run was made allowing only the same five variables as in the 'final' model to enter and the resulting five variable model had an identical associated F-statistic (55.08) but with the

[1] Variable 34 was not significant on an individual basis at $\alpha = .05$ in the four variable model without variable 38 and there were two misclassifications - both type I (failed classified as non-failed).

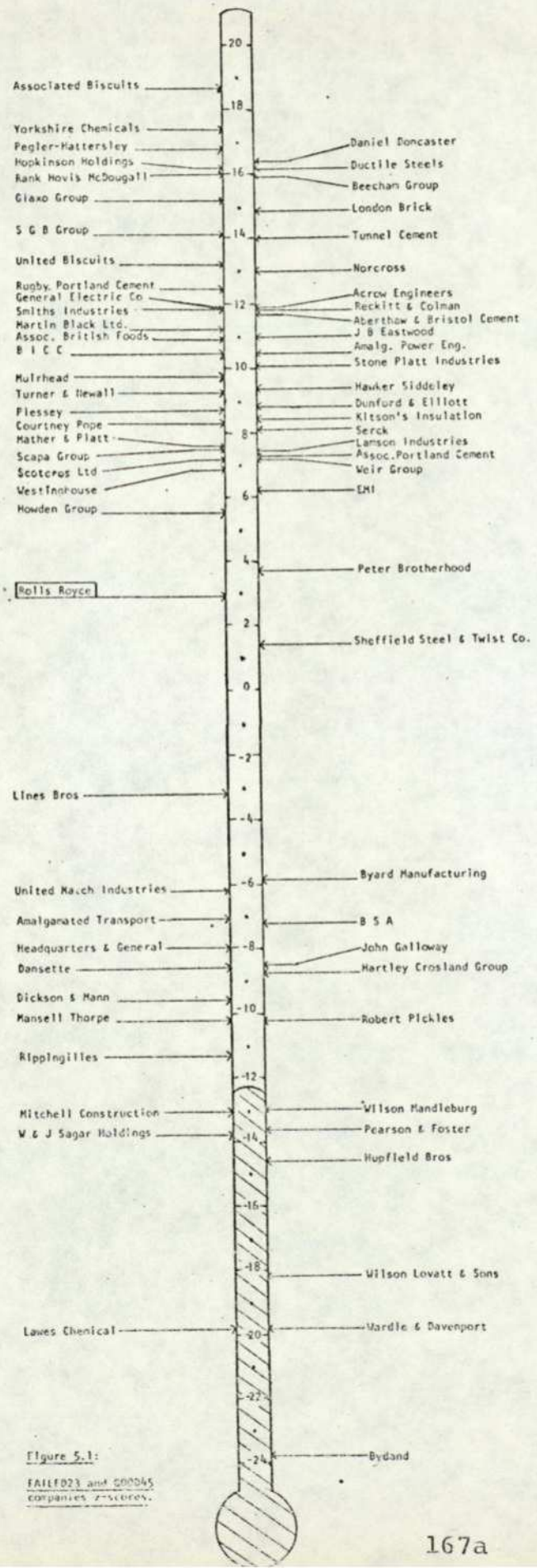


Figure 5.1:

FAILF023 and 000045
companies z-scores.

On the basis then of the runs substituting the ALL61 'continuing' firms for the well-solvent group, it can be seen that as expected, the results are similar in classificatory power although marginally less satisfactory from a statistical viewpoint. However, since the derived models discussed above are virtually identical in structure to the 'final' model arrived at using the GOOD45 set, it would appear that the use of a group of firms a priori classified as well-solvent as well as being theoretically more justifiable, can also be defended in statistical terms in so far as the judgemental aspects entering into the 1-4 'long-term credit-rating' classification cannot have biased the model very significantly.

6. The Validity of the Statistical Assumptions Underlying the Model

The discriminant analysis model that has been used above depends for ensuring minimisation of the probability of misclassification on the assumptions of separate multivariate normality for the populations in the analysis and equality of dispersion matrices. Departures from the first assumption are not too critical because the central limit theorem assures reasonable robustness (Marriott, 1974:37) however homogeneity of the variance-covariance matrices is far more important since if they are heterogeneous non-linear discriminant functions are required. (See appendix 6.5.3 or Morrison, 1969.)

The only related study which appears to have explicitly recognised these potential problems is that of Singh (1971:117-121) who rigorously tested for homogeneity of dispersion matrices using the Bartlett-Box test criterion (Cooley and Lohnes, 1971:228/9) and this approach is also adopted here. However he only examined whether his populations were separately multivariate normal indirectly. Pinches and Mingo (1973a:2/3) acknowledge the underlying assumptions but do not test to determine whether their

data conform (footnote pp 9/10) and consequently whether their classification criteria is appropriate.

6.1 Testing for Multivariate Normality

Two approaches can be utilised for examining the multinormality of multivariate data.

6.1.1

If a vector variable is multivariate normal then every one of its marginal and conditional distributions will each be normal although the converse is not necessarily true. Nevertheless if every possible linear component of a vector variable is normal then that vector variable is multivariate normal in distribution (Cooley and Lohnes:37/8).

Thus in our case for the 'final' discriminant model, the two populations could have been separately tested for multivariate normality by conducting principal component analyses on the 23 X 5 and 45 X 5 observation matrices and then testing all the resulting components individually for normality using the X^2-test.

6.1.2

An alternative approach (Cooley and Lohnes: 35/6) makes use of the fact that for a multivariate normal distribution in p-dimensions, the surface in a p-dimensional hyperplane for which the density function is a constant, is an ellipsoid specified by the quadratic form

$$d^2 = (X - \bar{x})' W^{-1} (X - \bar{x})$$

where X is the observation matrix, $\bar{x}$ the centroid and W the dispersion (variance - covariance) matrix.

For all points on the surface of a given ellipsoid, d^2 and the cumulative probability of an observation lying within the surface boundary are constant consequently in our

case considering d^2 as a distance function it is possible to identify observations (firms) which have individual Mahalanobis D^2 - multivariate distance $>d^2$ for a given cumulative probability value and consequently whether the multivariate distributions of the data set used to determine the final discriminant function are significantly non-multivariate normal.

The second approach was adopted in this study because of the ready availability of the Biomedical Computer Program BMD10M - Identification of Outliers (Dixon, 1973: 277-284) - which was used to provide a list of those firms in each population with Mahalanobis D^2 - distances outside of 95% and 99% probability contours (d^2) calculated from data for all the other firms. A description of the approach is given in appendix 5.4.1 and in appendix 5.4.2 the names of the firms lying outside the 95% and 99% contours are listed for both populations together with their industries. In appendix 5.4.3 a part of the output for the 95% contour GOOD45 run is provided and this indicates why the 8 firms are outside the boundary.

Table 5.11 below contains a summary of the results with numbers in brackets indicating the expected number of outliers.

Population	Firms Outside '95%-contour'		Firms Outside '99%-contour'	
GOOD45:	8	(2)	1	(½)
FAILED23:	1	(1)	0	(0)

Note: numbers in brackets denote expected number of outliers

Table 5.11: Outliers to the Data Distributions

On the basis of the table it would appear that the null hypothesis of significant departures from multivariate normality cannot be rejected for the FAILED23 set although this is not so for the GOOD45 population.

An examination of the industry distribution of the 8 GOOD45 firms outside the 95% contour in appendix 5.4.2 does seem to indicate potential inter-industry differences, however only one firm (London Brick) out of the 8 had a transformed ratio. (Its stock-turn figure was 5.04σ outside of the mean of the other firms and was consequently replaced by the mean value of the other companies.) It would appear in fact, at least tentatively, that process-type firms differ in their financial characteristics to more general manufacturing companies.

An interesting hypothesis may very circumspectly be suggested by these unexpected results, namely that 'failed' firms are a more homogeneous group in terms of their financial characteristics than well-solvent firms, however this thought will not be pursued any further here given the non-random selection of firms in the two sets and their small sizes.

63.2% of the dispersion in the case of the GOOD45 set was accounted for by the first two principal components and 68.9% in the case of the FAILED45 group.

6.2 Testing for the Homogeneity of Group Dispersion Matrices

Although as suggested above departures from multivariate normality are not necessarily very serious in most situations, this is not true for the Bartlett-Box multivariate test for homogeneity of group dispersions which is very sensitive to any depart-

ures from normality (Cooley and Lohnes:228/9).

This test was carried out on the two dispersion matrices and the null hypothesis of no significant differences was strongly rejected. (The calculated F-value with 15 and 8134 degrees of freedom was 5.22 but $F_{15,8134} \approx 2.70$ for $\alpha = .001$.) A description of the statistical test and the actual computations are given in appendix 5.5.

Because of the apparent departure from multivariate normality for the GOOD45 group, however, it is not strictly possible to determine whether the two dispersion matrices are truly heterogeneous or not. A cursory examination of the variances for the 5 variables in the model for each of the two groups which are given in table 5.8 above indicates potential differences on an univariate basis although these were not tested for statistically since no inference about differences between variance - covariance matrices on a multivariate basis could be derived and in any case the univariate F-test requires similar assumptions of normality.

Singh (1971:118) found initially that in most cases the null hypothesis was rejected by his data as well although this appeared to be largely due to the inclusion of a size variable which when removed improved the number of cases in which the null hypothesis could not be rejected at 5%. He points out that in the case of equality of 'sample' sizes and large number of observations, inequality of the dispersion matrices has no effect on the level of significance or on the power of Mahalanobis D^2 statistic used to assess the computed discriminant functions. However since population sizes differ in this study, this property cannot be applied here.

And, in any case, as Marriott (p39) indicates, to

fit a quadratic discriminant function (see appendix 6.5.3) large samples (which we do not possess) are necessary in all groups to avoid spurious discrimination. He further points out that since the underlying assumptions of the linear discriminant function are hardly ever realistic in a practical situation and working with non-linear functions is highly complex, it is best to transform the data such that the dispersion matrices are not grossly different and then use linear discriminant functions. This is the approach adopted here.

Ultimately, however, the non-conclusive results of the statistical tests on the dispersion matrices indicated above may not be of too much importance. What is of far more importance is whether the resulting model is valid when tested on other data than that used to derive it and in an operational context whether it can be used in a decision situation. The emphasis in this study is on deriving a 'satisfycing' model which is efficient for the purposes for which it is designed, if it is not a 'good' model for our purposes this will be shown up by the validation studies of Chapters VI and VII irrespective of whether the data from which it was derived strictly meets the assumptions specified or not.

Cooley and Lhones (p38) point out:

> "Prediction on replication samples is protection against capitalisation on chance. The hazards of overfitting in multivariate analysis are great. Although significance tests, when appropriate, can help to protect against reporting results that can never be replicated, we tend to treat our multivariate models as primarity heuristic rather than inferential procedures."

Although techniques are available for testing for the existence of 'sampling' and 'search' biases in a discriminant function and these will be discussed in the next chapter §6, the arguments of Cooley and Lhones, adapted to meet our needs, will be adopted in this study.

7. Summary and Conclusions

In this Chapter the various analyses undertaken to derive

the final classification model used subsequently were discussed in some detail together with various tests of their statistical significance.

In the first section after the introduction the reasons for adopting 2 group linear discriminant analysis (LDA) as opposed to 0-1 multiple linear regression (the linear probability function approach) were laid out.

In §3 the results of the initial 2 group LDA of the complete sets of 42 'failed' companies and 47 'well-solvent' firms were discussed; 3 firms only were misclassified. Nevertheless problems with the data employed including the inclusion of members' voluntary liquidation companies in the failed set and the need to sample many missing ratios from distributions derived from the other firm data, where turnover information was not available, meant that the model was not satisfactory. However it was conclusively shown that trend information was unlikely to add sufficient additional discriminating power to outweigh the additional computation and data collection tasks necessary.

In the next section the 2-group analysis of §3 was extended to include a third group - 'poor' companies. The 3-group runs indicated clearly that the 'poor' firms were not distinct from the 'well-solvent' set. This was commented upon particularly with reference to the intuitive models used by the financial analysts originally in assigning firms to each group.

Section 5 described the different runs which resulted in the final classification function to be employed in subsequent analyses and was made up of three parts. In the first the 2-group LDA runs with the 31 failed companies including the eight providing no-turnover data constituting the 'failed' set and 45 'well-solvent' firms - the 'good' set - were described. Two firms were misclassified. In the second part the results of runs leaving out the eight no-turnover companies from the 'failed' set but including the

7 ratios requiring turnover data for computation in the 50 variables from which the stepwise package constructed the final function, were discussed and compared with the runs of the first part of the section. Only one firm was 'misclassified' - Rolls Royce, and the reasons for this were discussed. It was concluded that Rolls Royce was actually being correctly classified. The provision of turnover information was found to be 'material' for our purposes and its inclusion more than outweighed the associated decrease in the size of the 'failed' set. The classification of the 68 firms from which the function was derived was laid out along a linear Z-scale.

Finally the runs adding the 'poor' companies to the 'well-solvent' set to constitute a continuing set of 61, but using the same 23 firm failed set as before, were discussed. Essentially although again only one firm (the same one) was misclassified, the best resulting model was not as satisfactory and this seemed to indicate that the approach taken here viz:- to work with financially sound companies rather than "continuing" firms was valid.

In the final section of the chapter before this the constituent data from which the function used in subsequent analyses was derived was tested for separate multivariate normality of the two groups in the analysis and the equality of their dispersion matrices - conditions necessary for valid application of LDA. It was concluded that the 'well-solvent' set was probably distributed non-multivariate normal although the 'failed' firms were and that in fact their dispersion matrices might not be identical. However since the test employed in the latter case depends on assumptions of multivariate normality nothing conclusive could be adduced.

However as was pointed out in the section, the only real test of the efficiency in an operational or decisional sense of the models with derivations discussed in this chapter lies in

their classificatory ability on other companies than those from which they were derived, and this is the approach adopted here. In any case the literature is very deficient on the effect of departures from separate multivariate normality of the underlying populations and equality of their dispersion matrices on the power of a linear discriminant classification model.

CHAPTER VI: TESTING THE OPERATIONAL UTILITY OF THE DISCRIMINANT FUNCTION

1. Introduction

In chapter V the results of the various discriminant analyses carried out to derive the final classification function used in subsequent parts of the research were discussed and its statistical significance together with the assumptions underlying valid application of the discriminant model were rigorously tested. However significance in a statistical sense is not synonymous with utility in a decision situation nor will the derived model, as was pointed out, be necessarily effective when applied to other data than that from which it was derived. Strictly speaking only replication studies can ensure that the model is efficient in an operational context which is what this chapter is concerned with assessing. However although there are various problems in testing the power of what is essentially a definitional model, it will be seen that the final function derived in the last chapter, referred to henceforth as the "z-" or "solvency-" classification or discriminant model or function, correctly classified as "insolvent" all those industrial firms which failed between 31.12.1973 and 21.7.1976, as well as all members of a sample of "well-solvent" firms.

In this chapter the results of various principal component analyses of the ratio data utilised in the study will first be discussed and then the ratios of the final model interpreted with reference to these and the results of previous American studies. The modifications made to the z-model to make it operational on other data than that from which it was derived will next be outlined and statistical models for evaluating the probability of correct classification discussed. Next the various approaches suggested in the literature for testing the power of discriminant functions in the absence of replication data will be commented upon.

The power of the z-model is then considered in detail by an analysis of the z-scores of other firms to those from which it was derived and the z-score and ratio behaviour of the FAILED23 and GOOD45 companies for previous years is described. Finally the dividend behaviour of the failed firms in the study as failure approaches is examined in some depth.

As well as containing the empirical results of the analyses described in the chapter, the appendices also discuss in detail the mathematical and statistical models employed.

2. The Dimensionality of the Accounting Ratio Data Employed

To understand the underlying dimensionality of the data used in the anlyses of this study various principal component analysis (PCA) runs were undertaken. Specifically separate analyses of the 50 ratios of appendix 4.9 for the FAILED23, GOOD45 and FAILED23 + GOOD45 sets of companies were conducted and varimax rotations of the component loadings matrices carried out. In appendix 6.1.1 the theory of PCA is discussed and in appendix 6.1.2 the method of varimax rotation.

Although factor analyses were also undertaken the results arrived at were similar, and since valid application of factor analysis requires the assumptions of normality of the observation variates and that the residuals of the model are uncorrelated random variables independently normally distributed (Marriott, 1974:44-50) and these may not have been met in our case, the results of these factor analyses will not be reported here. PCA on the other hand, consisting of transformation of an original data set into new axes, requires no such assumptions for valid application. In fact Marriott (1974:50) quotes Blackith and Reyment (1971) who after discussing a number of factor analyses studies in biology, geology and ecology concluded: "We have yet to discover any illustration of the superiority of factor analysis over principal component analysis."

In this section the results of principal component analysis

of the 68 GOOD45 + FAILED23 company set are first discussed and compared with those of Pinches et al (1974) introduced in chapter II§5, to investigate whether similar underlying factors are present in our UK data. Then the underlying ratio dimensions of the FAILED23 and GOOD45 firms taken separately are examined with a view to determining whether these differ between "well-solvent" and "failed" firms.

In appendix 6.2.1 the varimax loadings matrix for the first eight components of the GOOD45 + FAILED23 data taken together are provided and in appendices 6.2.2 and 6.2.3 the related matrices for the GOOD45 and FAILED23 data sets taken separately. The first 8 components were rotated in each case through consideration of Kaiser's Rule (see appendix 6.1.1) - the first seven eigenvalues were greater than 1 for each analysis - together with consideration of the large number of ratios relative to companies in each set. The results of varimax rotations are only provided here since the unrotated PCAs produced components that were similar but less distinct. In appendix 6.3 the equivalent results arrived at by Pinches at al are provided for comparison purposes. The computer package employed - FACCOM (Taylor and Peksa, 1971) was written at the London School of Economics and is similar to BMD08M - Factor Analysis (Dixon, 1973) but allows principal component analysis to be undertaken more readily.

2.1 Principal Component Analysis of the Aggregate 68 Company Data

The varimax rotated PCA of the 50 ratios of appendix 4.9 across the 68 GOOD45 + FAILED23 firms taken together resulted in the 6 distinct classifications of table 6.1 in which those ratios with loadings (simple correlations) of .7 or above ($.7^2 \approx .5$) on any component are listed. The first seven components accounted for 92.4% of the total variance in the data.

From the table the underlying types of inform-

ation conveyed by the ratio set can be interpreted without too much difficulty. The first component, profitability or return on investment is very distinct and similar to the Pinches et al first factor (see appendix 6.3). The second is also distinct although the reasons for the high positive loadings on the first four ratios are not obvious at first sight. However when it is considered that essentially for any given level of total assets (which is highly correlated with net worth or net capital employed) fixed assets and current assets are inversely related and working capital = current assets - current liabilities, the loadings appear meaningful. The component would appear to be measuring a similar dimension of the data to that of Pinches et al's sixth factor - Short Term Liquidity. It might in fact be better labelled "liquid asset position" in line with the liquid asset flow arguments of Walter (1957) and Beaver (1966) discussed in chapter IV §7. The presence of the ratios 33 and 37, $\log_{10}$ (CA/NW) and $\log_{10}$ (CA/NCE), highly loaded on the gearing or financial leverage component - which is similar to Pinches et al's fourth factor, are probably explained by their denominators which are common with those of the other ratios and the general positive correlation between balance sheet items when unadjusted by a measure of company size. In this type of analysis the high spurious correlations between ratios with common numerators or denominators must never be forgotten.

The fourth component "defensive assets position" is similar to Pinches et al's seventh "cash position" in that the seven days debtors element of the defensive assets measure is usually small relative to its cash + other liquid assets part.

their classificatory ability on other companies than those from which they were derived, and this is the approach adopted here. In any case the literature is very deficient on the effect of departures from separate multivariate normality of the underlying populations and equality of their dispersion matrices on the power of a linear discriminant classification model.

In fact the ratio for British manufacturing industry based on the provisional 1973 figures (DOI, 1975) was 1:3.4.

The quick asset measures loaded on the fifth component can probably be just as well thought of as accounts receivable ratios in that again cash holdings are usually low relative to debtors. In fact the ratio for British manufacturing industry using the same provisional 1973 figures was 1:2.67. This argument is given more weight by noting from appendix 6.2.1 that the days debtors measure (42) is loaded -.67 on the component as well. Examining Pinches et al's second component (Capital Turnover) on which QA/TA is highly loaded and their fifth (Receivable Turnover) on which their ratio "receivables/sales" which is equivalent to our days debtors is also highly loaded, we might be able to hypothesise that as a company's turnover is positively correlated with its debtors figure, our fifth component may be measuring the general activity of a company.

No ratios, as can be seen, were highly loaded on the sixth component and only days creditors on the seventh although ratios 40 - $\log_{10}$ ($S/NTWC_{t-1}$), 41 - S/Av.Inv. and 42 - days debtors were loaded at -.53, -.60 and .49 on it. The component may resemble some aspects of Pinches et al's third - Inventory Turnover; however more likely it may really be measuring turnover or cash generation.

Thus to summarise it would appear that the data this study has been concerned with, when taken in aggregate, seems to be measuring five or six distinct aspects of the firm's financial position viz:- its profitability, working capital position, gearing, defensive assets position (or cash), quick assets position (or debtors) and possibly creditors position.

Although our ratios do not include all those utilised by Pinches et al, it would nevertheless appear that our UK data contains similar dimensions to their US data and that consequently the underlying accounting numbers are measuring similar things in the different countries. If these results are duplicated on a larger set of UK companies then the empirical findings would probably be of considerable importance to comparative accounting theory.

2.2 Principal Component Analysis of the GOOD45 and FAILED23 Companies Considered Separately

In table 6.2 the ratio loadings above 0.7 on the first 7 varimax components for the GOOD45 and FAILED23 firm data sets taken separately are given together with the equivalent loadings in brackets, if above 0.5, for the other set if a ratio is only loaded at above 0.7 for one group of firms.

Broadly speaking similar dimensions, it can be seen, appear to exist in both sets of data although certain differences are present. However due to the very small numbers of firms in each set it is not possible to say these are not due to sampling bias.

The first and second components are similar for each set to those discussed previously except for the three profitability ratios for the GOOD45 data with opening current liabilities as denominator (4, 10 and 16) which are correlated although at below 0.7, with the third component. This factor is difficult to interpret in that it appears to contain both asset ratios and liability measures for both sets of data; although component five which would appear to be not unrelated, at least for the FAILED23 set, can probably be identified as measuring gearing. However a

Variable No.	Name	Varimax Component Loadings													
		G45 [1]	F23	G45 [2]	F23	G45 [3]	F23	G45 [4]	F23	G45 [5]	F23	G45 [6]	F23	G45 [7]	F23
1	FF/TA_{t-1}	-.94	-.99												
2	FF/NW_{t-1}	-.87	-.98												
3	FF/TL_{t-1}	(-.62)	-.93												
4	FF/CL_{t-1}		-.94			(.67)									
5	FF/NTC_{t-1}	-.91	-.97												
6	FF/NCE_{t-1}	-.93	-.97												
7	$EBIT/TA_{t-1}$	-.95	-.96												
8	$EBIT/NW_{t-1}$	-.92	-.93												
9	$EBIT/TL_{t-1}$	(-.67)	-.92												
10	$EBIT/CL_{t-1}$	(-.51)	-.93			(.65)									
11	$EBIT/NTC_{t-1}$ (adj)	-.93	-.94												
12	$EBIT/NCE_{t-1}$	-.94	-.94												
13	CF/TA_{t-1}	-.84	-.99												
14	CF/NW_{t-1}	-.82	-.97												
15	CF/TL_{t-1}	(-.66)	-.93												
16	CF/CL_{t-1}		-.94			(.56)									
17	CF/NTC_{t-1} (adj)	-.89	-.98												
18	CF/NCE_{t-1}	-.91	-.97												
19	TL/NW					(-.60)	(-.59)			-.72					
20	$\log_{10}$(FA/NW)			.81							(.64)				
21	FA/NCE			.89	.95										
22	TL/CA			.85	(.56)										
23	CL/TA					-.93	-.88								
24	TL/TA									-.71	-.78				
25	TL/NCE					-.85	(-.55)				(-.62)				
26	Debt/Equity									-.85	-.84				
27	$\log_{10}$(QA/CL)											(-.57)	-.89		
28	CL/CA			.77	.94										
29	QA/TA					-.71	-.72								
30	CA/TA			-.77	(-.68)										
31	WC/TA			-.97	-.98										
32	$\log_{10}$(QA/NW)					-.85					(-.68)				
33	$\log_{10}$(CA/NW)					-.79	(-.57)								
34	WC/NW			-.83	-.92										
35	TL/QA														
36	$\log_{10}$(QA/NCE)					-.90	-.92								
37	$\log_{10}$(CA/NCE)					-.80	-.84								
38	WC/NCE			-.92	-.95										
39	$\log_{10}$(Inv./NTWC)											.74	.73		
40	$\log_{10}$($S/NTWC_{t-1}$)			.78	(53)										
41	S/Av.Inv.[2]			.76											
42	Days Debtors												-.72	(-.60)	
43	Days Creditors													-.82	.77
44	$\log_{10}$(DA/CL)							.89	.34						
45	DA/TA							.95	.30						
46	$\log_{10}$(DA/NW)							.93	(.55)						
47	$\log_{10}$(DA/TL)							.90	.80						
48	DA/NCE						-.70	.94	(.64)						
49	$\log_{10}$(Dr.+Inv./Cr.)			-.73	(-.50)										
50	NTWC/NTC			-.85	-.75										
	Percentage Variance Explained by Component	24.6	35.0	20.7	15.4	18.8	13.2	11.7	8.6	8.2	7.8	3.5	7.5	4.4	3.5

Notes (i): These components are reversed in appendix 6.2.3
(ii): Ratio 4i-S/Av.Inv. is loaded -.67 on component 8 in the FAILED23 case.

Table 6.2: The First 7 Varimax Rotated Component Loadings for the GOOD45 and FAILED23 Firms

(Source: Appendices 6.2.2 and 6.2.3)

detailed examination of its constituent ratios probably allows component three to be meaningfully labelled as an "asset coverage" classification for both groups, indicating that higher liabilities are associated with higher assets, ie that liabilities have the function of financing the assets. The fourth classification is similar to that for the aggregate data as is component seven.

Component six however cannot be readily interpreted, at least for the FAILED23 group. It may be measuring inventory position for the GOOD45 set and some type of current asset mix for the FAILED23 group, however due to the small number of firms involved such speculation is not likely to be very productive.

In table 6.3 these components are summarised. All told they account for 91.9% of the variation in the GOOD45 data and 91% of the variation in the FAILED23 set.

Component	Description
1	Profitability (or Return on Investment)
2	Working Capital Position (or Liquid Asset Position)
3	Asset Coverage
4	Defensive Assets (or Cash)
5	Gearing
6	Inventory Position (GOOD45), Current Asset Mix (FAILED23)
7	Creditors Position

Table 6.3: Varimax Component Description for the GOOD45 and FAILED23 Data Set Analyses

It would appear then that similar dimensions exist in the accounting data reported by the GOOD45 and FAILED23 firms, ie although the magnitudes of the various ratios may differ considerably between firms in the different groups, their relationships viz-a-viz the other ratios calculated for the same firms remain stable. We would thus appear justified in considering both groups of firms together as we did in §2.1 above.

3. The Constituent Ratios of the Solvency Model

An examination of the loadings of the five ratios constituting the z-model on the varimax rotated factors of table 6.1 or appendix 6.2.1 shows that they are each separately highly correlated with a distinct component. This is illustrated in table 6.4 below.

Ratio no. (Appendix 4.9)	Ratio	Correlated with Component:	Simple Correlation Coefficient with Varimax Rotated Component
7	$EBIT/TA_{t-1}$	Profitability (1)	-.94
25	TL/NCE	Gearing (3)	-.89
29	QA/TA	Quick Assets Position (5)	-.84
34	WC/NW	Working Capital Position (2)	-.88
41	Stockturn	Creditors Position (7)	-.60

Table 6.4: Dimensions of Accounting Data Associated with the Z-Model Constituent Ratios

The inclusion of ratio 29, QA/TA, is interesting. One of the surprising results that came out of the discriminant analyses was that the "failed" firms had consistantly shorter days debtors than the "good" firms. This would suggest that firms in financial difficulties seek to realise money owing to them more rapidly than "well-solvent" firms - possibly by factoring their debts (?). But as we have seen above in §2.1, it can be argued that quick assets position is largely synonymous with debtors position and this explains why measure 42 (days debtors) is highly correlated on the same component as QA/TA for both the 68 company analysis (loading = -.67 on component 5) and the FAILED23 analysis (-.61 on component 3). In fact $r_{29,42}$ = 0.59 using the within groups simple correlation measure. This also explains why the alternative model of the footnote on page 164 of chapter V §5.2 with slightly higher F-statistic had days debtors substituted for QA/TA in the final solvency model. (It will be recollected that this model was rejected in favour of the one currently under discussion and used subsequently because of the counter-intuitive behaviour of

the measure on an univariate basis.)

The only distinct component not entering into the solvency function is the fourth - 'defensive assets position' which again as pointed out above in §2.1, is effectively measuring cash and equivalent holdings ie liquidity in a strict (cash) sense. This is at first sight surprising but may be due to different treatments of the cash item in the accounts of different firms - such as netting it off against bank overdraft or not and "window dressing" or other forms of end of year accounts manipulation.

It can be concluded then, on the basis of the PCA results, that the solvency model is made up of a number of fundamental accounting measures.

The role of each of the ratios in the ex post discriminating ability of the model can be examined by the approach suggested by Mosteller and Wallace (1963) ie:

$$r_j = d_j (\bar{x}_{j_1} - \bar{x}_{j_2})$$

where r_j = the relative discriminating power of ratio j in the model

d_j = the associated coeffecient

$\bar{x}_{j_1}$ = GOOD45 group mean for ratio j

$\bar{x}_{j_2}$ = FAILED23 group mean for ratio j

The r_j's denote the changes in 'z' associated with changes in x_j equivalent to movements between the group means on each variable and can be interpreted as that portion of the discriminant score separation between the groups due to the j'th measure.

Joy and Tollefson (1975:728/9) point out that conventionally the standardised coeffecients $d_j \sigma_j$ are employed to measure the relative importance of the variables, although wrongly, probably by analogy with the multiple regression model. See Morrison (1969:156) for example. The incorrect interpretations that can arise using this latter approach are illustrated by the Altman (1968) study as mentioned in

chapterIII§3.3 and in table 6.5 the "correct" ranking of his constituent ratios is compared with his ranking based on standardised coeffecients (given in his table 2 p597).

Variable	Altman's Ranking	"Correct" Ranking	r_j in %
WC/TA	5	4	11.1
Retained Earnings/TA	4	2	26.7
EBIT/TA	1	1	30.2
Equity/TL	3	3	24.3
S/TA	2	5	7.8

Table 6.5: The Ranking on Discriminatory Ability of Altman's (1968) Model Constituent Variables

In table 6.6 below our 5 constituent ratios are given with their associated means over the GOOD45 and FAILED23 groups, their discriminant coeffecients and the resultant values of r_j, the measure of relative discriminant power.

Ratio j	Description	Group means GOOD45 ($\bar{x}_{1j}$)	Group means FAILED23 ($\bar{x}_{2j}$)	Coeffecient (d_j)	Relative Discriminant Power r_j	Relative Discriminant Power % $(\bar{z}_1 - \bar{z}_2)$
1	$EBIT/TA_{t-1}$	.1477	-.0309	47.676	8.51	38.9
2	TL/NCE	.7776	1.5499	-11.204	8.65	39.6
3	QA/TA	.3226	.2591	16.293	1.04	4.7
4	WC/NW	.5606	.3371	8.267	1.85	8.5
5	Stockturn	5.3634	3.7233	1.102	1.81	8.3

Note: $\bar{z}_1$ and $\bar{z}_2$ are the mean z-scores for the two groups.

Table 6.6: The Relative Discriminatory Power of the Constituent 5 Ratios

From this it would appear that the most important single measure in a multivariate context is gearing followed very closely by profitability. The working capital position of a firm together with its stockturn are next most important followed finally by the quick assets measure. The stockturn ratio can probably be interpreted as a measure of cash generation or general activity, as suggested in §2.1 above, and the

quick assets ratio as a surrogate for debtors position.

These results then can be viewed as adding weight to the argument that the lack of working capital and particularly "immediate" cash is of less importance than the more fundamental aspects of a firm such as its gearing and its earning ability in determining its propensity for failure. These latter two measures are of course related in the sense that for example the higher the liabilities of a firm, the higher are the interest payments necessary to service the debts. Nevertheless in spite of this hierarchy of discriminatory ability, it is clear that only by considering the measures simultaneously is it possible to arrive at a complete picture of a company's state of solvency.

The constituent elements of the model, then, taken in conjunction with the principal component analyses discussed above can be used to test empirically the theoretical models and arguments considered in chapter IV §7 drawn upon in arriving at a list of the variable measures to be used in the discriminant analyses.

The approach taken in this study is not to derive a model that can predict firms that will fail (although as will be discussed later it appears capable on a "face value" basis of predictive use) but simply to identify firms at risk in terms of the degree of their similarity or lack of similarity as regards financial characteristics to comparable firms which have already failed or are "well-solvent". Failure in the sense considered here is viewed as a stochastically determined event brought about by the decision, say, of a trade creditor or the firm's bankers at a certain date; and consequently only propensity to fail can be measured. It will be seen below and particularly in the next chapter how a number of firms which have resembled "failed" firms for a number of years have been kept going by various means including government grants and loans, overdraft guarantees or drastic retrenchment etc. This no financial model can predict. Other firms, although only a small number have been identified by the author,

appear to have pulled themselves out of trouble, although it must be admitted that their z-scores in their worst year were never very negative. Consequently, attempts to measure debt payment ability in the short term such as those of Sorter and Benston (1960) and Davidson et al (1964) are not likely to prove useful avenues of approach and this is confirmed by the model in its lack of inclusion of a measure of defensive assets. Similarly the model confirms the lack of operational utility of the current ratio as argued on theoretical grounds by Lemke (1970).

What the results do coincide with are the gambler's ruin views of Wilcox (1971a, 1971b and 1973) - see chapter III §7 for a description of his approach - who attempts to measure the probability of ultimate failure of a firm. In fact the profitability and liquidity components of his probability function coincide with the profitability and gearing components of table 6.1 with which the two most important ratios in the z-model, $EBIT/TA_{t-1}$ and TL/NCE, are very highly correlated. They also appear to give credence to the liquid asset reservoir model of Walter (1957) and Beaver (1966) (see Chapter IV §7pp136/7) taken in a multivariate manner where the first step postulates a higher probability of failure given various factors. In our case the EBIT ratio can be considered as a funds flow from operations measure, the WC ratio a measure of the size of the liquid asset reservoir and the TL ratio a measure of the claims on resources. The results, however, do not confirm the importance of short term variability in inflows, outflows and claims on the business[1].

It would appear then, on the basis of this study, that in the case of company failure the financial state of a

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[1] There is, of course, a difference between "technical insolvency" (negative working capital) which a number of solvent firms particularly in the construction industry exhibit and with which comentators such as Walter are concerned and failure in the sense used here which usually means heavy losses for all concerned with the firm except the receiver or liquidator.

company must be fundamentally unsound, since its creditors and bankers have too much to lose to foreclose if it were meeting only temporary cash flow difficulties (if such can be identified for what they are). Consequently measures of short term changes in working capital and defensive assets etc as advocated in the literature are unlikely to be able to do much more than measure the company's ability to prevent foreclosure for a few months. Fundamental aspects of a firm's financial state which reflect its economic situation, and which can usually only change relatively slowly over time, such as its gearing, profitability and stockturn (measuring it is suggested general activity or cash generation ability) are what count in solvency measurement and the associated propensity of failure.

This point is borne out by Beaver (1968) in a comparison of the power of individual non-liquid asset compared with that of individual liquid asset ratios in "predicting" failure a number of years in advance. Although as indicated in chapter III §2, where both his 1966 and 1968 studies are discussed at length, his general approach must be considered methodologically suspect, his three non-liquid asset ratios: cash flow/total debt, net income/total assets and total debt/total assets, do appear to be considerably better 'discriminators' for each of the five years before failure than any of the eleven liquid assets measures he compares them with (consisting of cash, quick asset, current asset, current liability and working capital ratios). In addition their classificatory power on Beaver's basis (he does not provide separate tables for the type I and type II percentage errors), appeared fairly consistent over all five years.

His cash flow and net income measures are akin to the $EBIT/TA_{t-1}$ measure used in our discriminant model and would appear consequently to be measuring the same thing. The former constitutes ratio 15 in appendix 4.9, CF/TL_{t-1}, which is very highly correlated (-.92) with the first principal

component of table 6.1 measuring 'profitability'. Beaver's third non-liquid asset ratio, total debt/total assets, is very similar to our ratio 24, TL/TA, which is akin to the TL/NCE ratio employed in the discriminant model and is highly loaded (r = -.88) on the same component in table 6.1 representing gearing. Beaver himself comments (1968:117):

> "cash flow, net income and debt positions cannot be easily altered and represent permanent aspects of the firm. Because failure is so costly to all involved, the permanent, rather than the short-term, factors largely determine whether or not a firm will declare bankruptcy or default on a bond payment."

An examination of measures employed in the comparable studies with similar methodology listed in table 4.8 shows that Altman (1968) used EBIT/TA as one of the five ratios making up his discriminant function and that it appeared to contribute the most to its discriminating ability. The ratio employed in this study which seeks to measure the true profitability of the firm's assets (before interest and taxes are paid) uses total assets at the beginning of the year as the denominator to obtain a measure of the earning power of the assets explicitly excluding the change in net assets as a result of the operations during the year which, as Staubus (1966:402) points out, is effectively represented by the earnings figure. This Altman does not take into account possibly in an attempt to reduce the data collection task. The same ratio as Altman's is employed by White and Turnbull (1974:8) for similar reasons to ours and also by Lis (1972). A very similar one, net income/TA, was also employed by Deakin (1972) as one of his fourteen ratios and another related ratio CF/TL by Blum (1974). (CF/TL_{t-1} was loaded at -.92 on the first component in table 6.1.)

Altman employs the measure market value of equity (common + preference)/TL, ie a market value surrogate of the NW/TL ratio which is akin to the reciprocal of the TL/NCE measure used in our model. This introduces stock market informat-

ion into his model, although on the basis of this study it would appear able to add little improvement to the results and may in fact cause unecessary complication, eg when are the relevant prices measured, how are general changes in the market index allowed for etc? (See Argenti, 1976a, chapter 4 for an attempt to apply Altman's model to UK companies.) In addition the results of a study carried out by a student of this author under his direction (Gooi, 1974) seem to indicate that the UK Stock Market in most cases is unable to identify firms in a situation of impending failure as effectively as our model based wholly on financial ratios. (The results of this study will be discussed in a little more detail below on page 223 and related aspects concerned with the financial press comments on the state of continuing but apparently "insolvent" firms in chapter VII §8.) Blum (1974:11/12) in fact suggests that the market is unable "to anticipate the timing of failure... [and] prefers to invest in failing rather than nonfailing firms".

Lis, Blum and Tamari (1966) all use NW/TL and Deakin the measure TL/TA. (The ratios TL/NCE, TL/NW and TL/TA are all highly correlated, at -.89, -.91 and -.88, with the same component - gearing in table 6.1.)

Altman's measure WC/TA, providing the second least contribution of his five constituent ratios to his discriminant function, is highly loaded (at -.86) on the same component in table 6.1 (2) as our working capital ratio WC/NW which measures the net liquid assets of a firm relative to its net assets (TA-TL=NW) at the year end. Lis and Deakin use the same measure as Altman.

As regards the QA/TA ratio present in our solvency function, which as was pointed out above in §2.1 can effectively be considered a measure of debtors position, Deakin employs the same variable and also QA/sales - which is akin and measures a similar thing to our days debtors measure. Tamari uses a sales/debtors measure in his study.

The final variable in order in our z-model, stockturn, which measures inventory position or as suggested above cash generation ability, is only present in a similar form in the Tamari study with the numerator entitled "value of production" which he defines as sales plus change in finished goods and goods in process inventories, ie sales + Δ inventory.

4. The Operational Model

In this section the steps taken to make the solvency model operational so that it can be applied to evaluate continuing firms (the purpose of course for its development) which cannot be *a priori* classified to either of the FAILED23 or GOOD45 sets will be discussed. The main changes related to the method for handling extreme ratio values (since a firm could no longer be classified *a priori* as belonging to either of the populations it was not possible to adjust extreme ratio values using the respective mean and standard deviation figures), and to handle the situation of rapid asset growth over the year for which the firm's z-score was computed. This latter situation was explicitly avoided in the selection of firms for inclusion in the GOOD45 and POOR16 groups and may be due to general inflation, take-overs, the raising of new finance by various means or the inclusion of substantial earnings in the net assets figure, etc and has become more pronounced recently. (See the discussion of continuing firm z-scores in the next chapter.)

4.1 Growth in Total Assets

Firms for which total assets grew between 30% and 150% over the year had the denominator of the $EBIT/TA_{t-1}$ ratio replaced by the average total asset figure for the year, ie $(TA_{t-1}+TA_t)/2$ and for those with growth over 150% the earnings ratio was replaced by the mean value. Needless to say a company with total asset growth much above 30% is clearly exceptional and should have

its z-score treated with considerable circumspection.

Although there are problems associated with this approach such as discontinuity at 30% growth and inclusion of a measure of the change in net assets over the year in the final asset figure, this appeared to be the easiest way to overcome the problems associated with growth in total assets. As pointed out above any firm with growth of more than 30-40% in total assets would be suspect anyway as not being sufficiently stable for application of the model. For example a firm with a large acquisition at some time during the year may include the acquisition's share of profits for only that part of the year for which it was acquired and consequently a true EBIT measure may not be arrived at unless careful adjustment of the EBIT figure pro-rata is undertaken and the opening total asset figure for the parent adjusted to incorporate that of the acquisition's (see below).

Since no attempt is made here to pretend that it is possible to compute an exact z-score measure, because of problems in interpretation of the published accounting items making up the ratios and whether they exactly as opposed to approximately represent underlying economic reality etc, such problems are probably less material in practice than they appear on an a priori basis. The results of testing recently failed firms and an examination of the 700 odd sets of accounts for continuing firms discussed in the next chapter seem to indicate that for a firm the state of "failure"[1] can be identified from the published

[1] "Failure" is considered here in a definitional sense in terms of whether a company has a financial profile, as indicated by its z-score, more similar to that of firms which have already failed, the FAILED23 set, or that of the well-solvent GOOD45 companies.

accounts using a multivariate model however these accounts are presented and conversely for solvent companies.

4.2 Extreme Ratio Values-Ratios Outside Limits

To avoid distorted results for those firms with extreme values for a particular ratio - usually the stockturn measure (due to retail or process type activities) - which of course in itself would usually call into question the suitability of such a firm for application of the model, since as discussed above it was not possible to work with two separate sets of limits for "failed" and "good" firms, a single set of limits had to be derived. These were calculated by determining the means and standard deviations for each of the five ratios using the GOOD45 + 2 sets of the FAILED23 firms (ie 91 companies in all) and a range with boundaries $\mu \pm 3\sigma$ set outside of which ratios would be replaced by the appropriate limits. For a ratio value lying outside of $\mu \pm 9\sigma$ the mean would be substituted and the company considered unsuitable for application of the model. The ranges with boundaries $\mu \pm 3\sigma$ virtually enclose the ranges given by the further of the $\mu \pm 2.5\sigma$ boundaries for the FAILED23 and GOOD45 sets of firms taken separately. In table 6.7 the overall mean and standard deviation figures of the discriminant model's 5 constituent ratios calculated from the 91 GOOD45 and 2 X FAILED23 companies considered together are given together with the extreme boundaries of the $\mu \pm 3\sigma$ ranges and equivalent range limits for the FAILED23 and GOOD45 groups of firms treated as above. Figure 6.1 illustrates the construction of table 6.7.

Ratio	Overall ("Good" and "Failed")			Equivalent Extreme Range from GOOD45 and FAILED23 Groups
	Mean ($\bar{x}$)	St. deviation(s)	Range ($\bar{x}\pm3s$)	
1 $EBIT/TA_{t-1}$	.05740	.11733	-.295 → .409	$-.273_f$ → $.276_g$
2 TL/NCE	1.16800	.58010	0 → 2.908	0 → 2.977_f
3 QA/TA	.29053	.09978	0 → .590	0 → $.531_g$
4 WC/NW	.44765	.31973	-.512 → 1.407	$-.585_f$ → 1.260_f
5 Stockturn	4.53436	2.17950	0 → 11.073	0 → 11.691_g

Note: subscripts 'f' and 'g' refer to the FAILED23 and GOOD45 firms boundaries on the basis of ±2.5 standard deviations from the mean.

Table 6.7: Range Details Employed in the Operational Model

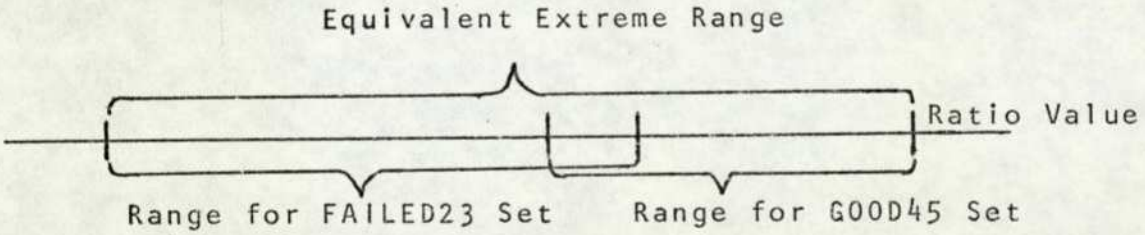


Fig 6.1: The Equivalent Extreme Range for the FAILED23 and GOOD45 Sets of Firms

4.3 Changes to Data Definitions

Additional minor changes in the definition of certain of the data items were recommended by the investment analysts at the stockbrokers, Laurence Prust and Co, who collected and made available much of the basic data used in the study, to handle certain rarely occuring situations. For most firms no significant difference would have resulted in their z-score.

Specifically it was suggested that minority interests in subsidiaries (that portion of the net assets of subsidiaries not owned by the company) should be treated as equity capital in the parent not as a long term liability. This has the effect of marginally reducing the numerator of the TL/NCE ratio but increasing the denominator of the WC/NW ratio. (Ie TL will now be defined as current liabilities + fixed interest capital + preference capital + deferred tax + provisions and NW as ordinary capital + reserves + preference capital + minority interest.)

Based on provisional 1973 figures for 605 publicly quoted companies followed by the Department of Industry Business Statistics Office, minority interests in fact worked out at 6.7% of net worth and 5.1% of total liabilities excluding minority interests (DOI, 1975:table 2)[1].

In line with this a marginal change in the treatment of associated company earnings[2] was also suggested ie instead of share of associated companies profits being added to net trading profit to arrive at an EBIT figure in the standardised accounts employed in this study, the dividend income (if any) from such associated companies was to be substituted to give a truer view of earnings. In the case of the BICC accounts to

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[1] An analysis of the GOOD45 companies indicated only 4 had minority interests representing more than 10% of their total liabilities excluding the minority interest figure: Associated British Foods - 12% (accounts to 31.3.1973), Associated Portland Cement - 15% (accounts to 31.12.72), BICC - 23% (accounts to 31.12.72) and Reckitt & Colman - 11% (accounts to 31.12.72). Even in the case of BICC, the net effect was to only increase the z-score by .516 to 10.98 with the TL/NCE ratio falling from .8118 to .6638 and the WC/NW ratio falling from .6760 to .5379.

[2] The share of associated companies figure in the standardised accounts employed in this study relates to the share of net assets of other companies which are not subsidiaries owned more than 20% by the company in question. (See Samuels & Wilkes, 1971:445/6.)

31.12.1972 the share of associated companies made up 8.8% of the EBIT figure, and even if the corresponding dividend income had been zero this would only have reduced the z-score by .49.

None of the above changes were considered sufficiently material to require the rerun of any of the stages in the analysis. Although experience with the model in practice indicated it was remarkably robust it was never envisaged that it would be applicable in a foolproof way in all situations. It was expected that each firm would be considered separately on its merits and that in any important decision situation it would only be employed by skilled analysts with access to the published annual reports as well as the card service of Extel. The model is only an additional investigative aid. The exceptional situations which the above changes were designed to handle would relate to firms in particular situations and very careful and skilled analysis would be required to handle them.

4.4 Treatment of Special Situations

Similar principles apply to the treatment of those other special situations encountered more frequently - changes of year end, take-overs and revaluation of fixed assets. The set of guide lines below was prepared to help prospective users of the model in these situations:

4.4.1 Change of Year End

Pro-rata turnover and EBIT figures should be used.

4.4.2 Acquisitions

If acquisitions are small and the total assets have been increased by less than 30% over the year then usually no adjust-

ments need be made.

If, however, there have been significant changes in the nature of the company, then the following data items need to be treated carefully:

4.4.2.1 Total Sales

It should be possible by knowing when the acquisitions took place together with details published in the company accounts or in Extel to determine what contribution the acquisitions made. A turnover figure with a year of acquisition data included calculated pro-rata should then be utilised.

4.4.2.2 Opening Stocks and Work in Progress

This item should be adjusted to include an estimate of the stock and work in progress figure for the acquisition at time of takeover. In this way an adjusted stockturn ratio (sales/average stock) can be computed. If the above is not feasible, the closing stock level should be used for the opening figure.

4.4.2.3 EBIT

Similar considerations apply here as with 'Total Sales'. Detective work is necessary especially with the interest charges.

4.4.2.4 Opening Total Assets

Similar considerations apply here as with 'Opening stocks and Work in Progress'. In this way a truer profitability measure can be determined.

4.4.3 Revaluation of Assets

The opening total asset figure should be increased (decreased) by the value of the revaluation (devaluation) so a truer measure of the earning power of the assets can be arrived at.

Finally a minimum set of data items necessary for collection allowing computation of all the ratios was compiled and laid out on a special input form suitable for input to a computer program available on an interactive basis through a visual display unit (VDU). This coding form used by the Laurence Prust & Co investment analysts is provided in appendix 6.4.

The computer program developed automatically adjusted the computed ratios for growth in total assets and modified them as appropriate when three standard deviation and nine standard deviation limits were exceeded. In these cases the resulting ratios were flagged and the user advised to treat the computed z-score with caution or in extreme cases that these results were totally misleading.

5. The Probability of Correct Classification

The firm of stockbrokers who compiled much of the necessary accounting data and who wished to utilise the function for investment analysis purposes found difficulty in working with an absolute z-score cut-off determining whether a firm could be classified as "solvent" or "insolvent". In addition the costs of misclassifying an "insolvent" firm as "solvent" - a type I error - are clearly greater than classifying a "solvent" firm as "insolvent" - a type II error. For example in the case of a bank being approached for a loan, in the former case it could stand to lose all money advanced but in the latter it would only be foregoing the difference between the interest it could earn on the loan and the next best alternative use of the funds ie the opportunity cost of not accepting the loan assuming no default. Likewise in the case of a stockbroker recommending a share to a client, the client could effectively

lose all his stake if the firm failed instead of just foregoing the difference between the capital appreciation (if any) + dividends from not buying the share compared to what he could have gained from his next best alternative investment.

The fact that there must clearly be far fewer "insolvent" quoted companies than sound ones also needs to be taken into account.

Taking note of these considerations then a different statistical classification model was developed allowing the computation of a probability equivalent measure for the likelihood of a firm belonging to each of the two groups. It also allowed the computation of the boundaries of a "zone of ignorance" or "grey area" in which it would not appear possible in a statistical sense, assuming multinormality of the underlying GOOD45 and FAILED23 data sets and equality of dispersion matrices, to classify a firm with 95% or more confidence to one or other of the populations.

In appendix 6.5.1 classification functions for measuring the degree of confidence with which any individual firm can be classified to the "good" ("solvent") or "failed" ("insolvent") populations are derived explicitly taking into account prior probability estimates and differential misclassification costs. They are of the form:

$$P(g) = \frac{e^{z}}{e^{z}+\ell} \text{ and } P(f) = \frac{e^{-z}}{e^{-z}+1/\ell}$$

where $P(g)$ = 'probability' with which the company should be classified "solvent"

$P(f)$ = 'probability' with which the company should be classified "insolvent"

z = the company's z-score

and ℓ = the 'likelihood' or 'probability-cost' ratio

= odds ratio x loss ratio

$$= \frac{p_f}{p_g} \chi \frac{c_{gf}}{c_{fg}}$$

where p_f and p_g are the a priori probability estimates and c_{gf} and c_{fg} the estimated costs of misclassification of an "insolvent" firm as "solvent" and vica versa respectively.

If the a priori odds of an "insolvent" firm are 10:1 against and it is 40 times as expensive to make a wrong decision in classifying an "insolvent" firm as "solvent" (a type I error) as it is to make a wrong decision in the other direction[1], then

$$\ell = \frac{1}{10} \times \frac{40}{1}$$
$$= 4$$

$$P(g) = \frac{e^z}{e^z+4}$$

$$\text{and } P(f) = 1 - P(g) = \frac{e^{-z}}{e^{-z}+\frac{1}{4}}$$

The lower 95% confidence limit can be derived for the "solvent" population thus:-

$$\text{If } P(g) = 0.95$$

$$\text{then } 0.95 = \frac{e^z}{e^z+4}$$

$$\text{and } \underline{z = 4.3306}$$

and the upper 95% confidence limit for the "insolvent population similarly:

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[1] These figures are the consensus results produced in the form of subjective estimates on the basis of experience by investment analysts at Laurence Prust & Co. No attempt is made here to justify them except to point out the results of analysis of several hundred continuing companies in the next chapter, that in most company failure situations equity holders receive little if anything at all, and to note as Beaver (1966:125) does in his reply to a discussant of his paper, that whatever the true monetary value of the loss ratio, in a world of risk aversion in terms of the decision-makers utility function, the loss ratio appears to be near infinity. The stockbrokers felt that the resulting classification model when applied subsequently to continuing companies gave valid results in terms of their experience.

$$\text{If } P(f) = 0.95$$

$$\text{then } 0.95 = \frac{e^{-z}}{e^{-z}+\frac{1}{4}}$$

$$\text{and } \underline{z = -1.5581}$$

For an equilikely classification

$$P(g) = P(f) = 0.5$$

$$\text{ie } 0.5 = \frac{e^{z}}{e^{z}+4}$$

$$\text{and } \underline{z = 1.3863}$$

A set of operational decision rules for investment purposes are thus derived explicitly taking into account different prior probability and misclassification costs viz:-

5.1 If $z<-1.56$ identify the firm as "insolvent" since we can be more than 95% confident of a "correct" classification to the "insolvent" population.

5.2 If $z>4.33$ identify the firm as "solvent" since we can be more than 95% confident of a "correct" classification to the "solvent" population.

5.3 If $-1.56<z<4.33$ assign the firm to the "grey area" since it is not possible to classify it to either of the populations with more than 95% confidence.

5.4 If $z<1.39$, the firm can be classified to the "insolvent" population with more than 50% confidence and in computing the degree of confidence, the expression for $P(f)$ above is used.

5.5 If $z>1.39$ the firm can be classified to the "solvent" population with more than 50% confidence and the expression for $P(g)$ above should be used to determine the degree of confidence in this case.

In figure 6.2 the amended solvency scale with "grey area" limits is laid out and in figure 6.3 the graphs of the

classification functions P(f) and P(g) are provided.

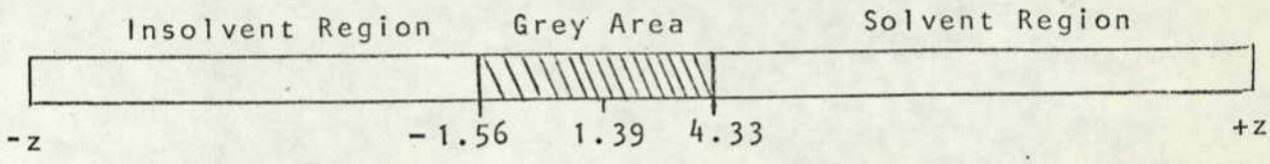


Fig 6.2: The Regions of the Solvency Scale

It of course should be pointed out once again that we are only saying a firm resembles, in terms of its financial characteristics, those which have failed as defined here more than those which have been classified as "well-solvent" by experienced financial analysts or vice-versa, not that it will necessarily fail or not. The derived function is strictly normative and definitional not predictive in spite of its predictive ability on a "face value" basis (see chapter VII §5).

A continuing firm is termed "insolvent" if it has a similar financial profile to those which have previously gone "bankrupt", and "solvent" if it resembles more the GOOD45 companies, the labels indicate strictly speaking nothing more.

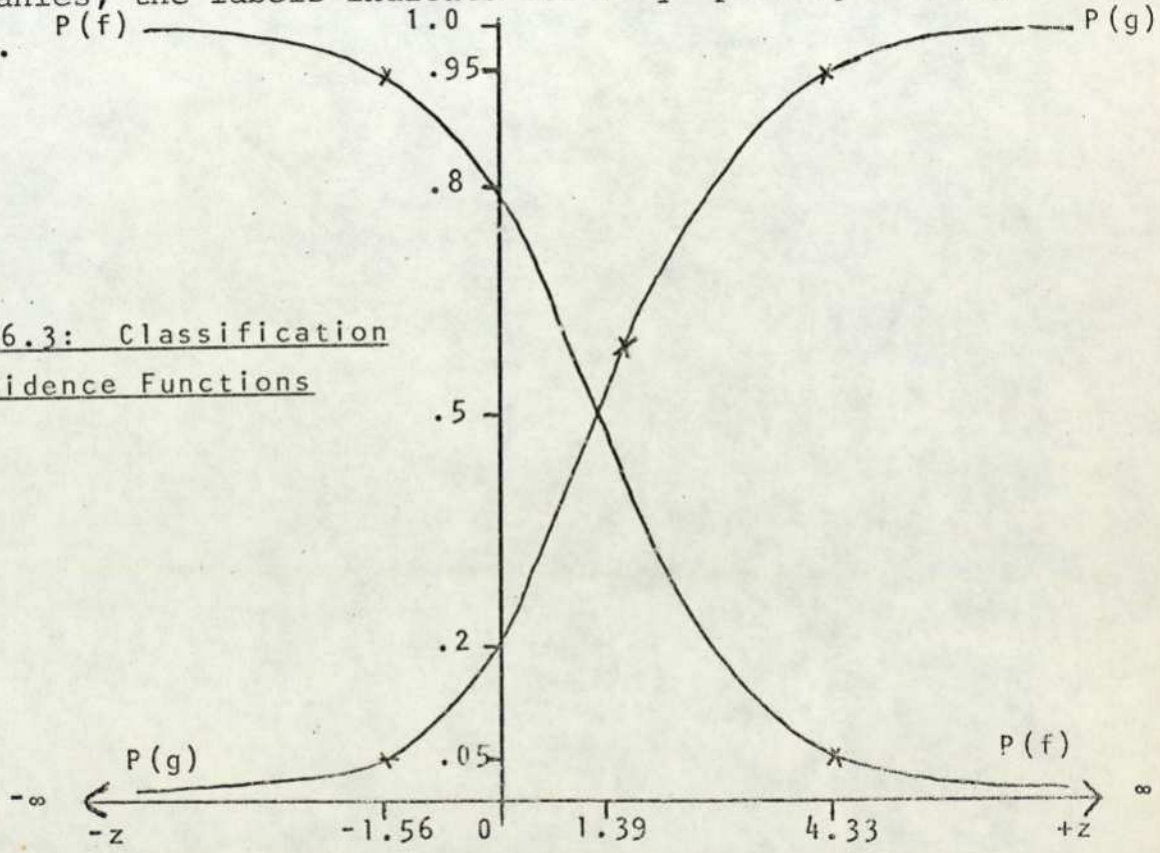


Fig 6.3: Classification Confidence Functions

The above decision rules and probability of correct classification functions were also programmed into the interactive computer program used by Laurence Prust & Co investment analysts referred to above on page 205.

In this way an operational model was developed for use by experienced financial analysts and the results of its application to around 700 sets of continuing company accounts are given in the next chapter.

In none of the previous studies listed in table 4.8 was such an explicit model for determining classification probabilities derived.

Altman (1968) utilised the decision rule of his computer package to construct his classification tables (see page 80). This was to assign a firm to his 'failed' or 'non-failed' groups on the basis of which group centroid its computed z-score was closer to; however he argued that the cut-off which minimised the total number of misclassifications for his original samples was more useful in practice (pp606/7). He also suggested "zone of ignorance" boundaries given by the extreme misclassified company z-scores and these encompassed 7/66 of his original sample companies. In his 1973 railroad study he utilised cut-offs in his different analyses which minimised the respective total numbers of misclassifications however in his French commercial loan evaluation article (Altman et al, 1974) no direct reference to the classification criteria employed was made.

Beaver (1966 and 1968) in his univariate studies used a classification criteria of minimisation of total number of misclassifications considering the costs of type I and type II errors to be identical, and equal prior probabilities of a "failed" or "solvent" firm, although he did point out this may not be so. He then went on to discuss the need for a Bayesian classification model which idea was taken up and developed by the discussant of his paper Neter (1966), who developed a model akin to that employed

here: effectively - 'predict nonfailure' if LR>ℓ and failure otherwise where his likelihood ratio LR is given by:

$$LR = \frac{\text{posterior probability of a 'nonfailed' firm}}{\text{posterior probability of a 'failed' firm}}$$

assuming equal prior probabilities and identical misclassification costs, and 1 is the 'probability - cost' ratio defined above (p206)[1]. It will be recollected from the detailed discussion of these papers in chapter III §2 that applying Beaver's classification criteria to a random sample of companies would probably result in less successful 'prediction' than a random 'prediction' decision rule or even such a pure strategy as to accept all firms as 'nonfailed'.

Blum (1974) appeared to be utilising cut-offs that minimised the total misclassification errors in each of his analyses assuming type I and type II errors had identical cost, although he was aware they did not.

Deakin (1972) employed the "chi-square rule" for classification of his firms. In appendix 6.5.2, it is shown that this is strictly equivalent to assigning a firm to the group centroid which its computed z-score is nearer.

Edmister (1972) employed a cut-off that minimised the total number of misclassification errors in a similar fashion to Blum, however he argued the need for a 'grey area' for loan classification purposes in which particular attention needed to be paid to applicants; the boundaries were the scores for the extreme misclassified firms as with Altman (1968).

Lis (1972) again used a cut-off that minimised his total number of misclassifications, however Meyer and Pifer (1971)

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[1] If ℓ is set to 1 in the ratio of P(g)/P(f) (from p206) then

$$LR = \frac{e^{z}}{e^{z}+1} \Big/ \frac{e^{-z}}{e^{-z}+1} = e^{z}$$

Consequently the comparison of LR with ℓ collapses into the comparison of e^{z} with ℓ; ie in our case with ℓ=4, the classification decision turns on whether z is greater than or less than 1.39 as before.

in their study into the "prediction" of bank failures only state the percentage of type I and type II errors derived from their samples for different cut-off values although they develop a sophisticated equation based on Bayesian analysis, which could be solved given certain subjective parameter estimates, to determine an optimal cut-off.

Orgler (1970) in his study of a commercial loan evaluation credit scoring model sets up arbitrary 'grey area' limits and produces only classification table results considering the 'grey area' as a third classification group. Trieschmann and Pinches (1973) and Pinches and Trieschmann (1974) use a straight cut-off given by the z-value midway between their 2 insurance company group centroids.

In the associated discriminant studies into take-overs of Singh (1971 and 1975) and Stevens (1973), the two synonymous approaches of assignment on the basis of minimum z-distance from group centroid and minimum X^2 statistic were used for classification purposes. However the studies are not strictly comparable in that no pretence, particularly in the case of Singh's work, was made that the results were operational in any sense and consequently only a straight classification rule was required; no differential costs of misclassification being relevant.

Pinches and Mingo (1973) in their study of industrial bond ratings employ a generalisation to 5 groups of the probability of group membership model of appendix 6.5.1, taking into account the different a priori probabilities. The posteriori probabilities of an observation belonging to the different groups were produced directly by the computer package BMD07M (Dixon, 1973) used in this study and are directly related to the Mahalanobis D^2 multivariate distance measures from the observation to the different group centroids (see appendix 5.1.5).

6. Testing Discriminant Functions - Statistical Approaches

In Chapter V a number of rigorous statistical tests carried out to determine

(i) whether the assumptions underlying the application of the discriminant model were valid in the case of the data used in this study,

and (ii) whether the resulting discriminant model was statistically significant, were discussed.

It was however pointed out that only by using the resulting model to classify firms apart from those from which it was derived and examining the results can its true significance in a decisional context be assessed. There is of course a world of difference between statistical significance and operational utility. Clearly with large enough sample sizes a correct classification of 52% of observations (when chance would indicate 50%) can be highly significant statistically but is unlikely to be of much utility to a decision maker (Morrison, 1969:158).

In a discriminant analysis the statistical tests discussed in Chapter V will be biassed if applied to the data from which the discriminant function is derived. Two classes of bias can be considered - bias due to sampling errors and search bias.

Sampling error bias arises as the discriminant coeffecients are calculated to maximise the proportion of correct classifications for the same sample from which the function was derived, not for the population(s) from which the sample was drawn. Search bias is that bias due to the search by the researcher for that subset of variables out of the original explanatory measures which works best for the particular sample under investigation. The procedure is termed "arm-twisting the data" or "searching for a good model" by Frank et al (1965:265).

Frank et al discuss two procedures for overcoming these problems, a 'split sample approach' (V_1) which attempts

to avoid both types of bias and a 'simulated sample approach' (V_2) which attempts to determine the bias due to sampling errors alone. Neither of these is strictly applicable to our data for different reasons, however an improvement on the first, examination of the results of the classification of other data, is discussed below.

In the first procedure all the original data is split into two subsamples, one for analysis and the other for validation and the discriminant function(s) derived from the analysis set are used to classify the validation set. A classification table, no longer affected by the classes of bias discussed above, is computed and used to test for significant classificatory ability. They suggest, in fact, that the validation procedure be repeated a number of times using different ways of assigning observations to the analysis and validation samples and the results averaged. Of course it should be pointed out that the procedure is designed only to test for the presence of true differences between samples and that the discriminant coeffecients derived from the total observation set should be used in a decision situation (see Morrison:160).

The test used in the 2-group case is the test of sample proportions (employing binominal distribution theory) and in the k group case (k>2) multinominal distribution theory is utilised.

In the case of two populations with n cases in total, Student's 't' test can be used to test whether the proportion of observations correctly classified by the discriminant function (p) is significantly different to that which can be expected by chance (π) where

$$t = \frac{p - \pi}{\sigma_{\pi}} = \frac{p - \pi}{\sqrt{\frac{\pi\ (1-\pi)}{n}}} .$$

π can be determined using conditional probability theory

(Morrison:158) by considering the classification table in fig 6.4 below where F and G represent two data samples (say "failed" and "good" firms in our case), α is the proportion of all cases belonging to the "failed" group and $(1-\alpha)$ the proportion of all cases belonging to the "good" group.

Actual:	Classified: F	Classified: G	
F	α^2	$\alpha\ (1-\alpha)$	α
G	$\alpha\ (1-\alpha)$	$(1-\alpha)^2$	$(1-\alpha)$
	α	$(1-\alpha)$	

Fig 6.4: Classification Table for computation of π

Then $\pi = \alpha^2 + (1 - \alpha)^2$
(This can also be derived directly using $P(C) = P(C/F).P(F) + P(C/G).P(G)$ where C denotes the event - correct classification.)

Let us ignore the problem that the assumption that p is generated from random drawings from a binomial distribution is patently violated when we use a classification table computed by application of a discriminant function to the data from which it was derived (see Frank et al:253).

Then in the case of the FAILED23 and GOOD45 groups from which our solvency model was derived,

$$\pi = (23/68)^2 + (45/68)^2 = .5523$$

and consequently $\sigma_\pi = 0.05429$

But p = 67/68 (only Rolls Royce was misclassified)

Thus $t_{calc} = 7.976$ which is significant at better than the .001 level ($t_{.001} = 3.460$ with 60 df $= 3.373$ with 120 df).

Altman (1968) used the procedure to test for the presence of true differences, not due to sampling error or search bias, between his two groups and the averaged results of 5 replications gave virtually the same correct classification

percentage (93.5% v 95.5%) indicating negligible sampling error or search bias present in the derivation of the original function. He also used the same procedure in his railroad study (1973), however here the average results for 5 validation samples were somewhat lower than the average results for the 5 associated analysis samples (83.5% v 98.5%) or those arrived at by classifying his original data by the function derived from it (83.5% v 97.6%).

These results taken together with those of the two studies quoted in Frank et al seem to suggest that problems arise particularly when the discriminant function consists of a large number of variables relative to the size of the samples from which it is computed, ie with a relatively limited number of degrees of freedom.

For example in the case of the "Innovation and Brand Choice" study reported in Frank et al (pp255-257), in which the original data consisted of 2 groups each of 98 observations and a 25 variable discriminant function was fitted, 5 replications using different arrangements of half the data for each of the analysis and the validation samples produced average correct classification percentages of 72.9% and 48.2% respectively! Application of the simulated sample approach (V_2) discussed below which attempts to determine the bias due to sampling errors resulted in an average over 10 replications of correct predictions using random data of 72.6%.

It would have been interesting to have had the discriminant coeffecients derived in each of the analysis runs reported so that an examination of their stability could have been carried out.

These results can be interpreted to suggest that search bias was negligible, and that the apparent good "fit" was due virtually entirely to the sampling errors arising from fitting a function of 25 variables using two groups of 49 members each.

In a similar way the reduction in significance in Altman's railroad study between his analysis and validation samples would probably be largely due to his use of a 7 variable function with coeffecients computed from analysis samples of group size 11 members and tested on validation samples each containing in total 20 members. The far better results in his 1968 study into corporate bankruptcy might be due to his smaller size discriminant function (5 variables) and his marginally larger analysis groups (16 members) and total validation sample sizes (34 members).

The other approach discussed by Frank et al (pp254/5) - the simulated sample procedure - is designed to test for sampling error only and they suggest its use mainly when the original data is not available. Effectively the approach consists of invoking the 'simple criterion of independence' and constructing random samples equal in size to the original samples by access to random tables of standardised normal deviates with each synthetic observation vector containing the same number of deviates as variable values. (Strictly speaking if the variance - covariance matrix for the data is available, variates sampled from the appropriate multinormal distribution should be used.)

The discriminant function(s) is/are then computed from these synthetic samples and associated classification table(s) constructed. Since the expected discriminatory power of the analysis is zero, departures from this, which can be tested for significance by the test of sample proportions discussed above or its multinormal equivalent, can be interpreted as a measure of the sampling error bias. The procedure can easily be replicated using different arrangements of the same synthetic data to provide more information. A variation of this approach can be used when the original data is available but the V_1 procedure above cannot be readily applied, possibly because of small sample sizes. Here the synthetic data samples are formed by scrambling the raw data and assigning cases to samples at random, thus effectively keeping the same variance - covariance matrix

as in the original analysis. This approach is used by Edmister (1972) and by Trieschmann and Pinches (1973).

Because of the small size of the "failed" sample in this study it was not possible to use the split sample - V_1 approach directly although the V_2 - synthetic sample approach to test for sampling bias alone could have been used.

However the large number of company failures after 31.12.1973 which was the cut-off point for selection of failed firms for the original failed set of companies allows much better tests of the power of the discriminant function in our study since the model itself can be tested rather than, strictly speakin the classificatory ability of other functions derived from subsets of the original data. The use of such new data is the best test of the model in a real-world decisional framework and it is additionally possible to test whether changes in the time frame appear to have reduced the value of the model since it is being applied operationally to the accounts of firms for years subsequent to the data from which it was derived. The results of these tests are discussed in the next section.

7. The Power of the Z-Model

To test the power of the derived solvency function, the z-scores for the 29 manufacturing companies failing between 31.12.73 and 21.7.76 were computed together with those for the 'no-turnover failed' group of 8 firms of table 4.2, the 16 'poor' firms of table 4.5, other failed firms not included in the original FAILED23 set for various reasons and a set of 10 firms classified a priori by knowledgeable investment analysts as "well-solvent".

The preponderence of failed firms in the above sets of tests is due to a number of reasons, specifically:

(i) their low prior probability makes them better data on which to test the function

(ii) the misclassification cost of a type I error is

so much greater than that of a type II error in most decision situations

(iii) the results of analysis of around 700 sets of accounts of continuing firms are described in Chapter VII

and (iv) there is a problem in the interpretation of what constitutes a "solvent" firm. Continuing (ie nonfailed) firms are not necessarily "solvent".

The Failing and Well-Solvent Test Firms

Considering first the "failing" and "well-solvent" test firms, in table 6.8 the 29 manufacturing firms failing between 31.12.1973 and 21.7.1976 together with their computed z-scores on the basis of the latest accounts prior to failure are listed. Every single firm, it will be noted, has a negative z-score[1] and their mean is -13.80 (or -8.95 excluding those five companies with z-scores less than -30). The mean for the original FAILED23 set was -11.25 applying the operational z-model. The average number of months between the date of the last accounts and first indication of failure for the recently failed firms was 13.04 with standard deviation of 5.85 months and these figures compare with a mean of 15.4 and standard deviation of 6.3 months for the original FAILED23 set. The companies were identified from the Stock Exchange Fact Book list of companies with listings temporarily suspended or cancelled, reference to the Statistics section of the Stock Exchange, the Stock Exchange Official Weekly Intelligence journal and press reports etc.

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[1] It could be argued that the z-score for Norbury Insulation should not have been computed taking into account the receiver's comments that £1m goodwill accruing as a result of acquisitions in the last year was valueless. However since effective application of the model depends on the quality of the accounting information available and in the case of Norbury Insulation this was suspect, it was felt justifiable to write the goodwill off. The z-score on the basis of the figures as presented in its accounts was 0.93.

Table 6.8: Analysis of Recent Failed Companies

Company	Z-Score	Date of Last a/cs	Months from date of last a/cs to first indications of failure	Stock Exchange Industrial Description	Stock Exchange Industry Code No.
A.D.M. Business Systems Ltd.	-15.099	31. 3.73	22	Office Equipment	69
Anglian Food Group	-0.981	29. 9.73	16	General Food Manufacturing	49
Bear Brand	-31.752	31.12.74	14	Clothing	59
British Leyland Motor Corporation	-12.968	30. 9.74	7	Motor Vehicles	43
British Steel Constructions (Birmingham) Ltd.	-19.034	31.10.73	25	Miscellaneous Engineering	27
Budge Brothers	-32.908	30.12.73	8	Contracting and Construction	18
Business Computers Ltd.	-5.062	31.12.72	17	Office Equipment	69
C.B.R Jersey (Holdings) Ltd.	-2.814	31.10.73	11	Miscellaneous Textiles	62
Cohen & Wilkes (Holdings) Ltd.	-45.880	31.12.74	14	Clothing	59
J Collett Ltd.	-7.543	31. 3.73	15	Clothing	59
Court Line	-9.164	30. 6.73	12	Shipping	71
John E Dallas & Sons Ltd.	-5.840	31. 3.74	10	Electronics, Radio and TV	35
Fairfax Jersey Group	-12.454	30. 6.75	8	Cotton & Synthetic	60
Ferranti Ltd.	-3.465	30. 3.74	6	Electricals (Excluding light Electronics, Radio&TV)	19
Fodens	-5.013	30. 3.74	9	Motor Vehicles	43
Heenan Spark Ltd.	-2.780	30. 4.74	14	Industrial Holding Co.	73
Alfred Herbert Ltd.	-5.695	31.10.74	0	Machine Tools	28
McIntyre & Sons Ltd.	-7.909	31.12.72	18	Contracting & Construction	18
A & H Meltzer (Holdings) Ltd.	-13.587	31. 9.74	16	Footwear etc.	64
Metal Products Co. (Willenhall)Ltd.	-2.186	31.12.74	8	Metallurgy	32
T&A Naylor Ltd.	-18.598	31. 3.75	15	Floor Covering	37
Norbury Insulation Group Ltd.	-4.084	31.12.72	14	Heating and Ventilating	30
Rosedale Industries	-22.098	31.12.74	6	Plastic and Rubber Fabricators	66
L Ryan (Holdings) Ltd.	-16.135	31. 1.74	14	Freight and Fuel Handling/ Fuel Manufacturing	72
Charles Spreckley Industries Ltd.	-5.876	30. 9.74	16	Contracting & Construction	18
G Stibbe & Co. Ltd.	-11.926	31.12.73	9	Industrial Plant, Engines & Compressors	22
Tan Sad Holdings Ltd.	-7.435	31. 7.73	22	Miscellaneous Engineering	27
Venesta Int.	-30.563	31. 3.75	8	Industrial Holding Co.	73
W. Wood & Sons Ltd.	-44.307	31.12.73	24	Footwear etc.	64

Four of the firms, British Leyland, Ferranti (which is strictly speaking not a public company as only its preference capital is quoted), Fodens and Alfred Herbert would have gone into liquidation in a conventional sense without Government action and thus were classified as "failed". In the case of Fodens, 8½ months after a Government guarantee of the company's increased overdraft, £3.1m was subscribed for convertible preference shares by a consortium of 30 City firms to avoid Government control of the firm and its equity listing was restored. As regards Alfred Herbert, there was no actual suspension of Stock Exchange listing and thus it is not possible to determine exactly when it 'failed'. On the 4.11.1974 a Government guarantee of £3m was given to the company's bankers in respect of its overdraft which is the date taken here as the first sign of trouble, although maybe a better date should be 10.7.1975 when the Government announced that it would subscribe long-term finance of up to £25m.

To test the robustness of the solvency model firms which had been publicly quoted for less than 5 years, were subsidiaries of other companies or with equity over 50% controlled by their directors were included in the list. Details of these companies and their z-score constituent ratios are given in appendices 6.6.1 and 6.6.2. Six other failed companies classified to the contracting and construction industry group (code 18) by the Stock Exchange were property developers and office and house builders etc with a very different structure to their accounts compared to that of conventional manufacturing firms. These were not included in table 6.8 although their z-scores were all very negative. The very large stock and work in progress item for such companies usually consists of a land bank and properties under development, financed by very high borrowings, both short and long term. An examination of their accounts indicates many such firms

appear 'insolvent' in terms of their z-score and also technically insolvent (negative working capital) although they are not insolvent in the opinion of financial analysts specialist in the property and construction sector, consequently the applicability of the z-function to this class of company must be strongly questioned.

A detailed discussion of the individual firms and the reasons for their failure is beyond the scope of this study although even a cursory examination yields many interesting insights. The paths to failure for example appeared in many cases to be strewn with glowing reports of progress in Chairmans' reports and optimism about the future. The lack of auditors qualifications of the accounts of these firms for going concern reasons in most cases is disturbing and requires a further investigation. Altman and McGough (1974) as pointed out in chapter III §4 in fact investigated this formally in the US and found that only 15 out of 34 companies examined that had entered bankruptcy proceedings during 1970-73 (46%) had had their last available financial reports qualified for going concern reasons. However application of the Altman model (1968) resulted in 'prediction of bankruptcy' in 28 out of the 34 cases (82%).

A number of these 29 firms had been able to make rights issues within 2 years of failure[1] or had been pursuing an active take-over campaign, and in a majority of cases their share prices did not appear to collapse until very shortly

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[1] Blum (1974), as pointed out in §3 p197 above, in fact suggests that the US stockmarket, at least, prefers to invest in failed rather than nonfailed firms.

before the actual date of failure[1]. A discussion of the American work in this area with references and its bearing on the "efficient market hypothesis" controversy (see for example Fama, 1965) will be found in Gooi (1974).

The z-scores for a number of years before failure were computed for British Leyland and Court Line because of their particular interest and these are given in figure 6.5 below:-

	Z-score based on accounts for year ending						
	1968	1969	1970	1971	1972	1973	1974
British Leyland (year end 30.9)	0.23	-1.48	-8.59	-5.43	-3.11	-2.63	-12.92
Court Line (year end 30.6)		-5.03	3.12	5.38	-6.87	-9.16	

Note: The closing 1968 TA and inventory figures were used as opening figures for BLMC in 1968.

Fig 6.5: Prior year Z-scores for BLMC and Court Line

It can be seen that British Leyland was consistently in financial difficulties (using the z-score definition) virtually from the time of the merger between BMC and Leyland in 1968. As regards Court Line it appears that the solvency model was able to anticipate the crash

[1] A study carried out by a student of the author under his direction using cusum techniques (Gooi, 1974) showed that out of the 27 companies examined, in ten cases failure was not detected at all by the stockmarket in terms of share price movements and for the other 17 cases the mean time of detection before failure was 15.3 months with standard deviation 11.5 months. For the nine companies in which both stockmarket price data and z-score data were available for a number of prior years, the results were 17.1 months for share price changes (s=13.4) and 35.4 months (s=14.0) for the solvency model using a cut-off at zero.

percentage (93.5% v 95.5%) indicating negligible sampling error or search bias present in the derivation of the original function. He also used the same procedure in his railroad study (1973), however here the average results for 5 validation samples were somewhat lower than the average results for the 5 associated analysis samples(83.5% v 98.5%) or those arrived at by classifying his original data by the function derived from it (83.5% v 97.6%).

These results taken together with those of the two studies quoted in Frank et al seem to suggest that problems arise particularly when the discriminant function consists of a large number of variables relative to the size of the samples from which it is computed, ie with a relatively limited number of degrees of freedom.

For example in the case of the "Innovation and Brand Choice" study reported in Frank et al (pp255-257), in which the original data consisted of 2 groups each of 98 observations and a 25 variable discriminant function was fitted, 5 replications using different arrangements of half the data for each of the analysis and the validation samples produced average correct classification percentages of 72.9% and 48.2% respectively! Application of the simulated sample approach (V_2) discussed below which attempts to determine the bias due to sampling errors resulted in an average over 10 replications of correct predictions using random data of 72.6%.

It would have been interesting to have had the discriminant coeffecients derived in each of the analysis runs reported so that an examination of their stability could have been carried out.

These results can be interpreted to suggest that search bias was negligible, and that the apparent good "fit" was due virtually entirely to the sampling errors arising from fitting a function of 25 variables using two groups of 49 members each.

Appendix 6.7 contains the z-scores for those manufacturing companies with turnover data failing prior to 31.12.1973 but not included in the "prime failed" group either because they had not failed for strict solvency reasons, had not been public companies for 5 years or their accounts were suspect. The model is not of course applicable in these situations.

To test the definitional ability of the solvency model with well-solvent firms the z-scores of the ten additional firms classified as "well-solvent" by investment analysts at Laurence Prust & Co which were added to their databank before the end of July 1974 were examined. Not unexpectedly there were no surprises. The results for the companies are given in appendix 6.8 with mean z-score of 12.193 and range 6.098 to 19.484. Further direct testing of the model on "well-solvent" firms was not carried out for the reasons given at the beginning of this section.

In fig 6.6 the results of the tests on the 29 recently failed firms and ten well-solvent firms are summarised; the model appears to distinguish between those which have gone bankrupt and those which are "well-solvent" with a 100% accuracy using a cut-off of zero. If a three way classification table is constructed, one of the failed firms - Anglian Food Group (z = -0.981) - would be classified to the "grey area" (see §5 above). In fact its z-score indicates it can be classified as 'failed' with greater than 90% but less than 95% confidence employing the expression for P(f) on p207.

		Classified by Model as:	
		Failed	Well-solvent
Actual:	Failed	29	0
	Well-solvent	0	10

Fig 6.6: Classification Table of the Secondary Test Groups

as in the original analysis. This approach is used by Edmister (1972) and by Trieschmann and Pinches (1973).

Because of the small size of the "failed" sample in this study it was not possible to use the split sample - V_1 approach directly although the V_2 - synthetic sample approach to test for sampling bias alone could have been used.

However the large number of company failures after 31.12.1973 which was the cut-off point for selection of failed firms for the original failed set of companies allows much better tests of the power of the discriminant function in our study since the model itself can be tested rather than, strictly speaking, the classificatory ability of other functions derived from subsets of the original data. The use of such new data is the best test of the model in a real-world decisional framework and it is additionally possible to test whether changes in the time frame appear to have reduced the value of the model since it is being applied operationally to the accounts of firms for years subsequent to the data from which it was derived. The results of these tests are discussed in the next section.

7. The Power of the Z-Model

To test the power of the derived solvency function, the z-scores for the 29 manufacturing companies failing between 31.12.73 and 21.7.76 were computed together with those for the 'no-turnover failed' group of 8 firms of table 4.2, the 16 'poor' firms of table 4.5, other failed firms not included in the original FAILED23 set for various reasons and a set of 10 firms classified *a priori* by knowledgeable investment analysts as "well-solvent".

The preponderence of failed firms in the above sets of tests is due to a number of reasons, specifically:

(i) their low prior probability makes them better data on which to test the function

(ii) the misclassification cost of a type I error is

These are given in table 6.11 below, and their scores back over 4 years in appendix 6.9.3. The distribution of the scores in table 6.11, three of which are negative, is such ($\bar{z}$ = 6.48, s_z = 5.25) that the basis of a separate classification of continuing but not "well-solvent" firms on the basis of investment analyst judgement must be called into question. In a similar fashion the ability of investment analysts to distinguish a sound firm from a firm with potential problems using inituitive models does not appear strictly proven by these results. However, because of problems associated with ensuring that the analysts understood what was required (see chapter V §4) and the small number of firms involved, no further discussion will take place. It will incidentally be recollected that in the 3-group discriminant runs (FAILED23, POOR16 and GOOD45) reported in chapter V §4 the POOR16 and GOOD45 groups of firms were not considered statistically different in terms of their Mahalanobis distance apart, although a simple t-test for significant difference in their sample means results in rejection of the null hypothesis of no difference even at α = .001 (t_{calc} = 3.597, $t_{.001}$ = 3.460).

As regards what has happened to the 'poor' firms subsequently, the z-score for Avon Rubber fell to -2.874 based on the accounts to 30.9.1974 and even further to -9.563 based on the accounts to 30.9.1975. It received State Aid early last year under the 1972 Industry Act and its Chairman and Managing Director both resigned last October. John Brown had a z-score of -0.491 based on it's accounts to 31.3.1974 but this fell to -7.840 on the basis of it's accounts to 31.3.1975. These z-scores would appear to indicate it is in a parlous condition although this is not borne out by its share price or press comment (see chapter VII §8 and appendix 7.8). The z-score for George Kent for the year to 31.3.74 was -0.40 and the takeover battle for it between the Swiss firm Brown Boveri and Rank Instruments will be

Table 6.8: Analysis of Recent Failed Companies

Company	Z-Score	Date of Last a/cs	Months from date of last a/cs to first indications of failure	Stock Exchange Industrial Description	Stock Exchange Industry Code No.
A.D.M. Business Systems Ltd.	-15.099	31. 3.73	22	Office Equipment	69
Anglian Food Group	-0.981	29. 9.73	16	General Food Manufacturing	49
Bear Brand	-31.752	31.12.74	14	Clothing	59
British Leyland Motor Corporation	-12.968	30. 9.74	7	Motor Vehicles	43
British Steel Constructions (Birmingham) Ltd.	-19.034	31.10.73	25	Miscellaneous Engineering	27
Budge Brothers	-32.908	30.12.73	8	Contracting and Construction	18
Business Computers Ltd.	-5.062	31.12.72	17	Office Equipment	69
C.B.R Jersey (Holdings) Ltd.	-2.814	31.10.73	11	Miscellaneous Textiles	62
Cohen & Wilkes (Holdings) Ltd.	-45.880	31.12.74	14	Clothing	59
J Collett Ltd.	-7.543	31. 3.73	15	Clothing	59
Court Line	-9.164	30. 6.73	12	Shipping	71
John E Dallas & Sons Ltd.	-5.840	31. 3.74	10	Electronics, Radio and TV	35
Fairfax Jersey Group	-12.454	30. 6.75	8	Cotton & Synthetic	60
Ferranti Ltd.	-3.465	30. 3.74	6	Electricals (Excluding light Electronics, Radio&TV)	19
Fodens	-5.013	30. 3.74	9	Motor Vehicles	43
Heenan Spark Ltd.	-2.780	30. 4.74	14	Industrial Holding Co.	73
Alfred Herbert Ltd.	-5.695	31.10.74	0	Machine Tools	28
McIntyre & Sons Ltd.	-7.909	31.12.72	18	Contracting & Construction	18
A & H Meltzer (Holdings) Ltd.	-13.587	31. 9.74	16	Footwear etc.	64
Metal Products Co. (Willenhall)Ltd.	-2.186	31.12.74	8	Metallurgy	32
T&A Naylor Ltd.	-18.598	31. 3.75	15	Floor Covering	37
Norbury Insulation Group Ltd.	-4.084	31.12.72	14	Heating and Ventilating	30
Rosedale Industries	-22.098	31.12.74	6	Plastic and Rubber Fabricators	66
L Ryan (Holdings) Ltd.	-16.135	31. 1.74	14	Freight and Fuel Handling/ Fuel Manufacturing	72
Charles Spreckley Industries Ltd.	-5.876	30. 9.74	16	Contracting & Construction	18
G Stibbe & Co. Ltd.	-11.926	31.12.73	9	Industrial Plant, Engines & Compressors	22
Tan Sad Holdings Ltd.	-7.435	31. 7.73	22	Miscellaneous Engineering	27
Venesta Int.	-30.563	31. 3.75	8	Industrial Holding Co.	73
W. Wood & Sons Ltd.	-44.307	31.12.73	24	Footwear etc.	64

recollected. Reyrolle Parsons recovered during 1973, its z-score for the year to 31.12.1973 rising to 5.519, however this does not apply to Strong and Fisher - its results based on the accounts for the years ending 31.5.1973 - 31.5.1975 were -0.536, -0.464 and -3.349. Neverthess neither its share price nor press comment reflected these scores and this is explained by the knowledgeable investment analysts consulted by the author as being due to its relatively high profits despite very heavy borrowings. (For the accounts to 31.5.1975, $EBIT/TA_{t-1}$ = 0.1356, TL/NCE = 1.6824, QA/TA = 0.3870, WC/NW = 0.3973, stockturn = 3.8800.) In fact they believed the z-score better represented the risk attached to the company which is in the hide and skin business and subject to very rapid movements in the price of its raw materials.

It will be noted that no claims are made for the predictive ability of the model above when discussing the prospects for the POOR16 firms. In fact tests on other firms, and those from which the solvency model was derived, strictly speaking, only indicate that a negative z-score is a necessary concomitant of failure not a predictor, ie it is a necessary but not a sufficient condition. This approach contrasts with that of the previous American studies which, as has previously been pointed out in chapter III, claim to be using such a discriminant model as a predictive device. This must clearly be wrong as evidenced by the large number of continuing companies with negative z-scores; a number of which are listed in the next chapter.

Companies recover from insolvency defined in terms of a negative z-score or continue for some time with z-scores less than zero without failing in the sense employed here. All that it is possible to suggest is that a

negative z-score would appear to increase the likelihood of liquidation or appointment of receiver etc which events depend upon the actions of such people as debenture holders, bankers or trade creditors which cannot be forecast; it is these which "tip the firm over the edge". Firms theoretically may be able to continue for many years with negative z-scores (ie resembling financially other firms which previously have failed more than well-solvent firms) without actually failing in an absolute sense.

Nevertheless experience gained from applying the z-model in practice, its underlying theoretical basis and the nature of its constituent ratio measures together with the structure of the statistical models employed to derive it, would suggest on a face value basis only, that the more negative a company's z-score is, the more likely it is to fail. Given of course, strictly speaking, it has been publicly quoted for a number of years, belongs to an industry for which the solvency function can be meaningfully applied and has undergone no major changes which might affect its accounts dramatically. The same would also appear to apply to the number of years of negative z-scores. The Wilcox Gambler's Ruin Markov Chain model (Wilcox, 1971a and b and 1973) would thus seem to be a valid conceptual approach as a three stage model with an absorbing state of the form of fig 6.7 below, with empirical data used to derive the functions $g_1(z)$, $g_2(z)$, and $g_3(z)$ and such an approach might be an interesting avenue to pursue.

		To State: Solvency	Insolvency	Bankruptcy
From State:	Solvency	$g_1(z)$	$1-g_1(z)$	0
	Insolvency	$g_2(z)$	$g_3(z)$	$1-g_2(z)-g_3(z)$
	Bankruptcy	0	0	1

Fig 6.7: A Conceptual Transition Matrix for a Markov Chain Approach to Failure 'Prediction'

8. Prior Year Z-score Profile Analysis

It is instructive to consider how far in advance of failure a firm appears 'insolvent' and to this end an analysis of the z-scores calculated by applying the discriminant model to the FAILED23 group of firms for 3 accounting years prior to the last available before failure was carried out. The results are given in appendix 6.9.1 together with the last available z-scores for comparison. (In appendices 6.9.2 and 6.9.3 the equivalent figures for the GOOD45 and POOR16 groups of companies based on the published accounts for the 4 financial years prior to and including the latest available at the time of analysis are also presented.) It will be noted that certain of the z-scores computed from the last available accounts do not coincide with those given in table 5.9 and this is because of the slightly different ratio limits used in the operational model (particularly for the TL/NCE and stockturn measures) and the fact that the denominator of the $EBIT/TA_{t-1}$ ratio was not adjusted for significant growth in total assets in the original data from which the function was derived.

In fig 6.8.1 the percentages of the 23 firms classified as 'insolvent' and 'solvent' for prior years of accounts to the last before failure on the basis of their z-scores being less than or greater than zero is presented and in fig 6.8.2 a three-way classification is presented using the "grey area" limits of the operational model (see §5 above) of -1.56 and 4.33 to define a "zone of ignorance" for investment purposes.

Not surprisingly the percentage of firms classified as 'solvent' falls off very rapidly as failure approaches, with only one firm (Amalgamated Transport) classified as 'solvent' outside the "grey area" on the basis of its penultimate set of accounts, and this firm in fact in the subsequent financial year took over a very large insolvent motor haulage concern which acquisition appeared

Classified as	Prior accounting years 4	3	2	last
Insolvent (z < 0)%	52.2	65.2	69.6	95.6
Solvent (z > 0)%	47.8	34.8	30.4	4.4

Fig 6.8.1: 2-way classification

Classified as	Prior accounting years 4	3	2	last
Insolvent (z<-1.56)%	39.1	52.2	65.2	91.3
Grey area (-1.56<z<4.33)%	17.4	26.1	30.4	8.7
Solvent (z>4.33)%	43.5	21.7	4.4	0

Fig 6.8.2: 3-way classification

Fig 6.8: Z-Model Classification of the FAILED23 Companies for Accounting Years Prior to and Including the Last Published Accounts

to be the cause of its demise. It should, of course, be recollected that because of the average 15.4 months lead time between the end of the financial year covered by the last set of accounts and actual failure, accounts for prior years refer to accounting years commencing on average 3 years 3 months, 4 years 3 months and 5 years 3 months before failure. These results, of course, can in no sense be used as a test of the long range predictive accuracy of the model in the sense of Altman (1968:604). Companies' financial states change over time, some decline, some appear to improve from apparent insolvency and some remain stable for many years. To examine this in detail data is necessary, which unfortunately was not available in the UK at the time the analysis was undertaken, allowing rigorous analysis of changes in company z-scores (measuring solvency) over time. (An attempt at some analysis of this

nature is however discussed in the next chapter.) Thus all it is possible to state strictly speaking is that 12 out of the 23 firms examined which subsequently failed were classified as 'insolvent' using a cut-off of $z = 0$ on the basis of their accounts published 3 years prior to the last available, 15 were similarly classified on the basis of accounts published 2 years prior, 16 on the basis of accounts published one year prior and 22 out of the 23 on the basis of their last published accounts. No attempt is made to predict failure, only to classify the firms under investigation as 'insolvent' or 'solvent'.

In the same way it is not possible strictly speaking to talk about type I and type II errors for prior year results because it is not possible to say whether a firm is actually "failed" or not because it is clearly continuing in existence. Beaver (1966:89/90) however felt this was meaningful.

As regards the previous related work, the results quoted here can only be compared with those of Altman (1968), the comparison is presented in table 6.12:

	Study	
Accounting Years Prior to Failure	Present (1976)	Altman (1968)
last	4.4	6.0
2	30.4	28.1
3	34.8	51.7
4	47.8	71.4
5		64.0

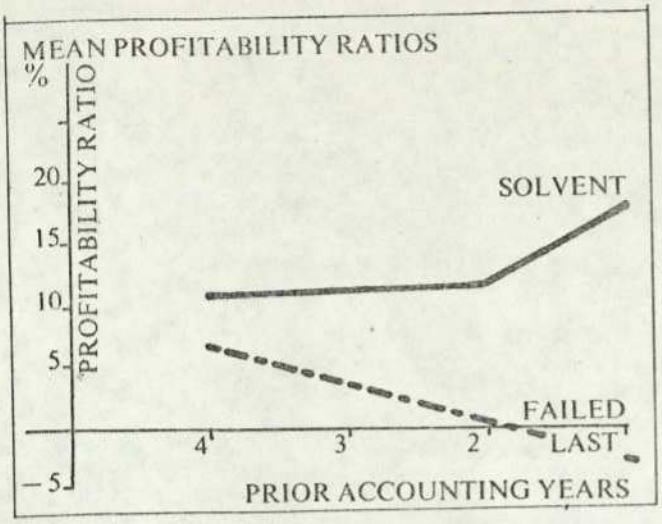
Table 6.12: Percentage of Firms Subsequently Failing Classified as Solvent in Prior Years

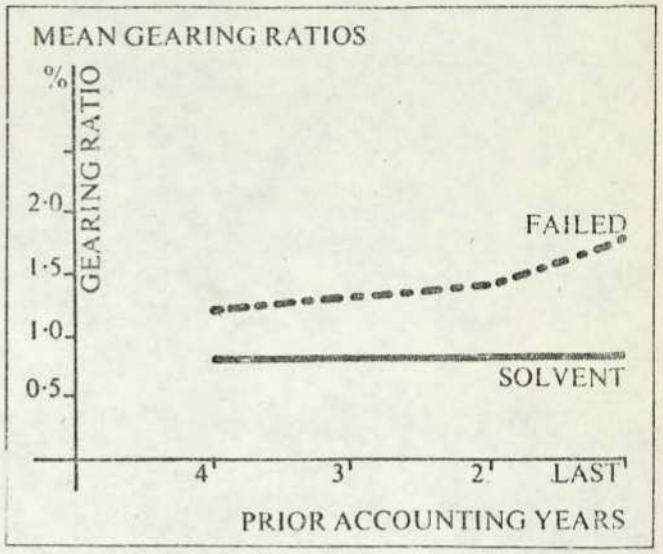
Blum (1974) adopts a different but non-operational approach in computing different sets of functions for different prior years and Deakin (1972) and Lis (1972) adopt a related approach. Beaver's (1966) examination of the

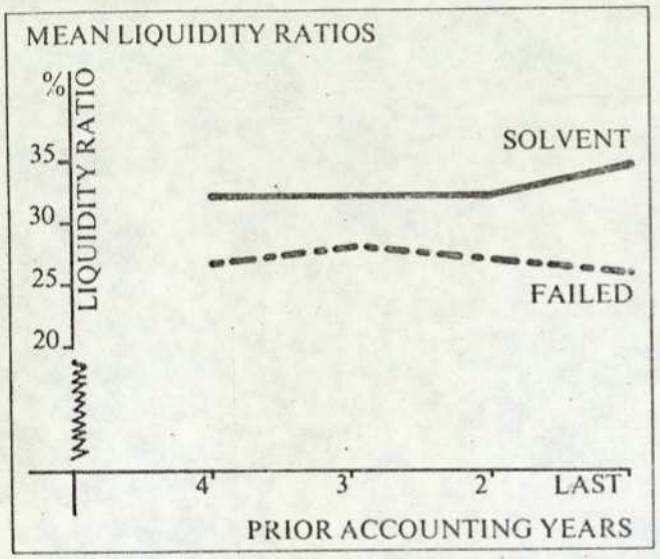
individual ratio values for failed and matched nonfailed firms for prior years is not strictly comparable. No other commentators examined this question.

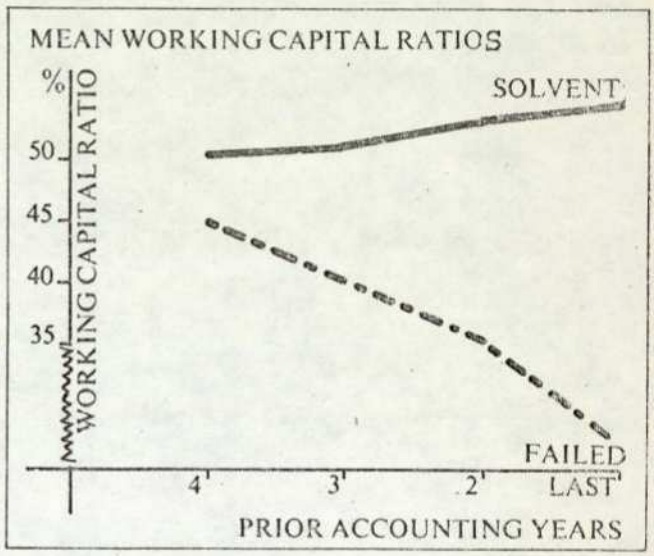
It is also interesting to carry out a profile analysis of the mean z-scores and mean constituent ratios derived from application of the operational model to the FAILED23 and GOOD45 firms (the latter for comparison purposes) as failure approaches. Because it was not considered necessary to match the well-solvent companies in any way the financial years for the two groups do not coincide. The prior year means for the good companies are the average results based on the published accounts for the 4 financial years prior to and including the latest available at the time of analysis (with 91% of year ends dated between 30.9.72 and 30.9.73), whereas those for the failed companies are straight prior year averages with in the case of the stockturn ratio the first available measure employed for those years where no turnover data was published.

In appendix 6.9 the prior year z-scores for the FAILED23, GOOD45 and POOR16 companies are reproduced and in appendix 6.10 the mean and standard deviations for the z-scores and constituent ratios for the FAILED23 and GOOD45 firms for prior years are given. The profiles of the groups back over time are reproduced visually in fig 6.9 (prior year z-score means) and fig 6.10 (prior year constituent ratio means.)









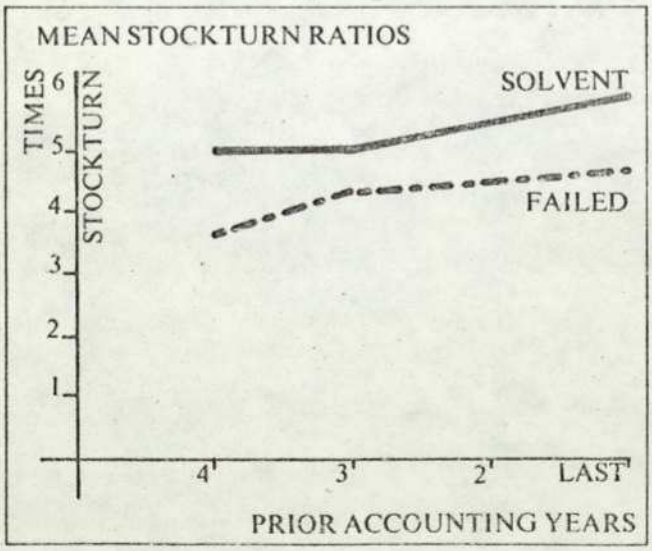


Fig 6.9: FAILED23 and GOOD45 Prior Year Z-Model Constituent Ratio Means

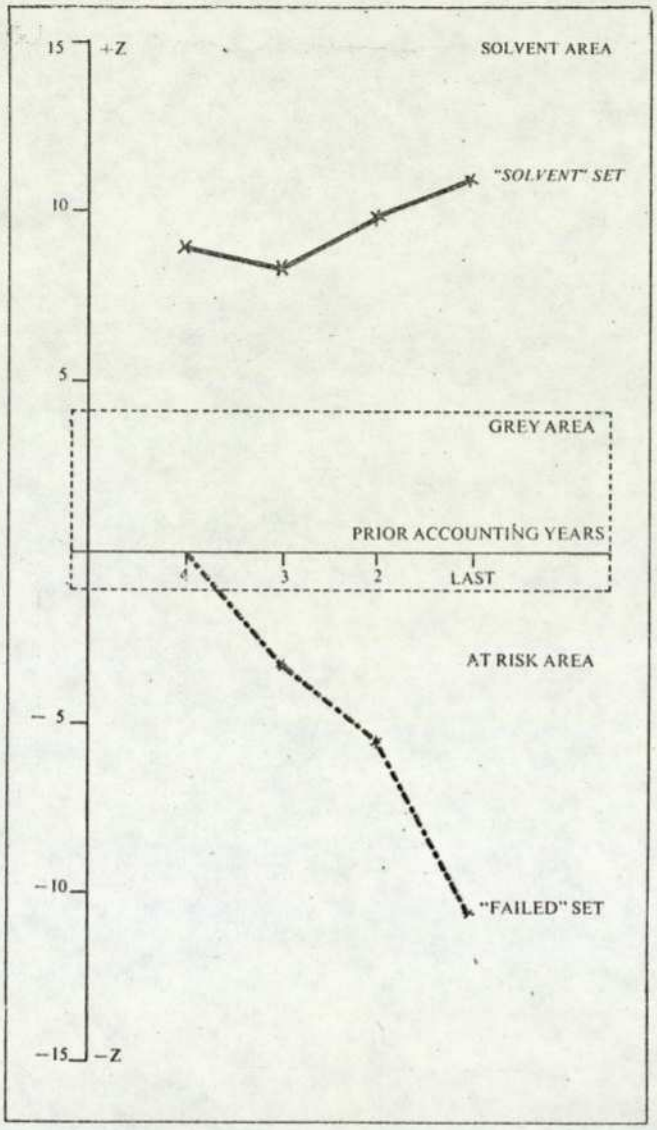


Fig 6.10: FAILED23 and GOOD45 Prior Year Z-Score Means

recollected. Reyrolle Parsons recovered during 1973, its z-score for the year to 31.12.1973 rising to 5.519, however this does not apply to Strong and Fisher - its results based on the accounts for the years ending 31.5.1973 - 31.5.1975 were -0.536, -0.464 and -3.349. Neverthess neither its share price nor press comment reflected these scores and this is explained by the knowledgeable investment analysts consulted by the author as being due to its relatively high profits despite very heavy borrowings. (For the accounts to 31.5.1975, $EBIT/TA_{t-1}$ = 0.1356, TL/NCE = 1.6824, QA/TA = 0.3870, WC/NW = 0.3973, stockturn = 3.8800.) In fact they believed the z-score better represented the risk attached to the company which is in the hide and skin business and subject to very rapid movements in the price of its raw materials.

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Companies recover from insolvency defined in terms of a negative z-score or continue for some time with z-scores less than zero without failing in the sense employed here. All that it is possible to suggest is that a

9. Dividend Behaviour and Company Profitability Before Failure

Before concluding this chapter a note on the dividend behaviour of the failed firms as failure approaches appears relevant.

Out of the 31 failed firms made up of the "prime" FAILED23 and the "no-turnover" FAILED8, 11 paid no dividends at all in their last 3 years and 22 showed negative total earnings before tax in their last published accounts of which 18 also showed negative EBIT. Out of these Wilson Lovatt and Handley Page maintained a full dividend, the latter for the previous year as well when it again showed negative total earnings before tax, and Royston with negative EBIT cut its dividends. (It will be recollected that the total earnings before tax figures for Handley Page and Rolls Royce were adjusted by the writing back of capitalised R & D expenditures.)

Of the 9 with positive total earnings before tax, Cyril Lord increased its dividend to 1.5 X its distributable earnings resulting in negative retained operating earnings! Two companies continued to pay a full dividend, Mitchell Construction and Headquarters and General Supplies, in the latter case because of an halving in earnings after tax, the dividend exceeded the distributable earnings. Three firms cut their dividends - Hartley Crosland, Lines Bros and Rolls Royce; Lines Bros's reduced dividend, however, exceeded its distributable earnings. In the case of Rolls Royce its distributable earnings were negative, nevertheless it paid out nearly twice its total earnings before tax to shareholders (£3.97m). In the previous year its ordinary dividend payment was nearly 9 times its distributable earnings (£7.38m v £0.85m) and in the year before that twice (£6.11m v £3.13m)! The other three paid no dividends (Wilson Mandleburg - increased profits, W J Sagar - profits became positive after 3 years of losses and Amalgamated Transport - very small total earnings before tax).

It would appear that a number of firms continue to pay dividends out of reserves despite impending failure possibly to maintain some measure of confidence both among creditors and in the Stock Market. Dividend payments are seen as an important determinant of a firms equity price by many commentators (see for example Brealey, 1971 chs 1/2). It would also appear that firms which fail are not necessarily making losses.

10. Summary and Conclusions

In this chapter detailed consideration was given to the utility for operational purposes of the final solvency function derived in the previous chapter and the results from testing the model on recently failed firms and other well-solvent firms were discussed.

In the first section after the introduction the results of varimax rotated principal component analyses of the 50 ratio set of appendix 4.9 for the GOOD45 and FAILED23 data sets, both taken together and considered separately, were discussed in detail. It was concluded that seven distinct dimensions existed in the accounting ratio data examined and these were present in both the GOOD45 and FAILED23 company data. Related dimensions appeared to be present in the American data with which our results were compared insofar as the ratios computed were similar.

In §3 the constituent ratios of the final solvency model were considered in the context of the principal component analysis results and it was seen that they were highly correlated with the factors - profitability, gearing, quick assets position, working capital position and creditors position, the latter measuring general company activity and cash generation. Their individual discriminatory power in the function was examined and it was shown that the first two ratios together accounted for 78.5% of the total. The reasons for the inclusion of the different ratios and their presence in previous studies were also considered.

In the next section the changes made to the model to make it strictly operational on continuing firm data ie firms which cannot be classified as 'solvent' or 'insolvent' on an a priori basis were outlined and rules for handling extreme ratio values and company growth etc laid out. Then the statistical models for appraising the probability of "correct" classification of a firm as resembling more, in terms of its financial characteristics, those which had previously failed or were "well-solvent" were discussed. Differential prior probabilities and misclassification costs were explicitly taken into account in deriving the functions and also the associated set of classification boundaries. These included a "grey area" in which classification could not be made with more than 95% confidence.

In §6 the different approaches suggested by the literature for testing the power of a discriminant function in the absence of replication data were discussed. However it was pointed out that tests on other data than that from which a function is derived are far more satisfactory and in the following section the results for such tests for the final model derived in this study were discussed. The z-model was able to correctly classify the 29 manufacturing firms which had failed between 31.12.73 and 21.7.76 and also 10 a priori classified "well-solvent" firms. Analysis of two other sets of failed firms and the 16 original continuing firms not classified a priori as "well-solvent" also yielded interesting results. It is of course recognised that ex post classification is not the same as ex ante prediction.

In §8 the prior year z-scores for the FAILED23 firms were examined and it was shown that 12 looked 'insolvent' on the basis of their accounts 4 years prior to failure, 15 on the basis of 3 year prior accounts and 16 on the basis of the two year prior figures. The behaviour of the constituent function ratios as failure approached was also described.

In the final section before this the dividend behaviour and profitability of the failed firms employed in the analysis were considered. It was concluded that firms do not necessarily cut their dividends as failure approaches nor are they by any means invariably making losses in their final accounting year.

The results of this chapter indicate that the solvency function appears to be a valid tool for purposes of short-term micro-economic analysis. In fact invoking our amended "predictive-ability" criterion of chapter II §§2-3 they suggest that the underlying data used in the analysis, taken in conjunction with the decision model employed (discriminant analysis), are "material" and valid for the purposes of defining the critical state of insolvency. What this is saying effectively is that the accounting items making up the audited published accounts of publicly quoted manufacturing companies are highly material for this particular purpose when taken in conjunction with the computed solvency function.

In addition it must be noted that unlike Beaver (1966) and Altman (1968) etc it is not maintained here that an empirical test of the utility of financial ratios per se has been carried out. The results of this chapter have only indicated that a certain set considered together in a certain way is able to clearly distinguish between firms which have failed and those which have not and consequently they have utility in this form for this one purpose. It is not possible to infer from the results of this study that other ratios uncorrelated with those constituting the function will necessarily have utility for the same purpose nor that the ratios employed here or any others will have any utility taken in conjunction with other decision models in any other situation requiring financial or economic analysis.

Chapter VII: What Do Continuing Companies Look Like?

1. Introduction

Throughout this study it has been consistently pointed out that the approach employed can only result in a definitional model which allows a company, on the basis of its financial characteristics as reflected by its accounting numbers, to be classified as resembling more other firms which have already 'failed' or are 'well-solvent'.

Unlike the previous related US studies no attempt has been made to claim "predictive ability" for the approach, in fact it has been made clear that this is something which cannot be proved by a derived model classifying already failed or continuing firms correctly on an ex post basis. This is borne out by the evidence that companies continue in an 'insolvent' state for a number of years and then recover on their own, are taken over as an alternative to actual failure in the sense employed here or are given government overdraft guarantees, grants or loans to continue in operation. Thus the accounting data employed or even the classification models themselves taken in conjunction with the accounting numbers utilised cannot be strictly predictive.

In an attempt to understand these matters better and to gain an empirical insight into the solvency of British companies, an analysis of z-scores and constituent ratio values for continuing manufacturing companies was undertaken.

A number of questions were considered specifically:

(i) what problems arise when calculating z-scores in practice?

(ii) what do continuing companies and the empirical distributions of their z-scores and constituent ratios look like?

(iii) what proportion of continuing companies appear insolvent and do they tend to recover?

(iv) what effect does government policy in the shape of the 1972 Industry Act appear to have had?

and (v) does the financial press appear to take sufficient notice of the warning signs of insolvency?

Some of the answers are provided in this chapter.

2. The Data Source

2.1 The Source

To examine the questions raised above readily using the z-function requires among other things an up-to-date reliable source of published financial data in standardised form on computer file covering all manufacturing companies and going back a number of years. Unfortunately a data source equivalent to the US Compustat tapes, as pointed out previously, was not available to the author at the time the analysis was conducted. However, by October, 1975 the stock-broking firm of Laurence,Prust & Co had already analysed around a thousand sets of accounts using the z-model and it proved possible by drawing on the information available from Extel cards, the McCarthy Press comment service, the Stock Exchange Official Year Book and the company accounts themselves to make use of their results to gain at least some tentative answers.

The data available from Laurence, Prust & Co related to companies with financial year ends between 1969 and 1975 with the vast majority for financial years ending in the calendar years 1973 and 1974. The z-scores had been calculated for companies followed by their investment analysts, in response to solvency and other queries from their clients and often after publication of annual results to provide an initial and quick 'thumb-nail' sketch. The question of bias in

the data is discussed below.

Considerable work however had to be undertaken before the data source was in a usable form. First of all companies which had already failed, could not be identified, were not publicly quoted, had duplicates, were subsidiaries of others (except in a few cases), appeared to have surprising results or extreme ratio values or had grown very rapidly over the year indicating either data errors or exceptional financial structure or behaviour were rejected unless input data errors were suspected when the results were recomputed from data drawn from Extel cards. All companies were then vetted to ensure they were strictly involved in manufacturing by reference to the entries describing their main activities in the Stock Exchange Official Year-Book for 1973-4 (Stock Exchange, 1973), and industry classifications in terms of the Stock Exchange industry code numbers were assigned by reference to the Extel list of classified companies for 1973 (Extel, 1973). Any company with significant retailing, financial, rental, overseas trading or contracting and construction activity etc was rejected.

Of the remaining firms all those appearing 'insolvent' and therefore most significant for the purpose of this study were checked by recompiling and recomputing their z-score from data abstracted from Extel cards. This was done to test the reliability with which Laurence, Prust & Co had computed the company z-scores. Apart from one or two instances there appeared no material difference and consequently the resulting company data provided by them was considered suitable for analysis purposes.

In any case accounting numbers can at best only be considered approximate measurements of economic reality and an accounting ratio, strictly speaking,

is a variate (ie stochastic observation of something absolute) not a variable. Consequently it is not possible to maintain that a z-score can in any way exactly reflect any 'true' and 'absolute' measure of economic reality. This, of course, reflects on the discussion of the materiality of accounting numbers in the early chapters of this study and provides ammunition for the argument that small differences in z-scores calculated from the same data by different analysts occasioned by slightly different interpretations of certain of the items cannot be considered very serious. (Compare the results of differing treatments of minority interests and other items in the last chapter §§4.3-4.4 when it was shown that because of the multivariate nature of the z-model the changes largely cancelled out. The following paragraphs also shed light on this issue.)

2.2 Problem Areas in the Interpretation of Accounting Data

Experience in working with the data needed for the z-model threw up a number of problem areas not foreseen previously with regard to differing treatments or classifications of similar account items between firms. These are listed below:

2.2.1 Progress Payments

Here some companies only provided stock and work in progress figures net of progress payments whereas others provided both the gross figure and progress payments separately. In the case of capital goods industries, shipbuilding and aircraft manufacturing companies etc with long production cycles, progress payments are very material and using a net figure for stock and work in progress (WIP) increases the stock-turn figure in many cases 2 or 3 times. This also has the result of improving the

profitability and liquidity ratios by reducing total assets by the amount of the progress payments and similarly effects the gearing measure. The recommended treatment where the progress payments were given separately was to use the gross stock and WIP figure for the stockturn computations and offset the progress payments by an increase in current liabilities of the same amount. Although the majority of the larger companies provided both gross figures and progress payments separately a number of the smaller ones did not and one or two companies were removed from the data set for this reason.

2.2.2 Goodwill

Meeks and Whittington (1975:831) point out "It is common for acquiring companies to pay more for an acquisition than the "victim's" book value and to deal with the surplus payment either by creating "goodwill" or by revaluing tangible fixed assets". (See the detailed discussion of this issue in Samuels and Wilkes, 1971 §§17.5-17.7.)

Some companies examined treated goodwill as an intangible asset and increased their capital account accordingly whereas others netted it off against reserves. To standardise treatment where possible the former alternative was employed and in many cases it proved possible by reference to the separate intangible assets column in the Extel card to identify cases where the alternative procedure had been adopted by the company and appropriate adjustments to the accounting numbers made. In fact unless the figures were very large, because of more

or less counterbalancing changes in the constituent ratios of the z-model the two differing approaches would not be expected to make a material difference to the z-score value.

2.2.3 Cash at Bank

A number of companies simultaneously had high cash at bank and overdraft figures. In this case the advised procedure was to net the figures out.

2.2.4 Bank Loans

In some cases it proved possible to argue over the classification of a bank loan to current or long term liabilities. In the end it was decided that the treatment should be as indicated in the published accounts.

2.2.5 Corporation Tax

Many companies classified part of their corporation tax liabilities as a long term liability on the basis presumably that since this portion would not have to be met for a year and a day after the end of the financial year it was long term. Where this was done the corporation tax item (not the deferred tax - see below) in long term liabilities was reclassified to current liabilities on the argument that it really constituted a current liability.

2.2.6 Deferred Tax

The deferred tax item in long term liabilities, representing the cumulative tax due on asset appreciation profits as a result of inflation and capital allowances and with payment postponed by the government, grew significantly in size in most companies over the period

of time considered here. As many financial commentators appear to believe that actual payment will never be required appropriate treatment of deferred tax was questioned. It was eventually decided to treat it as a conventional long term liability.

2.2.7 Exceptional items in the Profit and Loss Account

Although sometimes problems were met in deciding upon whether an item was of a trading or exceptional nature it was usually possible to determine whether it arose as a result of ordinary trading activity or not and to adjust the EBIT figure accordingly.

However, in virtually no instance would changes in classification of the above data items have resulted in a material change in a z-score by which is meant changing a company's classification from 'solvent' to 'insolvent' or vica versa.

It is finally worth noting the problems that appeared when applying the z-model to companies in processing industries such as food manufacture, bricks and cement etc. In many cases the stock-turn ratios of such firms were outside the acceptable limits and it would consequently appear that they are less amenable to analysis by the solvency function than engineering firms for example.

3. The Characteristics of the Continuing Firms

The ratio data for the firms remaining after those exhibiting problems of the nature discussed in the previous section had been removed was then laboriously transcribed in company alphabetical order onto coding sheets, the full and correct names of the firms were added together with their industry code, correct year end and information on their ownership

and number of years quoted if less than 5 (gathered from the Stock Exchange Official Year Book). These sheets were then punched into computer cards.

Computer programs were written to list the company information for the different years flagging company growth and ratio values outside limits and classifying firms as either 'solvent' ($z>4.33$) in 'gray area' ($-1.56<z<4.33$) or 'insolvent' ($z<-1.56$). In addition separate listings were provided for all firms with negative z-scores. Industry tabulations and z-score and constituent ratio histograms and ogives were also produced separately for each year. In appendix 7.1 the data for all the 641 firm z-scores finally analysed here is provided in alphabetic order by financial year in an easy to read format, in appendix 7.2 data relating to those firms with negative z-scores in years 1973 and 1974 is given and in appendix 7.3 information relating to the industry characteristics of the data in years 1973 and 1974. In appendix 7.4 the histograms and ogives for the z-scores and constituent model ratio distributions are given for the 1973 and 1974 data with histograms in both original and standardised form. In table 7.1 the means and standard deviations for the z-score and ratio distributions for the data are given, however only the figures of course for 1973 and 1974 are likely to be meaningful.

The main question to be asked given the non-random way in which companies were selected for analysis is how representative of the underlying population of publicly quoted manufacturing companies are the resulting firms for 1973 and 1974 (the years for which results will be discussed)?

Accounting year ending in calendar year	Number of companies	Number of -ve z-scores	Statistics	EBIT/TA_{t-1}	TL/NCE	QA/TA	WC/NW	Stock-turn	Z-score
1969	8	2	m =	.16	1.02	.33	.47	5.47	8.43
			s =	.16	.40	.13	.11	2.53	11.93
1970	8	4	m =	.06	.98	.31	.43	4.68	2.48
			s =	.09	.32	.10	.17	1.74	6.92
1971	15	3	m =	.09	.98	.32	.43	5.18	4.59
			s =	.12	.51	.09	.30	1.51	11.98
1972	31	4	m =	.12	.96	.33	.48	4.97	6.40
			s =	.06	.37	.07	.20	1.56	6.94
1973	296	26	m =	.15	.95	.35	.50	5.57	8.97
			s =	.06	.38	.08	.24	2.28	7.43
1974	252	38	m =	.15	1.03	.32	.51	4.96	7.11
			s =	.07	.38	.08	.24	1.94	7.20
1975	31	3	m =	.13	1.05	.29	.54	4.90	5.61
			s =	.05	.34	.08	.26	2.35	5.44
	641								

Note: m denotes sample mean
s denotes sample standard deviation

Table 7.1: Constituent Company Accounting Year, Z-score and Ratio Summary Information

The 1973 companies constitute 24.09% of the total companies clearly classified to manufacturing industry in the 1973-4 Stock Exchange Official Year-Book with the equivalent 1974 percentage 20.71%. When the unweighted averages over the 44 industrial groups are computed the respective figures are 27.56% and 23.26% which does not appear to indicate large bias in either case. In fact it can be seen from table 7.2 that the profiles of the 2 samples are very similar to each other but that they are weighted more heavily towards capital goods and consumer durables than is the overall company population. This reflects the sectors followed more closely by the stockbrokers.

Industrial Sector	Listed Population (%)	1973 Sample (%)	1974 Sample (%)
Capital Goods (SE codes 11-33)	41.0	49.0	50.6
Consumer Goods - durable (SE codes 35-43)	12.7	14.3	15.5
Consumer Goods - non-durable (SE codes 45-65)	28.8	21.4	21.5
Other Groups (SE codes 66-73)	17.5	15.3	12.4

Note: Headings and codes denote Stock Exchange industry classifications.

Table 7.2: Manufacturing Industry: Sector Breakdown - Company percentages (1973 and 1974 Samples)

Source: Stock Exchange Official Year-Book 1973-4

It should be noted, however, that the gross percentages of 24.09 for 1973 and 20.71 for 1974 are considerably understated since the total listed population of 1212 firms considered contains a large number of companies which would be excluded from analysis employing the same criteria as that used in arriving at the 2 samples, or through merger. In addition 17 companies with financial years ending in 1973 were excluded from inclusion in that year's sample by virtue of already being discussed under the heading of the POOR16 or GOOD45 sets.

Apart from the problem of industry classification bias there is also the potentially more serious problem of whether the sample firms within each industrial classification group tend to be biased towards low performers by virtue of companies being included for analysis originally because of *a priori* potential insolvency.

In chapter VI, footnote to p207, it was stated that on the basis of their experience the investment analysts at

Laurence, Prust & Co had estimated there were 10 times as many 'well-solvent' firms as those in financial difficulties and this figure was used to set up confidence limits and to define the boundaries of the 'gray area'. For the 1973 sample there were 18 firms with z-scores less than -2.30 (the cut-off with prior probabilities considered on this basis but with equal costs of misclassification[1]) and for 1974 there were 22, ie 6.1% and 8.7% of the total samples. (A number of the failed companies in table 6.8 which were included in the original sample data were excluded from these 2 samples.) It is not possible to say whether these figures are biased or not or use them to justify the Laurence, Prust & Co estimates, however, a priori it may be possible to argue that since 1974 was a considerably more difficult year for industry than 1973 with the three day week and even higher cost inflation, the increased percentage does make sense.

Nevertheless the latest available z-score for British manufacturing industry computed from aggregate accounting data for 605 continuing listed companies in the financial year 1973 published by the Department of Industry in its Business Monitor M3 series (DOI, 1975)[2] is 9.74. This contrasts with the figure computed here of 8.97 which given the very different bases of computation would not appear to indicate a very substantial downward bias[3].

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[1] $.5 = \frac{e^z}{e^z + \frac{1}{10}}$, $\therefore$ $z = -2.303$.

[2] A detailed discussion of the coverage and data definitions etc will be given in the next chapter when different industry trends over time will be analysed.

[3] The year 1973 is taken by the Department of Industry to denote the financial year to 5.4.1974 although as a result of the basis on which their provisional figures are compiled it is probably reasonably safe to consider that the two time periods, ours and theirs, more or less overlap. The M3 data also includes certain industries such as breweries and tobacco etc excluded from consideration here using the solvency function.

Other issues such as how the company size distributions of the two samples employed here and their constituent firm financial year ends compare to those of the total population, it is not possible to comment upon.

Thus it would not appear possible, strictly speaking, to determine whether or not the 1973 and 1974 samples are representative of the total population of continuing manufacturing companies which can be analysed using the z-model in these years; however no strong evidence of bias has been discovered. Nevertheless, even if no inference can be made about the underlying population on the basis of the two samples there is no reason why they cannot be considered and analysed as of interest in their own right. A separate examination of the 126 common companies with results available for both years is of interest as well to gain a clearer idea of the changes in industrial performance from one year to the next.

4. The Normality of the Z-score and Constituent Ratio Distributions

The first question to be asked is whether the individual ratio and z-score distributions are in fact separately normally distributed or not. In Chapter II §5 the existing literature was surveyed and the results of Horrigan (1965) and Deakin (1976) discussed in some depth. To investigate using our data the contention of Deakin (p95) viz:- "it would appear that assumptions of normality for financial accounting ratios would not be tenable except in the case of the TD/TA ratio", chi-square statistics were separately computed for the 5 ratio and z-score distributions for the years 1973 and 1974 from the distributions of appendix 7.4. The results are given in table 7.3 below:

profitability and liquidity ratios by reducing total assets by the amount of the progress payments and similarly effects the gearing measure. The recommended treatment where the progress payments were given separately was to use the gross stock and WIP figure for the stockturn computations and offset the progress payments by an increase in current liabilities of the same amount. Although the majority of the larger companies provided both gross figures and progress payments separately a number of the smaller ones did not and one or two companies were removed from the data set for this reason.

2.2.2 Goodwill

Meeks and Whittington (1975:831) point out "It is common for acquiring companies to pay more for an acquisition than the "victim's" book value and to deal with the surplus payment either by creating "goodwill" or by revaluing tangible fixed assets". (See the detailed discussion of this issue in Samuels and Wilkes, 1971 §§17.5-17.7.)

Some companies examined treated goodwill as an intangible asset and increased their capital account accordingly whereas others netted it off against reserves. To standardise treatment where possible the former alternative was employed and in many cases it proved possible by reference to the separate intangible assets column in the Extel card to identify cases where the alternative procedure had been adopted by the company and appropriate adjustments to the accounting numbers made. In fact unless the figures were very large, because of more

be suggested except that his data which was taken direct from the Compustat tapes included firms of the type rejected from inclusion in the samples here.

In the case of QA/TA, for both samples the normality assumption could not be rejected here whereas Deakin consistently found it non-normally distributed. However when he examined the distributions for 6 industrial groups separately in only 3 cases could the normality assumption be rejected at $\alpha=.05$. This, in fact, probably suggests similar problems in the tails of his distributions to those experienced here because in his separate industry analyses he used only 5 probability groups so as to have a minimum of 6 observations in each. It does not necessarily indicate that there is a higher degree of normality within industry groups as he correctly points out (p95).

Similar findings relate to our $EBIT/TA_{t-1}$ and his NI/TA ratios although for our 1974 data the distribution was highly non-normal due possibly to inflation and the discontinuous adjustments made in the denominator of our ratio to handle it (see p198). Deakin found that a square root transformation was helpful for a number of years of the data he considered.

Although the normality or otherwise of the data employed here cannot then, strictly speaking, be used to argue that in general ratio data is normally distributed, it cannot on the other hand be used to argue it is not. The results here do not agree exactly with those of Deakin but there would appear to be reasons why this may be and intrinsic differences between US and UK accounting practices and data are probably not among them.

However the problem is important given the parametric tests frequently used in the literature (the normality assumptions used in this study particularly in the derivation of z-region boundaries will be noted) and clearly more work needs

to be undertaken.

Nevertheless the following quotation from Deakin (p96), which is no less relevant in this section than it was in chapter II, adequately represents the view adopted here ie:

> "While probability statements from models based on financial accounting ratios may be subject to question because of the data themselves, a user could be better off with a ball-park estimate than with no estimate at all. Thus the ultimate test of the value of such a model lies not in its adherence to certain data assumptions, but, rather, in its adherence to its usefulness in decision making."

Deakin found differences in the ratio distributions he examined from one year to the next and in the sets of data examined here this as can be seen is also true. In our case it could be due to the only partial overlap of the coverage of the two samples. Of particular importance are the differences in the z-score distributions; this will be further discussed in chapter VIII.

The results however, although interesting in their own right, nevertheless do not help to any great degree in evaluating the extent to which the samples are typical of their underlying populations.

5. Do Insolvent Firms Recover or not?

In discussing potential selection bias in the 1973 and 1974 samples it was pointed out that strictly speaking it was not possible on the basis of these sample results to infer all that much about such things as the number of continuing manufacturing firms in the total listed population appearing 'insolvent'. In fact to assign an arbitrary cut-off on the a priori basis that there are 10 times as many continuing 'well-solvent' firms as 'insolvent' firms and then to search for the number of insolvent firms using the cut-off computed on this basis is tautologous. This would be the same for any cut-off assigned on an a priori basis.

Consequently it is probably not too meaningful to think in these terms. Also because the z-model is able to classify other firms than those from which it was derived with virtually a 100% success rate, again it is not possible to fall back on defining the 'gray area' and its boundaries as the region on the z-scale where the failed and continuing companies overlap or even to provide a cut-off on the basis of the minimum number of total misclassifications; both of which procedures have been used by previous US researchers (see chapter VI §5).

Thus it is probably best from a decisional point of view, say for investment or credit-rating purposes, to accept z=-2.303 as a cut-off (on the basis of equal misclassification costs) or z=1.386 (ie a type I error 'costs' 40 times as much as a type II error) but to work with an area of uncertainty as discussed in chapter VI §5. In the following analysis which attempts to determine something about whether 'insolvent' firms tend to recover or not, a cut-off of z=-2.303 ie that there are a priori 10 times as many continuing 'well-solvent' firms as 'insolvent' firms and that misclassification costs are equal will be employed as a working criteria (see the computations in the footnote on p252 above).

To conduct a full-scale study to determine in a thorough way what happens subsequently to companies with z-scores below -2.303 (ie classified as 'insolvent') in any particular year requires a longditudinal study with a large number of years of accounting and other data available for a very large sample of continuing firms so that their decline, if any, can be monitored together with their activities subsequent to their z-scores falling below -2.303. Do they recover and if so by what means, do they continue 'insolvent' for a number of years, are they taken over which as Singh (1975:498) points out is currently the main cause of company death or do they go into liquidation? A study of this kind is not feasible without the expenditure of a near impossible data collection task and consequently

in this section an examination of the behaviour of the companies with z-scores already computed and less than -2.303 in any year, compiled as described above, will be considered.

In appendix 7.5 the z-scores for all companies listed in appendix 7.1 with z-score less than -2.303 in any year are given with the latest available z-score (as at 29.2.1976) computed separately by the author for those firms appearing 'insolvent' on the basis of their last but one published accounts. Some additional z-scores were also added from appendix 6.9.3 or the Laurence, Prust & Co company databank mentioned in chapter IV §5 to make up a continuous run over time for a number of firms.

From this appendix it can be seen that only British Printing Corporation and Reyrolle Parsons were able to recover in any conclusive way from a z-score of less than -2.303. Three firms, Bear Brand, Fairfax Jersey and British Steel Constructions have in fact failed since the table was first drawn up in January 1976[1], however the number of companies which appear to have continued looking 'insolvent' or 'near-insolvent' for a number of years viz:- Bath and Portland Group, John Brown, Illingworth, Morris and Strong and Fisher will be noted[2].

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[1] Bear Brand and Fairfax Jersey were kept going by large government loans under Section 7 of the 1972 Industry Act. They will be discussed in more detail in §7 below.

[2] Bath and Portland Group has large construction interests which may make it not strictly amenable to z-function analysis.

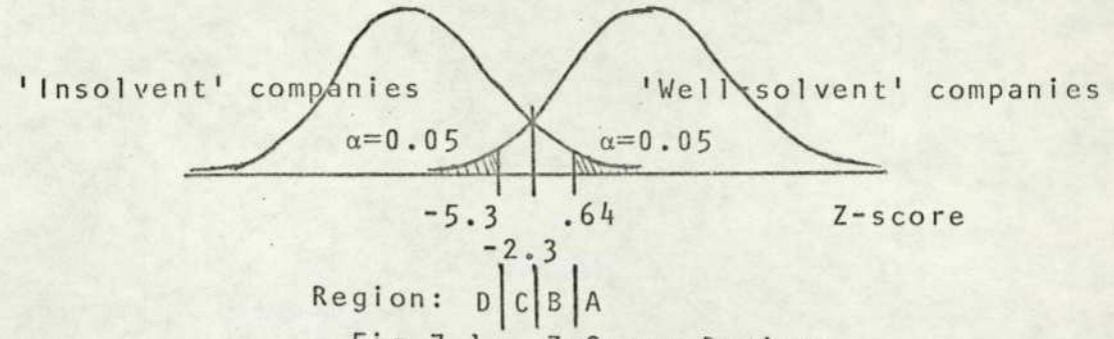


Fig 7.1: Z-Score Regions

To discover the extent to which 'insolvent' companies are able to recover from one year to the next, tables 7.4.1 and 7.4.2 were compiled from the z-scores of 26 companies[1] in appendix 7.5 which could be classified as 'insolvent' on the basis of the second to last available sets of accounts (as at 31.12.1975) and with the z-region divided into 4 intervals A-D on the basis indicated in fig 7.1. From these "partial transitional

		Z-score region on basis of last accounts A	B	C	D	Total companies
Z-score regions on basis of accounts before last	C	.11	.22	.33	.33	9
	D	.12	.06	.06	.76	17

(entries denotes probabilities)

Table 7.4.1: Z-score Region "Partial Transition Matrix"

		Z-score region on basis of last accounts A/B	C/D
Z-score regions on basis of accounts before last	C/D	.23 (6)	.77 (20)

(the figures in brackets denote number of companies)

Table 7.4.2: Aggregate Region "Partial Transition Matrix"

Tables 7.4: Probability "Partial Transition Matrices"

[1] Bear Brand and Fairfax Jersey were included as they had not failed by the end of 1975, however, General Engineering Co (Ratcliffe) and Brooke Tool Engineering were excluded in error. Associated Sprayers would be included on the basis of its latest z-score now being available if the analysis were to be repeated.

matrices" so termed because only transitions from the 'insolvent' regions (C and D) are examined[1] - it can be seen that over three-quarters of the insolvent companies did not recover from one year to the next and of the 13/17 insolvent companies outside of the statistical region of uncertainty (region D) only 2 recovered sufficiently to move totally outside the area into the 'solvent' part of the scale (region A).

Clearly it would be dangerous to read too much into these figures, however they are not consistent with the hypothesis that companies are able to recover 'spontaneously'. In fact they would appear to offer some supporting evidence that companies appearing 'insolvent' do not necessarily recover very readily.

If as a first approximation the assumption is made that these transition probabilities are typical of British industry as a whole and are likely to stay constant into the future, then assuming a firm continues in existence the probability of its recovery p(n) from region C/D to region A/B in n years time can be written as:

$p(n) = .23 \times .77^{n-1}$ whence table 7.5 can be calculated:

Years (n)	Cumulative probability of recovery after n yrs: $\sum_{i=1}^{n} p(i)$
1	.23
2	.4071
3	.5435
4	.6485
5	.7294

Table 7.5: Naive Cumulative Probabilities of Recovery from Insolvency

[1] Transitions throughout the range will be examined in the next section for the 126 companies for which z-scores were available for both of the accounting years 1973 and 1974.

For the FAILED23 set of companies, if Rolls Royce and Amalgamated Transport are excluded because their last available z-scores were not below -2.303, 7 of the remaining 21 appeared 'insolvent' ($z<-2.303$) on the basis of their last year of accounts, 3 for their last 2 years, 3 for their last 3 years and 8 for all four prior years of accounts although 3 of these were construction companies.

If these figures are assumed typical and the probability of a firm being able to continue classified as 'insolvent' for more than 4 years is considered negligible[1] then the probability tree of fig 7.2 can be drawn from which the probabilities of ultimate failure and recovery can be computed viz:

Probability of ultimate failure = .26+.085+.065+.13 = .54
Probability of ultimate recovery = 1-.54 = 0.46

These figures look high compared with the total of 29 companies failing between 31.12.73 - 21.7.76 in table 6.8 and of course they should not be taken too seriously given the problems with the data from which they were derived, the not very realistic assumptions made and the very different current economic situation compared with that of the previous few years when the companies in the FAILED23 set went into bankruptcy.

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[1] This is clearly not true, British Leyland for example springs immediately to mind. However it is highly unlikely that a firm would be able to continue for any extended period in a state of insolvency without eventually being taken over, entering into receivership, going into liquidation or receiving government aid.

Year	d.f	$EBIT/TA_{t-1}$	TL/NCE	QA/TA	WC/NW	Stockturn	Z-Score
1973	7	13.55 (a)	74.76	19.24 (d)	16.02 (c)	56.29	23.42
(n=296)	5	8.53 (a)		7.41 (a)	8.31 (a)		20.12
1974	7	26.29	35.55	9.88 (a)	9.49 (a)	51.58	19.85 (d)
(n=252)	5	21.55	35.07				11.26 (b)

Key: significant at α =	0.05	0.025	0.01	0.005
denoted by	(a)	(b)	(c)	(d)
7 d.f: χ^2 =	14.07	16.01	18.48	20.28
5 d.f: χ^2 =	11.07	12.83	15.09	16.75

Table 7.3: χ^2-Test Results of the Normality of the Ratio and Z-score Distributions

It will be noted that computations were carried out for 7 of the measures for two different class groupings with 7 and 5 degrees of freedom respectively. This was done to examine the effect on the sensitivity of the test of the small number of extreme observations present in most of the distributions. Deakin in fact used a test due to Granger and Orr to overcome (p92) "the insensitivity of the chi-square test to differences in the tails of distributions of data."

On the basis of table 7.3, then, it cannot be stated categorically that the ratio data employed is not normally distributed except in the case of the gearing and stockturn ratios which an examination of their distributions indicates would probably benefit considerably from a lognormal or possibly square root transformation. These results appear in principle to conflict with those of Deakin although this may be explained by the differences in the ratios employed - only QA/TA was present in both analyses although his net income/total assets (NI/TA) ratio is probably comparable to our $EBIT/TA_{t-1}$ measure. His use of sales as a denominator for certain of his ratios would probably explain much of the variation from normality in these cases because of its potential inter-industry differences, however for his other ratios a priori reasons for the rejection of the normality assumption could not

over may otherwise have failed. (See Conn, 1976 for a discussion and test of the 'failing firm/industry' hypotheses as explanations for conglomerate merger.) In any case they do indicate the need for more work to be undertaken in the area.

6. Company Performance Mobility and its Persistence

To examine the behaviour of companies from 1973 to 1974 in more detail, an analysis of the z-scores of the 126 firms for which data was available for financial years ending in both calendar years was undertaken. Of these 126 firms 109 were taken from the Laurence, Prust z-score library and the other 17 from the GOOD45 and POOR16 sets (appendices 6.9.2 and 6.9.3) for 1973 and the z-score library for 1974. The list of names is given in appendix 7.6 and the industry breakdown in appendix 7.3.

These firms represent 10.3% of the 1212 firms that can be classified as manufacturing from the 1973-4 Stock Exchange Official Yearbook and like the separate 1973 and 1974 samples (see table 7.2) they are again biased towards capital goods companies, as table 7.6 indicates:

Industrial Sector	Listed Population (%)*	1973/1974 Common Sample Percentage
Capital Goods (SE codes 11-33)	41.0	55.2
Consumer Goods - durable (SE codes 35-43)	12.7	12.8
Consumer Goods - non-durable (SE codes 45-65)	28.8	19.2
Other Groups (SE codes 66-73)	17.5	12.8

Note: Headings and codes denote Stock Exchange industry classifications

Table 7.6: Manufacturing Industry: Sector Breakdown - Company Percentages (Common 1973/1974 Sample)

* Source: Stock Exchange Official Year Book 1973-1974.

In appendix 7.7 the z-score histograms and ogives for these companies are given for 1973 and 1974 separately and the very clear downward shift from the one year to the next can be seen. Although the first distribution appears somewhat skewed to the left and the second somewhat skewed to the right, the null hypothesis that z is normally distributed at $\alpha = .05$ cannot be rejected in either case. ($\chi^2_{calc,1973} = 6.90$ and $\chi^2_{calc,1974} = 3.51$ {$\chi^2_{.05}$ with 4d.f. = 9.49}). The distributions both appeared far better behaved in their tail regions than the z-distributions of the separate 1973 and 1974 samples but although the respective means did not differ very much, the standard deviations of the separate samples (296 and 252 firms) were both around 15% greater. The 126 firm sample then would appear to be more homogeneous than either of the separate 1973 and 1974 sets of firms, at least in z-score terms. The mean for the 1973 data is 9.23 (s=6.64) and for the 1974 data 6.94 (s=6.16) which can probably be taken as a good indication of the very changed economic climate in those two years. However not too much should be inferred from these figures given the distribution of financial year ends in table 7.7 with 29.4% of the accounts ending in the first quarter, 11.9% in the second, 24.7% in the third and 34.2% in the last.

	Quarter 1			Quarter 2			Quarter 3			Quarter 4		
	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct	Nov.	Dec.
Percentage of companies:	4.8	1.6	23.0	0.8	0.8	10.3	5.6	2.4	16.7	4.0	0.0	30.2
Number of companies:	6	2	29	1	1	13	7	3	21	5	0	38

Note: The figures in brackets denote the number of companies

Table 7.7: Distribution of Accounting Period Ends for the 126 Common Companies

These figures in fact compare with those in the M3 Business Monitor (DOI, 1975:62) which showed that for the financial year 1972 (to the 5th April, 1973) about 40% of listed com-

panies had accounting periods ending in the fourth quarter of 1972 and another 30% in the first quarter of 1973.

In future work, consequently, it may be a better idea when comparing different accounting year results in aggregate to group companies according to taxation year rather than calendar year.

Of more interest to us here, however, is the extent of company mobility from one time period to the next and to this end the Spearman coeffecient of rank correlation for the 126 companies between the two time periods was computed and transition matrices measuring the movements between different segments of the z-scale derived. In chapter VIII the z-score (after an appropriate transformation is made) will be interpreted in a more general way as an explicit measure of performance and its very considerable advantages over the conventional rate of return measures commonly employed will be pointed out. Consequently when company z-score mobility is examined here, the term mobility broadly speaking is used to indicate relative more than absolute persistence of performance.

The question of the degree of persistency of profitability and growth over time has been empirically examined by a small number of authors. Of particular relevance here are the studies of Singh & Whittington (1968, chs 5 and 6), Whittington (1971 chs 4 and 5) and Lev (1969).

In the first study detailed evidence in the form of regression equations and Kendall's rank correlation coeffecients was produced to indicate that there was a strong tendency for an above average rate of return for the companies in the industries examined in the period 1948-1954 to be associated with an above average rate of return in the following 6 year period and vice versa ie for profitability to persist relative to the all company average, although in fact to a lesser degree. The implications of this as a criterion of good management and for the investor (ch 8§4)

were spelled out. Whittington extended the analysis considerably in terms of industry coverage with similar results although no rank correlation analysis was undertaken. However he additionally examined whether short-run profitability - over the one, two or three years to 1954 was better able to predict the level of average company profitability over the period 1954-60 than the previous 6 year average and for certain industries this appeared so. The influence of other factors on future profitability including size, past growth and external finance and their combinations with past profitability were also examined, however, no very strong relationships appeared to exist.

Lev, likewise, found statistically significant evidence that for the six ratios examined under the four headings - liquidity, gearing, asset turnover and return on investment, the firms in his sample had values which tended to move towards their industry averages from one year to the next. He interestingly however suggests that this is consistent with the hypothesis (p298) "that firms adjust their ratios according to industry-wide averages" although he does not rule out (p299) "some passive adjustment by allowing industry-wide effects to operate on the ratios".

In this chapter, however, as pointed out above, the concern is more with firm mobility in the sense of performance persistence in a relative rather than absolute sense, ie are individual company performance rankings in 1973 similar to those in 1974.

To investigate this transition matrices were computed on three different bases:-

(i) using quintiles derived from the 1973 296 company z-score distribution of appendix 7.4.1 as performance bands

(ii) using quintiles derived from the 1973 126 company z-score distribution of appendix 7.7.1

and(iii) using quintiles derived from the 1973 126 company

z-score distribution to classify the 1973 companies and quintiles derived from the 1974 126 company z-score distribution of appendix 7.7.2 to classify the 1974 companies.

The respective transition matrices are given in figures 7.3.1-7.3.3. A summary of their contents is provided in table 7.8.

Fig 7.3.1

1973 \ 1974	I	II	III	IV	V	
I	.(35)	.38	.11	.08	.08	26
II	.15	.(22)	.30	.22	.11	27
III		.05	.(23)	.54	.18	22
IV	.04		.08	.(57)	.31	26
V			.08	.16	.(76)	25
	14	17	20	39	36	

Fig 7.3.2

1973 \ 1974	I	II	III	IV	V	
I	.(35)	.38	.15		.12	26
II	.17	.(22)	.48		.13	23
III		.07	.(75)	.04	.14	28
IV	.04		.04	.(54)	.38	24
V			.12	.12	.(76)	25
	14	17	40	17	38	

Fig 7.3.3

1973 \ 1974	I	II	III	IV	V	
I	.(61)	.23	.04	.12		26
II	.31	.(39)	.17	.04	.09	23
III		.32	.(32)	.29	.07	28
IV	.04	.04	.25	.(50)	.17	24
V		.08	.08	.20	.(64)	25
	24	27	22	29	24	

Notes : The entries denote the fraction of companies in each state in 1973 classified to each of the 5 states in 1974, the numbers adjoining each row and column represent the total number of companies classified to each state in each of the 2 years. The diagonal entries are ringed for clarity. The unequal quintile sizes in figs 7.3.2 and 7.3.3 arose from interpolation problems with the ogives of appendix 7.7.

Figs 7.3: Performance Transition Matrices

(State I is the highest, state V the lowest)

Basis:	fig 7.3.1	fig 7.3.2	fig 7.3.3
Movement up:	10.4	11.2	26.4
No change:	42.6	52.4	49.2
Movement down:	47.0	36.4	24.4

Note: Entries denote percentages of the 126 companies in figures 7.3 which moved to a higher performance band, stayed at the same level or moved down from 1973-1974.

Table 7.8: Summary Company Z-score Mobility Data

Not surprisingly given the similar basis for the computation of figs 7.3.1 and 7.3.2 their results are not very different. The computed Spearman rank correlation coeffecient for the 126 firms between one year and the next when ranked in descending z-score sequence was .727 which is significant at $\alpha = .0001$. This would seem to reinforce the impression of relative persistence of performance over time.

When all these results are examined certain things can be observed. As already pointed out from the distribution characteristics there was a very strong downward movement in aggregate z-scores between 1973 and 1974. The fall in individual company z-scores is brought out very clearly in figs 7.3.1, 7.3.2 and table 7.8 whence it can be seen that on average around 4 times as many firms moved downwards in classification as moved up.

However probably of more interest than the measurement of absolute performance changes attempted above, (and as will be pointed out in chapter VIII, by using cumulative z-score frequencies to derive the class intervals the performance measure employed collapses into a linear form), are the relative changes in performance from one year to the next. Such a study may help to shed a little more light on the number of companies moving into or at least towards the 'insolvent' region of the z-scale. Because of the

non-random way in which the firms were selected no definite conclusions can be arrived at; however of the 121 companies with z-scores greater than -2.303 in 1973, the scores of 7 or 5.8% of them fell below -2.303 in 1974.

Examining the transitions between the different quintiles in fig 7.3.3 and considering the high rank correlation coeffecient, it would appear that relative company performance levels remained reasonably stable over the two time periods. In fact only 10.8% of the firms moved more than 1 class interval. Considering the z-score then as a performance measure, expressing it as a cumulative frequency, relative performance in this context appeared to persist over the two years. Because of the small number of firms, however, it would not have been meaningful to attempt to measure the degree of regression towards the 50th percentile which the literature discussed above would suggest might be of significant magnitude - although the "regression fallacy" cannot be ignored.

7. The 1972 Industry Act

Before examining the extent to which financial difficulties experienced by firms are recognised as such by financial journalists it is instructive to pause briefly and examine the role of the government in this area as regards its actions constituting an alternative to company bankruptcy. Its activities under the powers given to it under the 1972 Industry Act Sections 7 and 8 are of particular interest.

Under Section 7 the government is empowered to provide Regional Selective Assistance in the form of loans and grants to companies in assisted areas either to "increase employment" or "preserve employment". In the year ended 31.3.1975 loan and grant assistance offered totalled £69.2 million. In addition the government can offer assistance outside normal guidelines "for example when a company is facing acute financial difficulty" (Industry Act, 1975:8). Companies aided under this latter heading included Bear Brand (£350,000 loan), which has since gone

into receivership according to Bear Brand because the Department of Industry refused to make any further funds available (Times Business News, 27/2/1976)[1], Ferranti (£6 million overdraft increase guarantee) and Fodens (£2 million overdraft increase guarantee). These latter two firms have already been met in the last chapter.

Out of the 402 cases listed in the Annual Report (Industry Act, 1975) and Trade and Industry (17/10/75:192 and 23/1/1976:261) only 15 were classed as "preserving employment" including Bear Brand, Ferranti and Penrad (interest free loan of £300,000).

This latter company ($z_{31.12.74} = -35.2$)[2] is of particular interest in that despite a trading loss of £290,000, the expectations of Penrad management of no dividends before 1978, total borrowings of four times shareholders funds and heavy qualification of the latest accounts by the auditors (Times Business News, 13/3/1976:17), Penrad was offered another £100,000 by the Secretary of State for Wales, an increase in its overdaaft of £80,000 by its bankers and made a rights issue of £200,000 (Observer Business News 14/3/1976). Its net worth as at 31.12.74 according to its accounts was £548,000. Airfix Industries were also provided with £3.5m in the form of a loan, equity and a grant with regard to its subsidiary Triang-Pedigree formerly part of Lines Bros ($z_{31.12.69} = -3.2$). However of equal interest here are the grants and loans to "increase employment" made to the following companies for which negative z-scores were computed viz:-

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[1] The original loan was made against the judgement of the Industrial Development Advisory Board which decided that the chances of the company ever becoming profitable were remote (same source).

[2] $Z_{31.12.73} = -8.3$

Avon Rubber Co ($z_{28.9.74} = -2.9$, $z_{28.9.75} = -9.6$),
Brooke Tool Engineering
($z_{30.9.73} = -5.7$, $z_{30.9.74} = -11.1$, $z_{30.9.75} = -17.4$),
Dale Electric ($z_{29.12.73} = -1.3$, $z_{29.12.74} = 8.9$),
General Engineering Co (Ratcliffe)
($z_{31.3.74} = -14.5$, $z_{31.3.75} = -18.4$)
and Strong and Fisher ($z_{31.5.74} = -.5$, $z_{31.5.75} = -3.4$).

In addition Fairfax Jersey ($z_{30.6.75} = -12.5$) which has since collapsed received a loan of £350,000 from the Northern Ireland Development Corporation.

Under Section 8 of the Act - Selective Financial Assistance, Alfred Herbert ($z_{31.10.74} = -5.7$) and British Leyland ($z_{30.9.74} = -12.9$) were among the recipients.

The involvement of the government in the insolvency process is clearly well worth pursuing!

8. Does the Financial Press Identify 'Insolvent' Firms as Being at Risk?

Finally in this chapter it is of interest to examine the degree to which a company's z-score rating is consistent with financial press comment on its published accounts. To this end comments appearing in the Investors' Chronicle, taken as being representative of the financial press as a whole, relating to the latest published accounts where possible for all those firms listed in appendix 7.5 (with z-scores less than -2.303) were collated and classified. When no comments relating to the latest available accounts had been published, the last available reports were substituted.

A small number of firms' accounts were not reported upon at all possibly because of the small size of the companies and/or the restricted market for their shares.

These comments either appeared in the 'Company Analysis' section of the magazine or in the 'Company Results' section. Appendix 7.8 contains summaries in the form of quotations

In appendix 7.7 the z-score histograms and ogives for these companies are given for 1973 and 1974 separately and the very clear downward shift from the one year to the next can be seen. Although the first distribution appears somewhat skewed to the left and the second somewhat skewed to the right, the null hypothesis that z is normally distributed at $\alpha = .05$ cannot be rejected in either case. ($\chi^2_{calc,1973} = 6.90$ and $\chi^2_{calc,1974} = 3.51$ {$\chi^2_{.05}$ with 4d.f. = 9.49}). The distributions both appeared far better behaved in their tail regions than the z-distributions of the separate 1973 and 1974 samples but although the respective means did not differ very much, the standard deviations of the separate samples (296 and 252 firms) were both around 15% greater. The 126 firm sample then would appear to be more homogeneous than either of the separate 1973 and 1974 sets of firms, at least in z-score terms. The mean for the 1973 data is 9.23 (s=6.64) and for the 1974 data 6.94 (s=6.16) which can probably be taken as a good indication of the very changed economic climate in those two years. However not too much should be inferred from these figures given the distribution of financial year ends in table 7.7 with 29.4% of the accounts ending in the first quarter, 11.9% in the second, 24.7% in the third and 34.2% in the last.

	Quarter 1			Quarter 2			Quarter 3			Quarter 4		
	Jan.	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept	Oct	Nov.	Dec.
Percentage of companies:	4.8	1.6	23.0	0.8	0.8	10.3	5.6	2.4	16.7	4.0	0.0	30.2
Number of companies:	6	2	29	1	1	13	7	3	21	5	0	38

Note: The figures in brackets denote the number of companies

Table 7.7: Distribution of Accounting Period Ends for the 126 Common Companies

These figures in fact compare with those in the M3 Business Monitor (DOI, 1975:62) which showed that for the financial year 1972 (to the 5th April, 1973) about 40% of listed com-

seen, could be classified as being at risk on the basis of the press comments. One of these, Fairfax Jersey, classified as 'E' on the basis of its last but one set of accounts has since failed. No company was explicitly stated as having a high probability of failure but this may be due to the libel problems mentioned earlier in the study and such phrases as "very speculative" and "shares only for the brave" may be understood by investors as euphemisms for this. A casual investigation unearthed no very obvious relationship between press comment classification and z-score level. These preliminary results cannot be taken as evidence that financial journalists underestimate the possibility of failure when appraising a company's prospects - in fact it is not possible to argue in any absolute sense on the basis of these results that the press comments examined are less fair views of the companies' prospects than their z-score ratings. Nevertheless they would appear to indicate, taking into account what has gone before in this study, that this is quite possible. To really consider the matter fully financial press comments on the accounts of companies prior to failure need to be examined. Nevertheless, the fact that only 30% of 'insolvent' companies could be classified as being at some degree of risk on the basis of Investors' Chronicle reports is of interest in its own right. It may very well be that firms in difficulties are viewed in the Stock Market as recovery stocks, clearly if such a firm turns around capital appreciation will be very rapid. This may explain why Blum (1974:12) suggests that on the basis of his evidence, the US "market prefers to invest in failing rather than non-failing firms".

9. Summary and Conclusions

In this chapter an analysis of continuing company z-score data was undertaken under a number of different headings.

The first section after the introduction was divided into two parts, a description of the data source and a discussion

of the additional problems encountered in the interpretation of certain accounting items when the operational model was applied to the continuing firms.

In section 3 the statistics relating to the constituent ratio and z-score data for the different years were analysed with special emphasis placed on the 296 firms with financial year ends in 1973 and the 252 with financial year ends in 1974 particularly as regards the extent to which they were representative of the parent population of around 1200 listed manufacturing companies. It was tentatively estimated that if the samples used were unbiased, which they may not have been, then about 6.1% of companies in 1973 could be classed as 'insolvent' using a 50% cut-off and ignoring differential misclassification costs and 8.7% of those in 1974. If companies which had failed in those years or were insolvent in 1973 but taken over in 1974 were taken into account, together with the probable overstatement of the size of the parent population, then despite the potential bias, these figures would appear to suggest that well over 7% and 10% of British manufacturing industry in 1973 and 1974 respectively resembled financially previously failed firms more than 'well-solvent' firms.

In the following section the normality of the 1973 and 1974 company ratio and z-score distributions was considered. Only in the case of two of the ratios was the null hypothesis consistently rejected. These results were compared with those of related US studies and reasons for the different conclusions were suggested.

In section 5 an examination of the probability with which firms classified as 'insolvent' were likely to eventually recover was attempted and it was found that for companies 'insolvent' on the basis of their last but one set of accounts, only 23% no longer looked 'insolvent' on the basis of the following set. (Companies which went from 'insolvency' into 'failure' prior to the date at which the analysis was undertaken, were excluded.) A very simple

Markov chain approach was then used to analyse the eventual probability of recovery using an estimate of the distribution of number of years of 'insolvency' prior to 'failure' derived from the FAILED23 set. The results indicated that an 'insolvent' firm had only a 46% chance of eventual recovery under its own steam on the basis of the naive simplifying assumptions employed. It was pointed out that given the present rate of failures, and if there is no rapid upturn in the economy this estimate may not in fact be too unrealistic.

In the following section transition matrices were derived for the 126 firms for which z-scores were available for both 1973 and 1974 and it was found that apart from the substantial absolute fall in average z-scores, the firms tended to maintain similar relative positions.

A brief examination of the workings of the 1972 Industry Act and the role of government intervention in aiding firms in financial difficulties was next undertaken and its considerable activity in this area was pointed out with reference to those 'insolvent' continuing firms with z-score data available which were being aided, many of these it was implicitly suggested were unlikely ever to become viable. This was followed by a brief section reporting a preliminary study which appeared to indicate that financial journalists did not necessarily recognise 'insolvent' companies as being at financial risk.

In summary, then, it could be concluded that on the evidence presented in the chapter the z-model would appear to have considerable utility as a tool for the micro-economic analysis of industrial insolvency.

Chapter VIII: A Novel Approach to the Measurement of Company Performance

1. Introduction

In the final chapter of this study before the conclusions are laid out the z-model appropriately modified will be considered as a multivariate analogue of a company performance measure and its advantages compared with the conventional profitability or growth concepts and the other approaches appearing in the literature will be discussed.

The chapter will then continue with a detailed analysis using various multivariate statistical techniques including cluster analysis, of the aggregate accounts of different manufacturing industries specifically as regards average company size, differing ratio characteristics and similarities in economic terms.

The performance model derived from the z-model will then be applied to this data to examine the performance characteristics of these different industries over time and also to constitute a test of its utility in practice.

2. Approaches in the Measurement of Company Performance

The evaluation of the performance of a firm requires a simple measure which allows comparison of its performance with previous or forecast results, other companies or some desired standard. The objectives of such performance comparison may be to facilitate selection or to monitor or control the firm's operations so that they can be improved.

In practice very substantial problems arise, these can be grouped under three headings, viz:-

(i) firms simultaneously pursue a variety of goals with differing levels of importance which change over time.

(ii) existing owners, prospective shareholders, management, workers, creditors, customers and society all view performance in different terms and consequently

require different measures for evaluation purposes.

and (iii) the information required for recent performance evaluation may not be readily available.

In the literature measures of profitability usually expressed in ratio form, such as return on capital employed (ROCE), are almost invariably employed in empirical studies as measures of economic efficiency with the term 'profitability' being used synonymously with economic performance. This would appear to be partially the result of the emphasis placed on profit in the neo-classical theory of the firm and the simplicity of computation of such types of return measure[1].

The problems associated with using such ratios for performance evaluation are well rehearsed. There are problems in the definition of their numerators and their denominators (eg Bentley, 1973), the data available from published company accounts used to construct the measures have serious shortcomings (see for example Singh & Whittington, 1968:90 and 218-221, Amey, 1969:ch 6 and the discussions of previous chapters) and can at best be only very imperfect

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[1] Growth, however, has also been considered as both an implicit and explicit performance measure in studies concerned with analysing merger activity and related issues, (see for example Meeks & Whittington (1975) where growth is the performance measure given most emphasis), particularly in the recent empirical work subsequent to the formulation of the managerial view of the firm termed by Marris (1964) "Managerial Capitalism". In fact not surprisingly since the profits on a year's operations are reflected in a firm's net asset growth, profitability and growth have been found to be highly correlated - see for example Singh & Whittington (1968, ch 7) and Whittington (1971, ch 5). Additionally unpublished factor analyses, conducted by this author using the original Singh & Whittington databank and computed variables similar to those employed in their studies, consistently highly weighted the various profitability and growth measures on the same factor (the first one).

representations of the underlying economic characteristics of a firm, so it is argued.

These ratios it is maintained also do not allow for short-term changes in the economic environment of the firm outside the control of its management, nor for the level of risk faced by the company (a high return for example may be associated with a high level of risk). This risk can take two forms, a company's business (or external) risk, due to instability in the various markets in which it operates or from which it purchases resources, resulting in liquidity problems, and financial (or internal) risk arising from its capital structure and in particular its use of debt. (See Amey, 1969:32.)

In addition the return on capital employed measure cannot tell us anything about how well the firm meets other possibly alternative and conflicting goals, such as those suggested by the managerial and behavioural schools. (See for example Marris, 1964, March & Simon, 1958 etc.) Problems also arise when such measures are actually used for comparison purposes both when internal standards, for example those set by previous years' results, or external standards, such as those set by related firms in the same industry or an industry average, are used. In the former case it is argued it would appear impossible to adjust for changes in the economic environment and investment opportunities faced by a firm in different years to make sequential return on capital employed measures comparable and even if this were possible it could only indicate relative performance and not say anything about the absolute efficiency of the firm in the use of the resources at its disposal. In the latter case, it might a priori be expected that cross-sectional comparisons with firms in the same industry are more meaningful because such companies face the same levels of risk and investment opportunities. However in practice this is not so, as Amey (1964 or 1969:38-40) points out, because of the drawbacks inherent in the existing industry classifica-

tion data, firm size differences, different accounting period ends and so on.

He concludes in fact (1969:40) "The measure [return on capital employed] does not, ...then, offer any opportunity of eventually equating profits (or rate of return on capital) with economic efficiency."

Nevertheless measures for evaluating a company's performance are required by all groups associated with it in any way and certain alternatives to return on capital employed have been suggested in the literature in an attempt to overcome some of the problems discussed above. These approaches can be classified as follows:

2.1 Alternative single ratios, frequently alternative definitions of ROCE

2.2 The use of a set or hierarchy of ratios (Bentley, 1973: 196/7, Vice, 1968 and interfirm comparison schemes such as that operated by the Centre for Interim Comparison etc)

2.3 The use of budgeted profitability figures for comparison purposes (Amey, 1969:40-54)

2.4 The use of cash flow data (Lawson, 1970)

2.5 The use of an econometric modelling approach (Elliott, 1972)

2.6 The use of a scalogram approach (Falk and Heintz, 1974 or 1975)

and 2.7 The use of multiple ratios with associated weights arrived at in different ways to produce a single index, (Tamari, 1966, Shashua and Goldschmidt, 1974 and Burch Jnr, 1972).

Not all of these approaches, however, are open to the user of published financial statements external to the firm who generally speaking only has such data available to describe, however imperfectly, the underlying economic reality of

the firm[1].

The approach taken by Amey (1969:40) ie: "economic efficiency is best measured by a comparison of actual and budgeted profitability, the budget being set in a particular way, viz in economic terms" is appealing. However for external groups it necessitates the issue of published profit forecasts with the annual report and accounts and there are associated problems with this. (See for example Dev and Webb, 1972, Dev, 1974 and Mallinson, 1974.)

The ingenious approach of Falk & Heintz who examined elements of company risk using a scalogram technique due to Guttman which obviates the need for weighting the constituent ratios, is also of interest, however the methodology would appear to require further development to allow comparisons between firms (or industries) when it is not possible to place any firm in a higher ordinal category than another because at least one of the ratio values in its profile is below that of the comparison firm. (In fact a conventional weighting system may be required to overcome this problem.) The approach is described in more detail and applied to company size data in §5 below.

The most interesting operational approaches available to the external analyst are those utilising a single index constructed from a number of weighted constituent measures. These approaches will be examined in a little more detail in this section as they appear to overcome many of the problems outlined above. A measure based on the solvency function of previous chapters will then be compared in section 3 and it will be argued that this proposed index

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[1] No consideration is given here to stockmarket-based performance indicators such as price/earnings or dividend yield measures. As in the rest of this study only ratios derived from conventional accounting data are of interest.

is not only more intuitively meaningful but is also likely to perform more effectively.

In their important article, Shashua and Goldschmidt first outline some of the problems associated with the construction of indices to measure overall performance and discuss the limitations of certain of the analytical techniques available to overcome these. They then specify a model using a number of factors (financial ratio measures) with their index(p801) "a preference-ordered index based on the concept of utility of an outsider who evaluates the performance of the firm".

The form of the model is given by the linear function

$$I_i = \sum_j w_j p_{ij} ,$$

where i denotes ratio i, j denotes ratio j and w_j are the associated weights and $p_{ij} = Pr(x_{ij} \geq x_j^*)$ where x_{ij} is the value of firm i on ratio j and x_j^* is the minimum value of x_{ij} on ratio j.

$$0 \leq I_i \leq 100 .$$

This formulation is of particular interest in its use of distribution-free data through making use of the p_{ij}'s in distribution function form instead of the original x_{ij}'s thereby overcoming drawbacks associated with non-linearity between values of each of the constituent ratios and the resulting index (utility function). This would otherwise have resulted in an S-shape relationship between 'true' performance and the utility for an outsider of the firm - see figs 8.1a and 8.1b below.

Figs 8.1: Utility/Performance Relationships

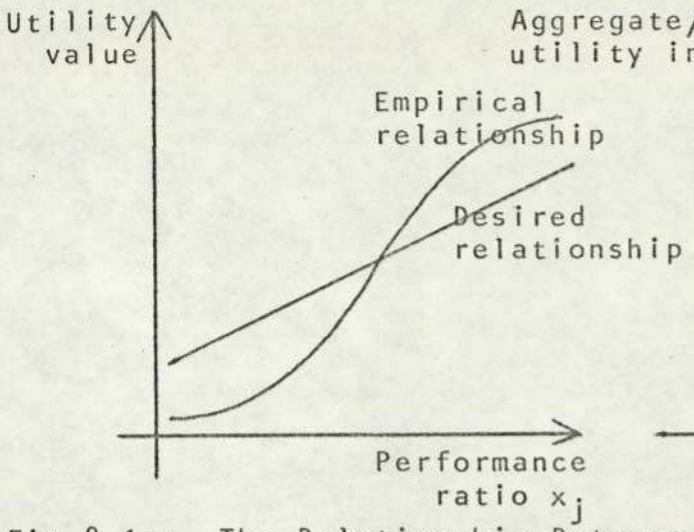


Fig 8.1a: The Relationship Between the Constituent Ratios x_j and the Utility for an Outsider

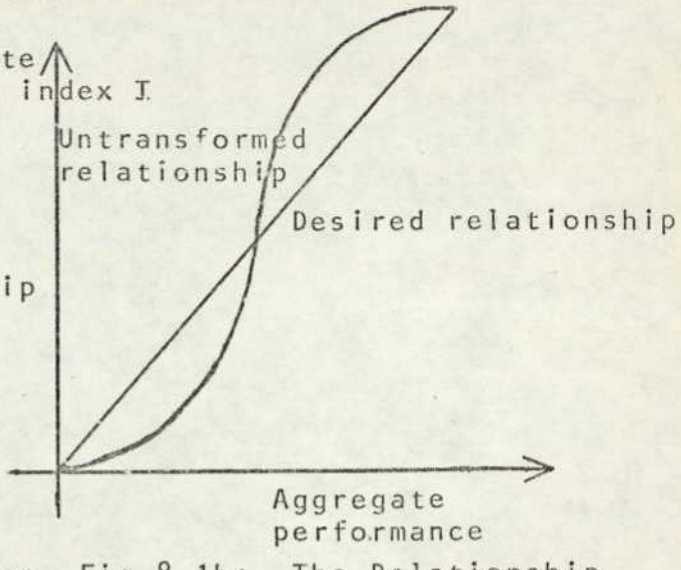


Fig 8.1b: The Relationship Between Aggregate Performance and Aggregate Utility

Three methods for deriving the weights were suggested viz:-

(i) the egalitarian method (equal weights)

(ii) value judgement (relative weights either determined by an expert or company rankings determined and the weights fitted by regression analysis)

(iii) principal component analysis of the P_{ij}'s with weights derived from the first component.

These were applied to ratio data relating to 216 Israeli kibbutzim. The six ratios utilised were selected on theoretical grounds (p806): "every ratio stands for a different objective of the firm (short run, long run, uncertainty) [and separately representing] a different aspect of the firm's level of success". However the average of their intercorrelations was 0.67.

Probably because of this, which would appear to suggest that the ratios were not in fact measuring distinctly different performance characteristics, and this is also borne out by an examination of their definitions, the three methods together with two arbitrary assignments of weights resulted in very similar rankings for the 216 firms. This would of course not be so in other situations with less highly intercorrelated constituent measures. The average r^2 between ratings arrived at by application of the "egalitarian" method and the other four approaches was .98. The authors

in fact argue (p804) that highly correlated variables are the case "in most economic phenomena" and appear to view this as a necessary condition for application of their approach (pp802 and 805). However this would seem to indicate tautological measures being employed.

They finally apply a version of their model to analyse individual kibbutz performance and aggregate kibbutz performance from 1957 to 1968 using the ratings as an index of economic progress.

Burch Jnr in an article, which consists of a study of 10 measures for 7 firms and is more valuable for the approach advocated than the content of the actual analysis, suggests a performance measure based on the principal component scores of the companies under investigation on the first factor of a principal component analysis derived from a matrix of rank correlation coefficients between the different variables (ratios) making up the performance measure (see appendix 6.1 for a discussion of the theory of PCA).

However although the rankings of his 7 firms under the advocated basis is identical to that published in the book on investment analysis - Graham, Dodd and Cottle (1962) - from which the data was taken, when the 10 measures were given equal weights, this is not a sufficient justification for the interpretation of the first component as a performance measure. In any case, as pointed out above, these results are to be expected if the constituent variables are highly correlated.

There is no <u>a priori</u> reason why the dimension along which the variance in the data is maximised should relate to performance even though all weights on the factor are positive and the scale is stretched out in this direction more than in any other. The very high correlation between most of the ten measures and the first factor would only appear to indicate high multicollinearity and redundancy

in the variable set employed (this is also suggested by an examination of Burch's rank correlation matrix and the definitions of his measures).

The same critisism can be levelled at Shashua and Goldschmidt who again state in support of the use of this approach (p800) "the first principal component...is an indicator of general 'size' and [therefore] can be considered as an overall performance measure".

Tamari, as discussed in chapter III §3, provides an example of a linear rating function with a priori determined weights which he calls an 'index of risk', however as we will see below 'risk' is an integral part of any performance measurement.

3. The Proposed P-Model for Multivariate Performance Measurement

The studies of the previous section, however, in the final analysis all fail to define performance or success in any coherent way. Burch distinguishes between real and apparent performance (p29) where:

> "Real performance depicts an objective and absolute phenomenon but is more a philosophical than a quantitative concept. Since it is not absolutely known, it cannot be precisely defined....[and] Apparent performance, or that which can be observed, is a representation of the effect of real performance. It can be measured by specific factors."

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The z-model discussed in previous chapters when expressed in a slightly different form, and termed a 'P-model' with P

standing for performance, can be used however to get considerably closer to a measure of 'real performance' by virtue of the approach taken in its derivation.

Consider first of all the problem of assembling two groups of firms, very poor performers and very good performers, ignoring for the moment the question of what is meant by performance in a real sense. Firms which have failed in the sense used here can effectively be considered as exhibiting zero performance and conversely it is probably not too difficult to obtain general agreement from knowledgeable investment analysts on the constituent members of a group of very successful firms providing these do not have to be ranked in any way and the individual selection models employed, which experience would suggest are likely to be intuitive in most cases, do not have to be specified.

Working with ratio data for these two groups a stepwise discriminant analysis can then be performed which results in a linear discriminant function which separates the members of each of the two groups in an efficient way (given of course the underlying assumptions of the technique are met) and this can be used to assign other firms to membership of the success group with a given degree of confidence.

It is not too far to step consequently to suggest that this function which has been developed to describe the degree to which a firm resembles 'zero' performers (failed firms) or very successful firms can be employed as a performance measure in its own right dropping reference to the notional fixed points (zero performance and good performance) used in its derivation.

An examination of the distribution of z-scores for the sample of 252 continuing manufacturing companies with financial years ending in the calendar year 1974 and with mean = 7.11 and standard deviation = 7.20, indicated that

its departure from normality was not strictly proven (see ch VII §4 pp253-6).

Assuming normality and that the z-distribution for these firms mirrors that for the population of all manufacturing firms then the z-function derived in previous chapters can be re-written with

$$z^* = \frac{z - 7.1095}{7.2012} \quad \text{such that } z^* \sim N(0,1)$$

$$\text{ie } z^* = -1.43182 + 5.63338 \times EBIT/TA_{t-1} - 2.54312 \times TL/NCE + 1.27520 \times QA/TA + .16075 \times WC/NW - .83429 \times \text{stockturn}$$

and a rectangular distributed performance index P_i for firm i in the range 0-100 can be determined by the relationship

$P_i = Pr\ (z_i^* \geq z_{min}^*)$ or by determining the area under the N(0,1) distribution below z_i^* from normal distribution tables. (Alternatively of course the empirical z-distribution ogive of appendix 7.4.2 can be used directly with similar results.)

This proposed performance evaluation model (termed P-model) then has the following properties:

(i) It would appear to measure a concept of 'real performance' by virtue of the effectively absolute performance data used in its derivation

(ii) Most of the pitfalls associated with arbitrary ratio selection were avoided in its computation by allowing a stepwise procedure to decide on the constituent parts of the model

(iii) The variable measures constituting the function are largely uncorrelated and as discussed in chapter VI §§2-3 they represent in a distinct and coherent way the most important dimensions of a firm's financial/economic status and performance

(iv) Problems associated with multicollinearity in the

constituent index measures, which other analytical methods advocated in the literature, as discussed above, appeared to require for deriving weights are avoided

(v) The constituent ratio weights assigned are 'optimal' within the context of the statistical methodology employed and between them surrogate for any other possibly important ratio in this context

(vi) There is a linear relationship between the utility level corresponding to any value P_i by virtue of the transformation of z employed and

(vii) The scale is in the range 0-100 for firms in 1974; in fact using this approach no firm for any year can have a score lying outside this interval. (Contrast Shashua and Goldschmidt, p 807. It will be recollected that this problem also arises in the linear probability function approach - see ch V §2.)

By use of formal 2 group discriminant analysis rather than employing a linear probability function approach (regression analysis with 0-1 dependent variables) problems of heteroskedasticity do not arise and in addition providing the statistical assumptions underlying the application of the model are met so that a linear function can be developed there are no problems in using unequal sample sizes.

Similarly by employing a cumulative scale in the range 0-100 along which to compare and rank firms with other continuing firms rather than considering absolute probability measures of the degree to which firms resemble financially more those which have already failed or are 'well-solvent' as was the objective in the previous chapters, problems of differential group sizes in the parent populations and associated a priori probability estimates do not arise.

Examining the constituent ratios of the model the only measure which possibly cannot be conceptually interpreted directly and in an unambiguous way as being related to

performance is TL/NCE - which we term here gearing. Modigliani and Miller (1958) argue that in a perfect world at least, the value of a firm is independent of its degree of leverage, and the studies reviewed by Brealey (1971, ch3) seem largely to support their conclusions. However the ratio employed here to measure leverage -

$$\frac{\text{Current liabilities + long term liabilities}}{\text{Net worth (shareholders interest) + long term liabilities}}$$

is not measuring the same thing and is better thought of as regards a measure of financial risk in terms of default on financial obligations or even failure[1]. It will be recollected that the measure contributes most to the discriminant function out of its five constituent ratios (ch VI§3) and has an average value for the FAILED23 firms more than twice that of the GOOD45 set. Its negative weighting can consequently be interpreted in a meaningful manner.

The only special drawbacks to this particular approach appear to lie in it only making use of 'extreme' firm data although this is the basis of the derivation of the model. Working with a random sample of continuing firms substituted for the selected group of high performers would have resulted in a less efficient discriminant function (cf chV §5.3) which also would produce a less meaningful ranking by virtue of the continuing firm groups containing some firms resembling the 'failed' set in terms of their financial characteristics, some very high performers and others in between. If a three group discriminant approach were undertaken of the nature of that discussed in chapter V §4 with firms classified a priori as 'failed', 'poor' and 'good' then possibly this criticism could be overcome, however it will be recollected that the investment analysts at Laurence, Prust & Co who classified the firms they were familiar

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[1] See Amey, (1969:32) and previous chapters. Gale (1972) makes this point explicitly although his "leverage" measure, the ratio of equity to total capital differs from the gearing measure employed here. See also Hurdle (1974) and Prusmann & Murphy (1968).

with to the POOR16 and GOOD45 groups were in fact unable to produce statistically distinct groups recognised as such by the derived discriminant functions.

This performance model developed from the solvency function in which a number of different and distinct financial ratios are combined together to form a single performance index, then, would appear to be able to measure financial success of firms in different manufacturing industries in a meaningful, conceptually straightforward unambiguous and objective way. It is, in addition, easy to apply requiring only facility with abstracting conventionally published financial data and normal distribution tables. It can be used readily both for cross-sectional analyses and for analysing trends over time both for individual firms and for different industries with P-scores interpretable in an absolute sense relative to the distribution of the P-scores for British manufacturing companies on the basis of their 1974 accounts.

Its multivariate nature ensures that data relating to 5 separate and distinct aspects of a firm's financial performance - profitability, risk (gearing), liquidity, working capital position and asset turnover (stockturn) and their interactions can be considered simultaneously in an efficient way by virtue of the collapse of all the separate indicator scores into one index which also takes into account other continuing firm data through the cumulative distribution approach employed. If necessary the model can be given a probability interpretation as discussed in chapter VI where a method for determining the probability of a firm resembling failed firms (zero performers and good companies (high performers) was discussed.

An illustration of its potential utility for economic performance analysis will be given in the following sections when the comparative performance of different sectors of British industry over time will be considered.

4. Analysis of Inter-temporal Industrial Performance: the Data

To provide a good test of the operational utility of the performance model an analysis of the comparative performance of different British industries from 1969-1973 was undertaken using as the data source industry aggregate balance sheet and appropriation of trading and other income data published by the Department of Industry in their Business Monitor series M3 - Company Finance (DOI, 1975). (It is of course noted that aggregate industry ratios may not necessarily relate to individual company measures).
In chapter II §5 the available empirical evidence on inter-industry differences in financial ratios was reviewed in some detail and it was concluded on the basis of the available statistical evidence that

(i) the financial ratio values of firms constituting an industry reflect its economic structure

and (ii) although mean industry ratio measures suggest certain industrial groupings are reasonably distinct in terms of their economic structure as reflected by their ratio values, when the intra-industry dispersion of company ratio values is taken into account this picture is not so valid and this tendency is probably increasing over time.

However answers to the questions of what constitutes an industry and how can meaningful boundaries be drawn around different groups of companies considering the diversified activities of the modern firm were not attempted. The literature is very deficient on this as well in spite of its considerable importance to much of the current work in industrial economics and associated areas, although the problems themselves are comparatively well documented eg Amey (1969:38-39).

It was implicitly argued that within the broad manufacturing sector, at least for the purposes of the research discussed here, differences between the financial characteristics of firms in different product groups would not generally be

expected to be very material. This has in fact been borne out by the results of applying the z-model in practice over the last 2 years or so to a very large number of firms in very different manufacturing activities, some of the results of which were discussed in chapters VI and VII. The only sectors, as mentioned previously, which appeared marginally less amenable to such analysis were those such as cement, bricks and food which can be thought of as constituting more process type operations.

The data available from the Department of Industry consists of standardised accounts for different industrial sectors considered in aggregate with industry definitions those of the 1968 Standard Industrial Classification at 2 digit level, and from these the aggregate industry ratios required to compute industry-wide z-scores for different years could be calculated. The quoted company population to which the figures relate consists of those companies operating mainly in the United Kingdom with net assets of £2m or more or gross income of £200,000 or more in 1968. The size of this manufacturing population, in fact, fell from 910 in 1969 to 786 companies in 1972 (a geometric decline of 3.7% per annum) through company takeovers and failure; new firms are only added intermittently when population revisions are made, the last being in 1969-70. The figures relate to companies' accounting years finishing between 6th April of the year shown and 5th April of the following year. About 40% of companies had their accounting years ending in the last quarter and 30% in the first quarter of the calendar year.

Data was abstracted from the accounts for 13 separate industries plus 'Aggregate Manufacturing Industry' in the majority of cases for the years 1969-1973 with the 1973 figures representing provisional results (identified by B in the accounts) for those firms submitting accounts before 30th September 1974. In addition to examine the likely bias inherent in the 1973 figures, the comparative provisional figures for most of the industries compiled for 1972

in the variable set employed (this is also suggested by an examination of Burch's rank correlation matrix and the definitions of his measures).

The same critisism can be levelled at Shashua and Goldschmidt who again state in support of the use of this approach (p800) "the first principal component...is an indicator of general 'size' and [therefore] can be considered as an overall performance measure".

Tamari, as discussed in chapter III §3, provides an example of a linear rating function with a priori determined weights which he calls an 'index of risk', however as we will see below 'risk' is an integral part of any performance measurement.

3. The Proposed P-Model for Multivariate Performance Measurement

The studies of the previous section, however, in the final analysis all fail to define performance or success in any coherent way. Burch distinguishes between real and apparent performance (p29) where:

> "Real performance depicts an objective and absolute phenomenon but is more a philosophical than a quantitative concept. Since it is not absolutely known, it cannot be precisely defined....[and] Apparent performance, or that which can be observed, is a representation of the effect of real performance. It can be measured by specific factors."

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The z-model discussed in previous chapters when expressed in a slightly different form, and termed a 'P-model' with P

In appendix 8.1 the data and resulting z-scores together with the constituent ratio values are listed.

5. Characteristics of the Industry Data

Before computing industry P-scores and examining their exhibited performances over time, a comparison of certain salient features of the industry data was undertaken in an attempt to gain some insight into differential industry characteristics.
In table 8.1 the average size of a listed firm measured

Industry	Number of firms	Total Assets (£m)	Net Capital Employed (£m)	Net Worth (£m)	Sales (£m)
Manufacturing Industry	605	54.8	36.2	24.8	65.9
Bricks, pottery, glass and cement etc	33	25.9 (9)	17.7 (9)	13.1 (9)	27.0 (11)
Chemicals and allied industries	36	147.0 (1)	103.6 (1)	60.3 (1)	125.7 (2)
Clothing and footwear	24	17.0 (12)	11.3 (11)	9.1 (11)	17.6 (12)
Construction	61	23.6 (10)	10.5 (12)	7.7 (12)	36.1 (9)
Drink	38	76.2 (4)	58.9 (4)	40.9 (4)	71.1 (5)
Electrical Engineering	37	100.5 (3)	64.1 (3)	47.2 (3)	104.7 (3)
Food	30	127.3 (2)	74.7 (2)	50.3 (2)	216.5 (1)
Metal manufacture	35	45.8 (7)	27.2 (7)	17.4 (7)	60.9 (6)
Non-electrical engineering	115	23.5 (11)	13.4 (10)	10.5 (10)	27.4 (10)
Paper, printing and publishing	50	49.2 (6)	30.5 (6)	19.8 (6)	59.5 (7)
Textiles	59	38.4 (8)	24.5 (8)	16.3 (8)	44.2 (8)
Timber and furniture	20	11.0 (13)	5.5 (13)	4.7 (13)	15.1 (13)
Vehicles	28	64.4 (5)	31.3 (5)	22.2 (5)	95.8 (4)

Note: the figures in brackets denote the ranking on the measure

Table 8.1: Average Company Size in Different Industries, Provisional 1973 figures

under four headings in each of 13 distinct and aggregate manufacturing industry groupings based on its 1973 accounts is given together with its associated size rankings according to each measure. It can be readily observed that the rankings are virtually identical for all 4 measures. To illustrate the relationships more clearly a scalogram approach suggested by Falk and Heintz (1974 or 1975) allowing a strict ordinal ranking is given as fig 8.2. Working downwards for example it indicates that the average firm in chemicals is larger on all 4 criteria than the average electrical engineering firm or any other joined to it, but it cannot be directly compared with the average firm in the food industry as not all of its measures are greater (the average food company has higher turnover). (Easton, 1973: 308-309 discusses an averaging and factor analysis methodology for constructing a single surrogate size variable which would appear to overcome the drawbacks associated with this approach.)

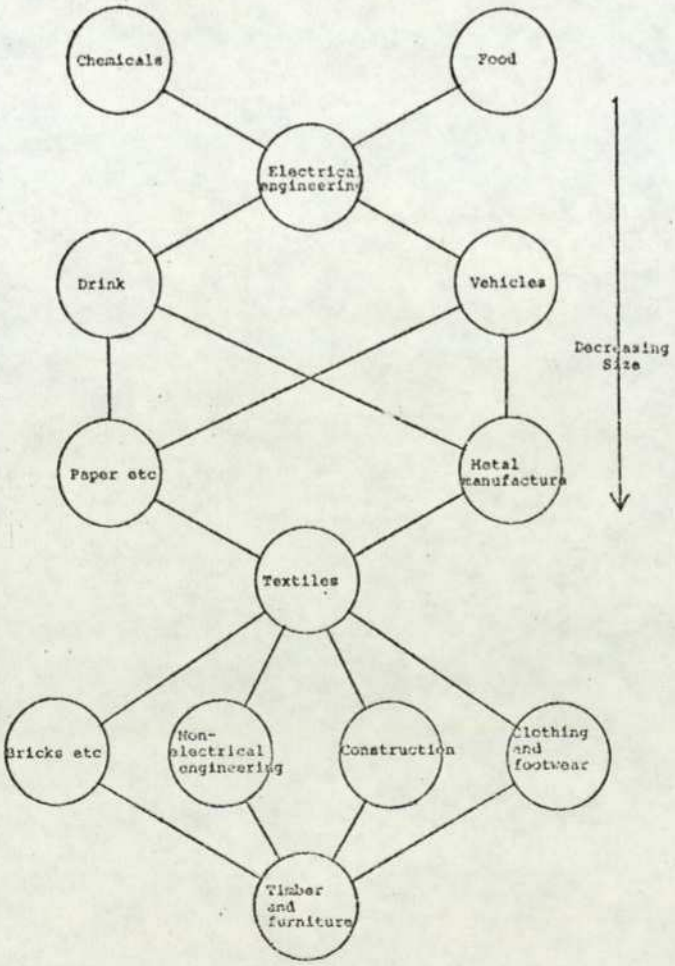


Fig. 8.2 Scalogram: Industries According to Size

To examine the relative economic structure of the different industries as exhibited by their financial ratio characteristics two approaches were taken, the construction of industry profiles and cluster analysis.

In chapter VI §§2-3 the results of the principal component analyses reported showed that at least the first four of the five constituent measures of the z-model represented fundamental and distinct dimensions of financial data with the fifth tentatively identified as an activity or asset turnover measure.

In table 8.2 the ratio values for each of the same 13 industries plus "Aggregate Manufacturing' over all 5 ratios constituting the z-model for the year 1973 are given and these provide the basic data with which to work.

	$EBIT/TA_{t-1}$	TL/NCE	(TCE/TL)	QA/TA	WC/NW	Stockturn
Aggregate Manufacturing Ind.	.1431	.8448	(1.1837)	.3254	.5267	5.3768
Bricks etc	.1681	.7329	(1.3644)	.3150	.3171	7.2653
Chemicals & allied inds.	.1571	.8437	(1.1853)	.3261	.5081	5.4584
Clothing and footwear	.1258	.7159	(1.3968)	.2108	.2339	4.7528
Construction	.1336	1.5226	(.6568)	.3132	.3970	4.9943
Drink	.1482	.6217	(1.6085)	.1950	.3402	4.6968
Electrical engineering	.1432	.8369	(1.1949)	.3830	.5970	4.5576
Food	.1267	1.0491	(.9532)	.2797	.3066	7.8931
Metal manufacture	.1454	1.0589	(.9444)	.3367	.5180	5.7805
Non-electrical engineering	.1274	.9883	(1.0118)	.3879	.5764	4.2836
Paper, printing and publishing	.1387	.9862	(1.0140)	.3621	.3770	8.0733
Textiles	.1786	.9170	(1.0905)	.3355	.6705	4.1447
Timber and furniture, etc	.2294	1.1753	(.8509)	.3382	.3451	5.8879
Vehicles	.0944	1.3687	(.7306)	.3307	.5862	4.1341

Table 8.2: Industry Ratio Values for 1973

(Provisional figures)

performance is TL/NCE - which we term here gearing. Modigliani and Miller (1958) argue that in a perfect world at least, the value of a firm is independent of its degree of leverage, and the studies reviewed by Brealey (1971, ch3) seem largely to support their conclusions. However the ratio employed here to measure leverage -

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Its multivariate nature ensures that data relating to 5 separate and distinct aspects of a firm's financial performance - profitability, risk (gearing), liquidity, working capital position and asset turnover (stockturn) and their interactions can be considered simultaneously in an efficient way by virtue of the collapse of all the separate indicator scores into one index which also takes into account other continuing firm data through the cumulative distribution approach employed. If necessary the model can be given a probability interpretation as discussed in chapter VI where a method for determining the probability of a firm resembling failed firms (zero performers and good companies (high performers) was discussed.

An illustration of its potential utility for economic performance analysis will be given in the following sections when the comparative performance of different sectors of British industry over time will be considered.

Group 1	Group 2	Outlying industries
(Aggregate Manufacturing Industry)	Bricks, pottery, glass, cement, etc	Construction
Chemicals and allied industries	Clothing & footwear	Drink
Electrical engineering	Food	Textiles
Metal manufacture	Paper, printing, publishing	Timber & furniture
Non-electrical engineering		
Vehicles		

Table 8.4: Industry Grouping by Ratio Profile

2 distinct groups of size 5 and 4 together with 4 outliers can be identified from these profiles with constituent group industries listed in table 8.4. Group 1 which contains industries with similar characteristics to those of aggregate manufacturing industry can be broadly categorised as heavy industry whereas group 2 is more a group of process and consumer non-durable industries.

The nature of the aggregate data employed probably does not justify any more detailed analysis.

It was pointed out in chapter II §5 when discussing the study of Gupta and Huefner (1972), who undertook a very similar type of analysis but only grouped their industries on the basis of their four highly correlated ratios taken separately, that a multivariate approach is necessary to gain an overall view and the data of table 8.2 was subjected to hierarchical cluster analysis with somewhat similar classification results to the above. (The visual grouping procedure employed above is effectively, of course, a method of cluster analysis.)

The program employed known as GROUP was developed by the author specifically for hierarchical cluster analysis of financial ratio data, however its special features do not

need to concern us here[1]. It allows the user to specify any of a number of clustering methods (Nearest neighbour, Furthest neighbour, Group average, Median, Weighted average, Centroid or Ward's method - see Everitt, 1974, pp8-23 or appendix 8.2.1 here for the mathematical theory) and will cluster from an Euclidean distance matrix derived either from raw data or normalised data or from a correlation matrix and prints the results out in the form of a dendogram or tree with the lengths of the branches measuring the multivariate distances between the groups formed.

In the case of the 13 industry plus 'Aggregate Manufacturing Industry' provisional 1973 data of table 8.2 with NCE/TL employed instead of TL/NCE, a Euclidean distance matrix was used computed from data separately normalised over each ratio. The normalised data and distance matrix are given in appendix 8.2.2 and from the matrix the two closest points in 5-dimension space can be seen to be industries 'Chemicals' and 'Manufacturing'. In the clustering procedures these were first fused and replaced by a single point representing a combination of their two positions with co-ordinates computed according to the particular clustering method used. The Euclidean distances between this new point and all the remaining industries were then computed and the nearest two points joined and so on.

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[1] The program was originally developed for industrial classification analysis of company data in the Singh and Whittington databank. Various preliminary investigations using this database were undertaken including an examination of the extent to which firms drawn from different industries would cluster into their 'correct' groups on the basis of their common characteristics as measured by their financial ratio values. In fact a sample of 60 companies drawn from five industries at random - electrical engineering, non-electrical engineering, clothing and footwear, food and wholesale and retail distribution could not be grouped in any meaningful way. Similar negative findings also resulted from the application of 5-group discriminant analysis when only 65 out of the 158 companies sampled from the same industries were correctly classified by the 6 variable functions derived from the data. The detailed results of these analyses, which were of a pilot nature only, do not directly concern us here.

In figure 8.4 the way in which the industries cluster for one particular method, Ward's method, is presented in the form of a dendogram. From this it can be seen that 'Chemicals' and 'Manufacturing' industries are most similar and that the point representing the pair subsequently joins with 'Metal Manufacture' and that the sub-group subsequently joins up with another sub-group consisting of 'Textiles', 'Non-electrical Engineering' and 'Electrical Engineering' at a later stage in the clustering procedure and that eventually all industries are joined.

Problems arise in determining a cut-off distance to arrive at separate groupings and this is normally done by eye with decreasing group homogeneity as the distance along the scale increases continuously being weighed up against the advantages of having larger groups. In the case here it is relatively simple in that there is a large gap between 5.945 where the two subgroups mentioned above join and 16.945 where the next linkage takes place and consequently a cut-off just above 5.945 resulting in four reasonably homogeneous-looking groups (although one is far larger than the others) makes sense. In table 8.5 the constituent group members according to Ward's method are listed.

Cluster 1	Cluster 2	Cluster 3	Cluster 4	Outliers
Vehicles	Textiles	Paper etc	Drink	Timber
Construction	Non-electrical Engineering	Food	Clothing & footwear	
	Electrical engineering	Bricks etc		
	Metal manufacture			
	Chemicals			
	(Aggregate Manufacturing)			

Table 8.5: Clusters formed according to Ward's Method

Cluster(i)	Cluster(j)	Distance(dij)
1	3	.242
7	10	.749
3	9	1.249
4	5	1.471
8	11	2.889
2	11	4.188
10	12	4.541
5	14	4.797
9	12	5.945
11	13	16.948
12	14	20.674
6	13	31.382
13	14	44.977

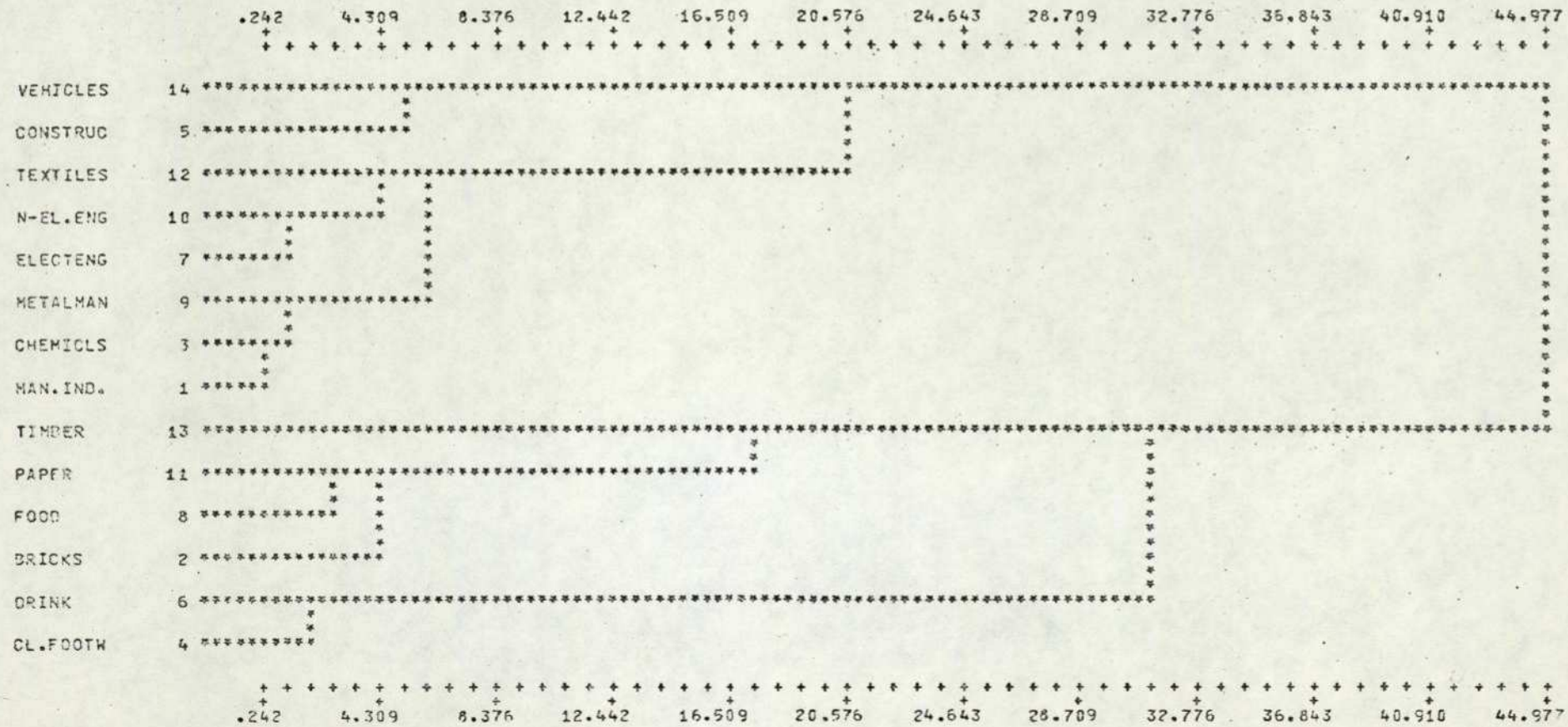


Fig 8.4: Industry Cluster Analysis Dendogram - Ward's Method

In appendix 8.2.3 the clusters formed according to the other 6 different hierarchical clustering methods are listed and in appendix 8.2.4 the dendogram for the 'Nearest Neighbour' method is given. The different methods as can be seen from inspection of the appendix result in very similar groupings except for 'Nearest Neighbour' which appears to suffer from 'chaining' with an intermediate observation causing spurious linkage (see Everitt:92). It is in fact usual in practice to analyse a set of data using a number of different methods to gain some consensus idea of group membership.

A comparison of the results due to application of Ward's method and visual profile analysis indicates some similarities in that 'Aggregate Manufacturing', 'Chemicals', 'Electrical Engineering', 'Metal Manufacture' and 'Non-electrical Engineering' are grouped in both cases as are 'Bricks', 'Food' and 'Paper'. A re-examination of the industry profiles indicated that in effect relative shape rather than size criteria had been employed for grouping by eye and this appeared to largely explain the differences in the groupings arrived at. In any case since profile analysis is really only a method for visual representation of data the somewhat different groupings are not surprising.

Attempting an interpretation of the results it would appear that 'Vehicles' and 'Construction' are grouped under cluster analysis on the basis of equally poor characteristics. The second group which is reasonably homogeneous is largely of a heavy manufacturing nature except for 'Textiles' which is not a very central member. 'Chemicals' covers a wide range of SIC codes including manufactured fuel, inorganic and organic chemicals as well as consumer products and fertilisers and clearly appears in aggregate to resemble other members of the cluster in its financial characteristics. 'Paper', 'Food' and 'Bricks' are process type industries and 'Drink' and 'Clothing and Footwear' are both consumer non-durable industries. The reasons for 'Timber' constituting the consistent outlier in all methods are not immedia-

tely clear.

The objectives of undertaking these introductory analyses were essentially threefold:

(i) to examine whether the results were similar to those of Gupta and Huefner (1972) and whether the multivariate approaches adopted here would be likely to give more useful results than examining ratios on an univariate basis.

(ii) to examine the amenability of financial ratio data to profile and hierarchical cluster analysis, and to compare the two approaches

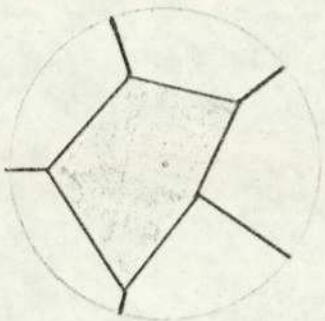
and(iii) to examine whether industry characteristics are represented by industry aggregate financial data and whether broad sectors are largely similar.

In the case of comparison with Gupta and Huefner it was not in fact possible to compare their results with those here because of the different industry definitions applied, the different ratio measures employed and particularly the different univariate and multivariate agglomeration techniques utilised. Examining their univariate results it is clear that the multivariate approach adopted here is far more useful. (The results of Goronzy, 1969 can also be usefully compared.)

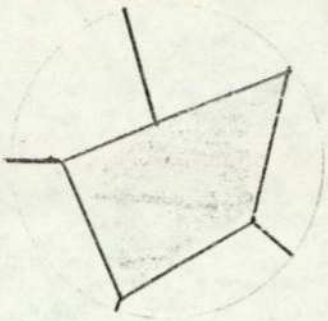
It also appears that the aggregate industry data expressed in ratio form is amenable to multivariate cluster analysis and some tentative evidence that profile analysis is not as suitable as more formal cluster analysis for discovering groups, at least in this type of situation, can be presented.

Finally it would appear possible, on the basis of the results produced above, to suggest that the financial ratio data employed would appear to represent underlying industry characteristics and that different industrial groupings, at least in aggregate, may be more similar in financial terms than expected on an a priori basis. A lot more work

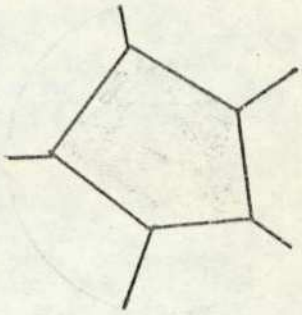
Figure 8.3: Industry Profiles 1973 Provisional Results basis



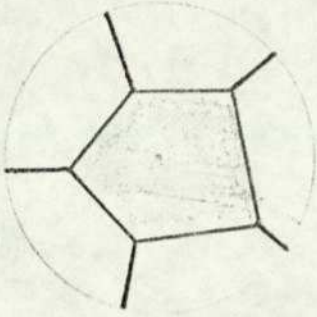
Manufacturing Industry



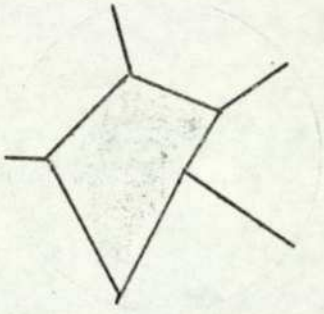
Drink



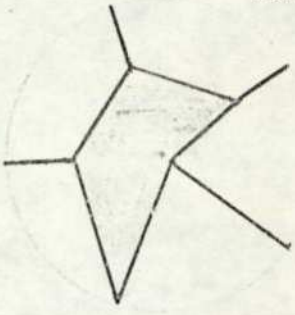
Paper, printing and publishing



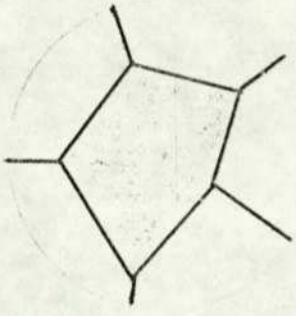
Bricks, pottery, glass, cement



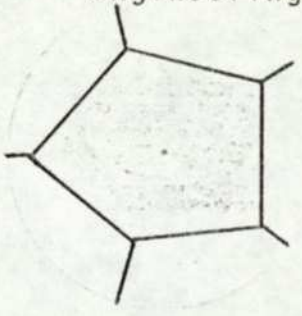
Electrical engineering



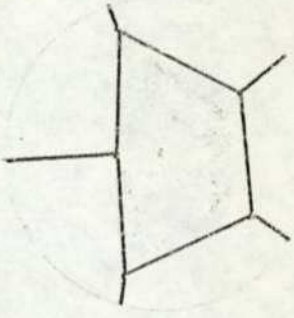
Textiles



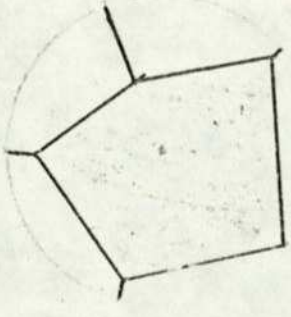
Chemicals and allied inds.



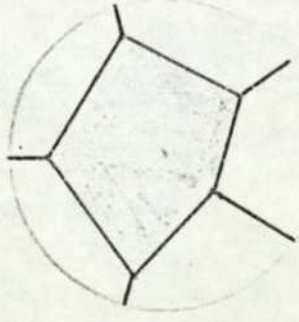
Food



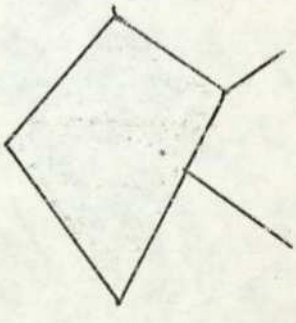
Timber, furniture etc.



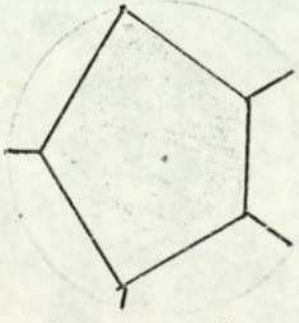
Clothing and footwear



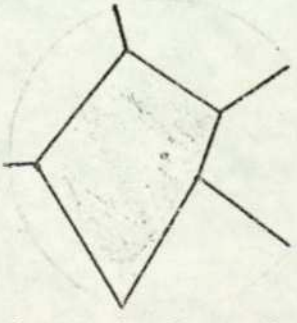
Metal manufacture



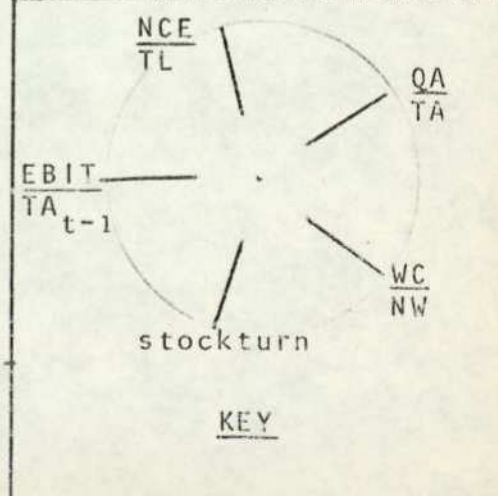
Vehicles



Construction



Non-electrical engineering



In figure 8.3 industry profiles are drawn using a technique known as "profile analysis" for visually representing multivariate data. (See Dobbs, 1975 who also discusses alternative approaches including "glyphs" and "faces".) The lengths of the radii given in the associated table 8.3 represent the percentage by which the ratio value for a particular industry exceeds the minimum on that measure. The leverage measure TL/NCE is inverted so that its radius dimension can be interpreted consistently. Essentially the longer the radii and the smaller the 'spider' the better the industry can be considered to perform. The 'spiders' allow for ready visual comparison of the ratio characteristics and for grouping of the industries on the basis of their shapes.

	$EBIT/TA_{t-1}$	TCE/TL	QA/TA	WC/NW	Stockturn
Aggregate Manufacturing Ind.	0.5	0.8	0.7	1.3	0.3
Bricks	0.8	1.1	0.6	0.4	0.8
Chemicals & allied inds.	0.7	0.8	0.7	1.2	0.3
Clothing and footwear	0.3	1.1	0.1	0	0.2
Construction	0.4	0	0.6	0.7	0.2
Drink	0.6	1.5	0	0.5	0.1
Electrical engineering	0.5	0.8	1.0	1.6	0.1
Food	0.3	0.5	0.4	0.3	0.9
Metal manufacture	0.5	0.4	0.7	1.2	0.4
Non-electrical engineering	0.4	0.5	1.0	1.5	0
Paper, printing and publishing	0.5	0.5	0.9	0.6	1.0
Textiles	0.9	0.7	0.7	1.9	0
Timber and furniture, etc	1.4	0.3	0.7	0.5	0.4
Vehicles	0	0.1	0.7	1.5	0

Note: the values represent the decimal percentage by which the minimum value on each ratio is exceeded

Table 8.3: Profile Radii Values for the 5 Measures for Different Industries
(1973 provisional data)

The first thing to notice is the substantial difference in some industries between provisional and final 1972 figures. An examination of the corresponding z-scores and constituent ratio values highlights this. The point about bias in terms of different distributions of company year ends in the provisional and final sets has already been made. Consequently it would appear that the statement made at the end of the more recent M3's, viz:- "On past experience, the provisional figures provide for most items and most industries a good guide to changes as compared with the previous year" is not true for our purposes. As a result the 1973 provisional P-scores should be treated with caution for certain of the industries.

Probably the next thing of interest to note, apart from the continuously poor performance of 'Vehicles' (possibly partly reflecting the disproportionate size of British Leyland - see fig 6.5 for its z-scores back over time) is the cyclical performance exhibited by the majority of industries. 'Metal Manufacture's' P-score has fallen drastically over the period and its recovery, if that is what is indicated by the upward movement between 1972 and 1973 is a year behind that of 'Chemicals' and 'Non-electrical Engineering' and two years behind 'Electrical Engineering' and 'Aggregate Manufacturing Industry' generally. The consumer goods industries 'Food' and 'Clothing and Footwear' seem reasonably stable over time possibly reflecting inelastic products although on the basis of the 1972 figures the 1973 final results may be quite different. Also the apparent lack of improvement in the 'Clothing and Footwear' industry does not reconcile with the performance of 'Textiles'.

Broadly speaking it would appear then that 'Chemicals', 'Electrical' and 'Non-electrical Engineering' and also 'Textiles' appear to perform in a similar way over time to 'Aggregate Manufacturing Industry' and that 'Food' and 'Clothing and Footwear' also resemble each other in relative performance over time. 1969-1971 appeared uniformly very

bad for all industries except perhaps 'Metal Manufacture' but things appeared to be improving very rapidly in 1972 and 1973. 1973 could consequently be considered a boom year on this basis. (Because of the way the provisional figures were compiled, see page 291 above, the effects of the 3-day week at the beginning of 1974 are probably not significantly reflected in the P-scores for 1973.)

In fact examining 'Aggregate Manufacturing Industry' P-scores for the 5 years, it is possible to interpret them as indicating that the performance level in 1969 was only 64.5% of that in 1973, in 1970 it was only 49.8%, in 1971 it was 55.6% and 1972 69.9%. These figures make some intuitive sense.

In this way, then, the value of P-score performance analysis as a tool for economic investigation can be illustrated on a preliminary basis and can be contrasted with the type of results from employing conventional rate of return type measures. Effectively what has been stated is that if an industry can be considered as a company "writ-large" then its performance relative to the distribution of company performances in 1973 can be measured, interpreted and used as a descriptive measure of what is happening to it over time.

Clearly, of course, an industry in an aggregate sense cannot be thought of as a large company and probably the average of the P-scores for the firms constituting each of the industries separately would not equal the P-scores computed from aggregate data. Nevertheless a study of aggregate industry performance on this basis can probably be justified as of considerable interest in its own right and the results certainly make intuitive sense. They would also appear to illustrate the utility of 'P-analysis' as well as its sensitivity to changes in the economic environment over time.

7. Summary and Conclusions

In the first section of this chapter after the introduction the issue of company performance measurement was raised and both the requirements for an operational system and the problems facing the development of such were discussed. The conventional methods such as the use of various return on capital employed measures were described in detail and their lack of utility for many purposes spelt out, for example they take little account of the level of risk faced by a firm. Alternative approaches suggested in the literature were also closely examined.

In section 3 a novel multivariate performance measure termed the 'P-model' based on the z-model appropriately transformed into a linear scale in the range 0-100 through the use of 1974 company z-score distribution data was described and its advantages compared to other methods were spelt out. Effectively the approach considers a company simultaneously along each of the five appropriately weighted orthogonal performance indicators making up the z-model and positions it on a linear scale depending on the extent, relative to all other firms, it resembles "zero-performers" - previously failed firms or high performers. It would appear, in fact, to have potentially very wide applicability allowing both comparative cross-sectional performance evaluation for firms in both the same and different industries and also meaningful comparisons for the same or different firms over time.

In the next section the nature of the aggregate industry accounts published by the Department of Industry and used in subsequent sections were discussed, and in section 5 industry characteristics as expressed by their accounting data were analysed specifically in terms of average constituent company size and industry economic characteristics. The multivariate techniques utilised included profile analysis and hierarchical cluster analysis and in the latter case four distinct groups were observed - poor performers,

capital goods and engineering, process industries and consumer non-durables. It was concluded that if it is meaningful to think in terms of such industries, then on the basis of their financial profiles they do not appear necessarily very distinct.

In the final section before this the P-model was used to examine the performance of 8 manufacturing industries and 'Aggregate British Manufacturing' over the years 1969-1973 and the results were of considerable interest in highlighting the differential effects on the different industries of changes in the economy over that time period, the cyclical nature of some and stability of others over time, and the differential lags between industries before the short-lived 1973 boom took off.

The utility of the P-model for performance analysis of this type was clearly illustrated and its increased sensitivity by virtue of its multivariate nature compared say to that of a conventional return on capital employed measure was indicated in practice.

CHAPTER IX: CONCLUSIONS AND FURTHER RESEARCH

1. Introduction

This study has addressed itself to a number of related questions predominantly concerned with the results from the application of multivariate statistical techniques to conventional accounting data expressed in ratio form for purposes of economic analysis.

The main empirical thrusts have been the construction of an explicit operational model for the identification of manufacturing firms at risk of failure on the basis of their published accounts and its use, suitably transformed, as an holistic measure of micro-economic performance.

2. The Z-Model

The model, which appears to be the first of its type to have been successfully developed for the UK environment, differs from the previous related US work in a number of ways. Firstly, in the choice of the sample of continuing companies explicit recognition that continuity is not necessarily synonymous with "well-solvency" and that certain presently functioning companies may well have financial characteristics resembling those of actual bankrupts was taken. Also as regards the selection of the statistical measures employed, their transformations, the use of the stepwise discriminant approach and the statistical tests applied to evaluate the amenability of the underlying data to such analysis, it is hoped that those aspects of previous work open to criticism have been largely avoided here.

The explicit incorporation in the final model of the differential prior probabilities of "solvent" and "at risk" firms in the population considered and the unequal misclassification costs of type I and type II errors, together with the approach adopted to handle the extreme data values exhibited by some companies in practice, also, apparently has not been attempted in previous work; nor has any

probability interpretation of the kind developed here been used. In addition the rigorous testing undertaken of the classificatory effectiveness of the final model developed can hopefully be fully defended.

However probably of most importance is that here, in this research, no attempt whatsoever is made to claim predictive ability for the approach, which virtually all previous related studies do. The final model developed allows manufacturing companies to be classified only on the basis of whether their financial characteristics resemble to a greater or lesser degree those of previously failed firms or firms considered a priori to be financially sound. It is essentially definitional in nature not predictive in a conventional sense, although firms classified by it as "insolvent" or "at risk" do appear to present a high probability of eventual bankruptcy. Actual company failure considered here in terms of receivership or liquidation depends on so many factors outside the capability of such a model based on strictly historical accounting information to measure, such as the general economic climate, government action, the attitudes of the firms bankers and creditors etc, that only a propensity of failure can be measured.

3. The Multivariate Performance Model

Although such a solvency function is of considerable value in its own right for credit-rating purposes and particularly as an 'early-warning' device to alert company management (or the government) so that action can be taken to avert failure before it is too late, it is of just as much interest as a tool for more general economic analysis and particularly when transformed into a linear measure as a multivariate model for the measurement of company performance. This "P-model" by virtue of its construction together with a consideration of its constituent ratio variables which measure 5 fundamental (both in factor analytic and economic terms) aspects of a company viz:- its profitability, internal risk (gearing), liquidity (debtors position), working capital

and activity (stockturn) - would appear to allow the ready comparison of a company's performance with other firms in the same or different manufacturing industries or with itself over time, in a far more meaningful and comprehensive way than the conventional profitability/return on capital employed measures. For example the P-model, because of its multivariate nature and the way in which an empirical distribution of company scores is used to derive its linear performance scale, allows companies engaged in different manufacturing activities or with dissimilar capital structures to be readily compared without the need to stratify by industry etc as with conventional approaches.

4. Other Results

Nevertheless other conclusions of this study are also hopefully pertinent, such as the estimate that in the present economic climates a company "at risk" in the terms of the 'solvency model' has only about a 45% chance of eventual recovery and that once facing problems companies find considerable difficulty in moving out of the danger zone.

Also of interest, it is believed, are the results of the principal component analyses (PCAs) reported which suggest that there are essentially only a small number of distinct dimensions of a company's financial state being measured by conventional accounting ratios, which factors, incidentally, are similar to those present in US data. Consequently, strictly speaking, a small set of only around 5-6 carefully selected ratios (each separately highly loaded on a different factor) should appear able to satisfy most users of ratio data; minimal additional information is likely to be gained by the use of a larger number (which are in any case often highly correlated by virtue of the use of identical numerators or denominators) as advocated frequently in the literature.

The question as to what constitutes an industry was also

raised and tentative conclusions were arrived at through application of cluster analysis techniques that when considered in aggregate most manufacturing industry groups are not at all distinct entities in terms of their financial ratio values although there do appear differences between general manufacturing and process-type industries. The general methodology adopted - factor analysis and cluster analysis - in fact does appear to offer, on the basis of the preliminary results arrived at here, a way of examining related questions at company level and this the author hopes to do in the near future using the recently available computerised database described below.

Some of the other issues raised in passing are possibly of more academic interest. For example the results of the empirical computations undertaken in this study do not support the prevalent theory that the age failure distribution of companies is currently exponential distributed as it might have been a hundred years ago. In fact the conditional probability of company failure, at least in the US, does not necessarily even appear to fall off continuously with company age.

Some empirical analysis of the normality of financial ratio data was also undertaken with results that conflicted somewhat with those of other studies[1].

Also it was argued here that the concept of the predictive-ability of accounting data per se considered out of context of the particular users needs and the decisional models employed, which appears to be widely accepted as an operational criterion, at least in the US, for the evaluation of different treatments of accounting numbers etc, in fact makes little sense as conventionally stated. The same criticism was also levelled, for similar reasons, at the concept of materiality. The two issues were seen as interrelated and revised criteria taking into account the arguments made were suggested.

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[1] Particularly Deakin, 1976 (see pp50/51 and ch 7 §4 pp253-6 above).

Nevertheless the results of this study do indicate that conventional historic accounting data can be highly material for the purposes at least of this study when taken together with the particular multivariate statistical methodology employed and that the effect of differing treatments of accounting items between firms and such things as 'window-dressing' and 'creative accounting' generally together with the results of inflation, which the literature appears frequently to argue on strictly theoretical grounds seriously undermines the utility of published historic accounting data, are actually not so important at all. This is probably to a certain extent due to the stepwise methodology and multivariate framework adopted.

5. Further Work

It is a truism that no research study is ever really complete and this is no exception. During its progress many avenues for relevant additional work were opened up although progress down these would have been frequently effectively prohibited by the lack of a source of computerised accounting data in standardised form similar to the US Compustat tapes.

However very recently just such a database containing the latest 4 years of accounts in standardised form in the format of fig 9.1 for about 8,000 quoted and private companies became available for academic research[1]. Using its data structure the author is presently engaged in constructing a new Z-model in a form allowing interrogation of the computer tape to answer some of the outstanding questions raised in this study particularly the extent of 'insolvency' in British manufacturing industry and the degree of company recovery from this state. The additional manufacturing firms which have failed since the model described here was developed have been included to increase the size of the 'failed' set to near 50 and the lessons learnt in the first analysis are being applied.

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[1] The database was compiled and is being marketed by Jordan Dataquest Limited, Jordan House, 47 Brunswick Place, London N.1.

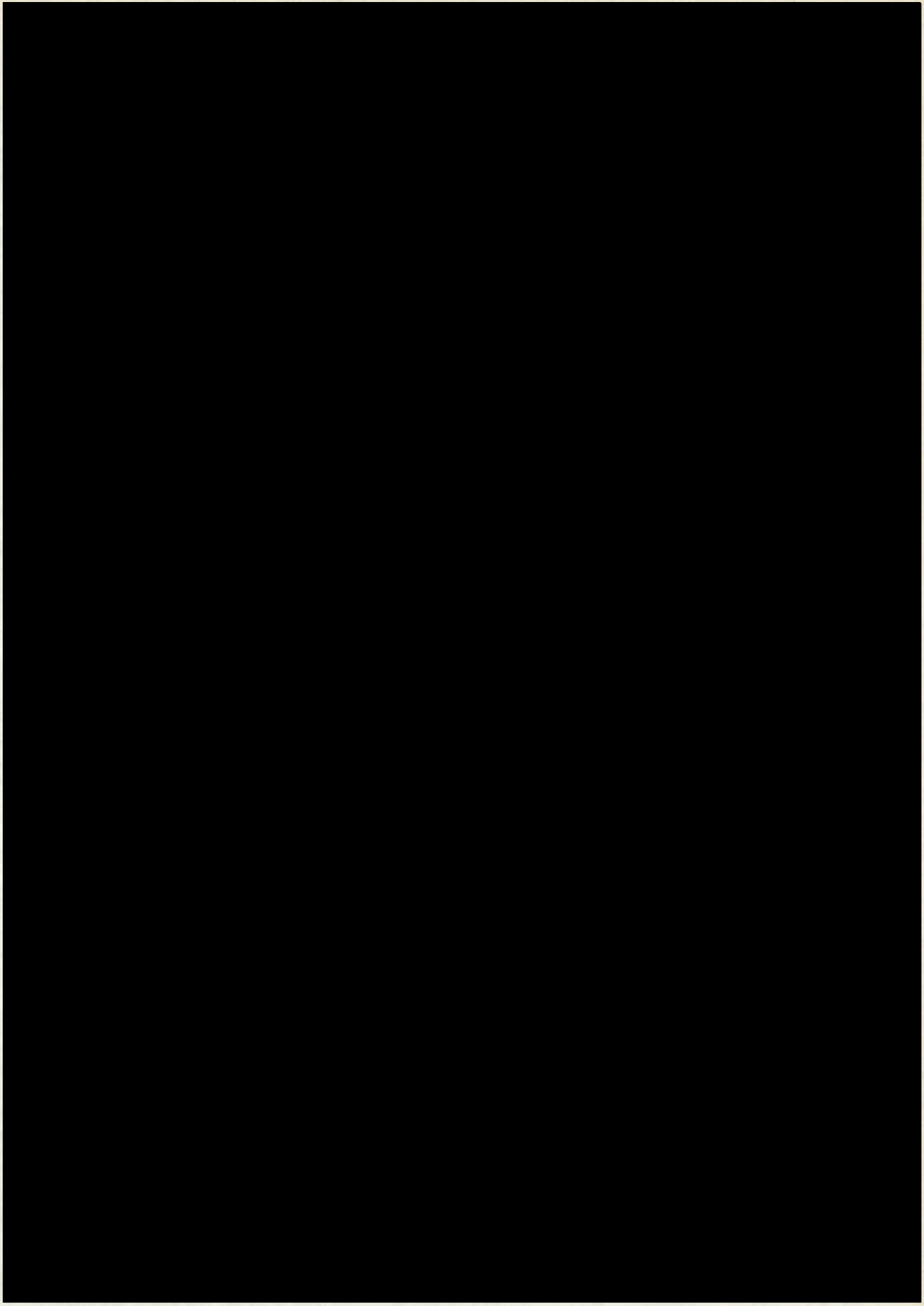


Fig 9.1: Company Data Held in the Jordan Dataquest Database

This new model will also be used to examine takeovers and rights issues from the point of view of these constituting alternative courses of action to bankruptcy in certain cases. Preliminary results from applying the existing Z-model to 1973 data, and not reported here, suggest that some additional understanding of these phenomena may well be gained from such an approach. Consideration will also be given to the utility of the model for the auditor in the examination of 'going-concern' problems and related issues. The lack of qualification of the last available set of accounts prior to bankruptcy for 'going-concern' reasons of all but 3 or 4 of the failed firms studied here must give rise for some concern.

This Jordan Dataquest database has already been used by a student of the author's in the development of a very successful model, similar in nature to that described here, for private manufacturing companies with turnover of around £1m and above. On the basis of the results of this model it does appear that for purposes of solvency measurement at least, the criticisms of private company accounting data frequently made can be overcome by the adoption of a careful multivariate modelling approach. This piece of work incidentally might constitute the first successful attempt at the development of such a strictly operational model for private companies reported on either side of the Atlantic[1]. Following on from this another of the author's students has been using the database to analyse the differences in financial structure in a multivariate context between matched samples of quoted and private manufacturing firms.

Another study in its preliminary stages is the use of the P-model to examine the extent to which the stockmarket valuation of a company in terms of its market relative price-earnings (P/E) ratio is related to its 'P-score'.

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[1]The only related study known to the author (Edmister, 1972) was comparatively unsuccessful, to a large extent due to the methodology adopted and the way in which the company data were selected (see pp91-93 above).

On the basis of his experiences in this study, the author concludes that the potential power of the multivariate approach for purposes of economic and financial analysis appears to have been very much neglected in the literature, particularly in the UK, and that the worries of the theoretical accountants and others regarding the informational content of historic accounting numbers are probably exaggerated in very many cases, particularly when a multivariate methodology is adopted.

THE APPENDICES

Appendix 4.1: Rolls Royce Standardised Accounts 1965-1969

Profit & Loss A/c.

ROLLS ROYCE LTD — SUMMARY INCOME STATEMENT

YEAR ENDING: 31/ 12	1965	1966	1967	1968	1969
TOTAL SALES	126600	170276	263582	319536	299363
LESS TOTAL WAGES	49974	65889	104906	111986	114112
OTHER(C)	65226	90433	136296	182037	161863
GROSS TRADING PROFIT(C)	11400	13954	22380	25513	23388
LESS DEPRECIATION	3680	4613	7894	8876	10941
PROVISIONS	-0	-0	1933	2639	3605
INVESTMENT GRANT	0	0	0	0	0
NET TRADING PROFIT(C)	7720	9341	12553	13998	8842
ADD SHARE OF ASSOC. COS.	442	1030	1255	1602	1443
INVESTMENT INCOME	777	1082	1576	1412	1614
E.B.I.T.(C)	8939	11453	15384	17012	11899
LESS INTEREST:FIXED	2006	3224	7567	8959	9692
O/DRAFT	-0	-0	-0	-0	-0
TOTAL EARNINGS BEFORE TAX	6933	8229	7817	8053	2207
LESS TOTAL TAX	2379	3142	4575	7126	2272
EARNINGS AFTER TAX(C)	4554	5087	3242	927	-65
LESS PREF.DIVIDEND	-0	-0	-0	-0	-0
MIN.INTEREST	58	19	113	75	118
RETAINED IN ASSOC.COS.	-0	-0	-0	-0	-0
DISTRIBUTABLE EARNINGS(C)	4496	5068	3129	852	-183
LESS ORDINARY DIVIDEND	1633	3669	6108	7376	3973
RETAINED OP.EARNINGS(C)	2863	1399	-2979	-6524	-4156
EXCEPTIONAL ITEMS	-0	-0	-52	328	-10700
RETAINED EARNINGS TO B/S(C)	2863	1399	-3031	-6196	-14856

ROLLS ROYCE LTD — SUMMARY BALANCE SHEET

AS AT: 31/ 12	1965	1966	1967	1968	1969
NET FIXED ASSETS	21934	53029	62516	77495	89374
ASSOC. COS.	-0	-0	-0	-0	-0
TRADE INVEST.	-0	-0	-0	-0	-0
INTANGIBLE ASSETS	5263	30835	28404	24587	11760
CASH ETC.≤OTH.LIQU.ASS.	386	1041	710	1118	848
DEBTORS	40783	84056	98332	118026	110947
NET STOCKS ≤ W.I.P.	53683	108582	124603	115642	112101
CURRENT ASSETS(C)	94852	193679	223649	234786	223896
TOTAL ASSETS(C)	122049	277543	314565	336868	325030
CREDITORS	22180	78415	64244	63579	62305
FUTURE TAX,DIVS. PROG.PAY≤OTHER	5784	9333	13363	13771	3849
BANK O/D.≤LOANS	19311	41000	56284	46375	54027
CURRENT LIABILITIES(C)	47275	128748	133891	123725	120181
NET CAPITAL EMPLOYED(C1)	74774	148795	180674	213143	204849
REPRESENTED BY:					
FIXED INTEREST CAPITAL	14867	38597	48572	57163	56650
PREFERENCE CAPITAL	-0	-0	-0	-0	-0
TAX EQUALIZATION A/C	0	11783	5076	10330	13174
PROVISIONS	5424	6905	7295	7129	7029
MINORITY INTEREST	335	327	499	539	617
LONG TERM LIABILITIES(C)	20626	57612	61442	75161	77470
INVESTMENT GRANTS	-0	-0	-0	-0	-0
ORD.CAPITAL ≤ RESERVES	54148	91183	119231	137982	127379
NET CAPITAL EMPLOYED(C2)	74774	148795	180673	213143	204849

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5. Further Work

It is a truism that no research study is ever really complete and this is no exception. During its progress many avenues for relevant additional work were opened up although progress down these would have been frequently effectively prohibited by the lack of a source of computerised accounting data in standardised form similar to the US Compustat tapes.

However very recently just such a database containing the latest 4 years of accounts in standardised form in the format of fig 9.1 for about 8,000 quoted and private companies became available for academic research[1]. Using its data structure the author is presently engaged in constructing a new Z-model in a form allowing interrogation of the computer tape to answer some of the outstanding questions raised in this study particularly the extent of 'insolvency' in British manufacturing industry and the degree of company recovery from this state. The additional manufacturing firms which have failed since the model described here was developed have been included to increase the size of the 'failed' set to near 50 and the lessons learnt in the first analysis are being applied.

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[1] The database was compiled and is being marketed by Jordan Dataquest Limited, Jordan House, 47 Brunswick Place, London N.1.

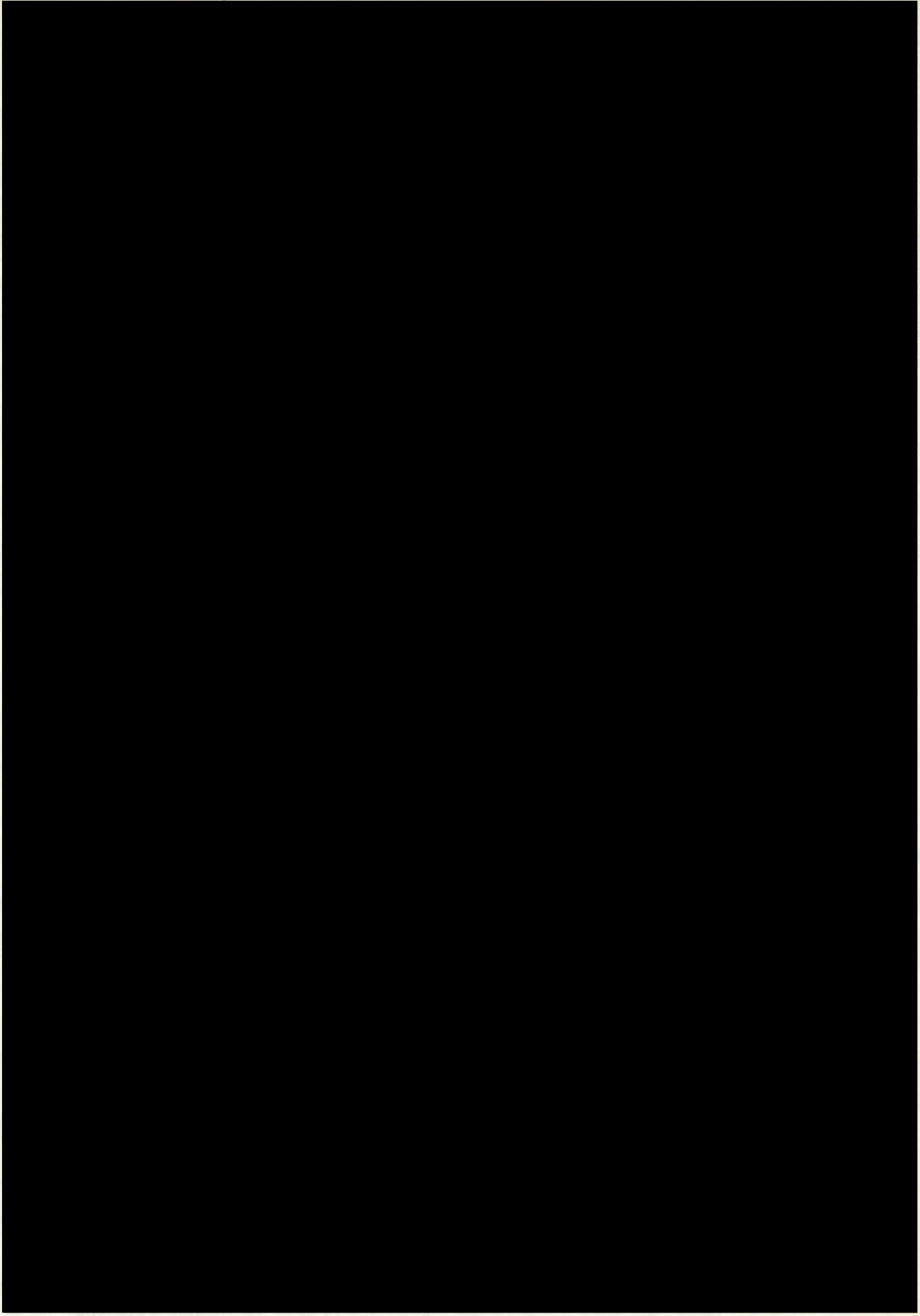


Fig 9.1: Company Data Held in the Jordan Dataquest Database

This new model will also be used to examine takeovers and rights issues from the point of view of these constituting alternative courses of action to bankruptcy in certain cases. Preliminary results from applying the existing Z-model to 1973 data, and not reported here, suggest that some additional understanding of these phenomena may well be gained from such an approach. Consideration will also be given to the utility of the model for the auditor in the examination of 'going-concern' problems and related issues. The lack of qualification of the last available set of accounts prior to bankruptcy for 'going-concern' reasons of all but 3 or 4 of the failed firms studied here must give rise for some concern.

This Jordan Dataquest database has already been used by a student of the author's in the development of a very successful model, similar in nature to that described here, for private manufacturing companies with turnover of around £1m and above. On the basis of the results of this model it does appear that for purposes of solvency measurement at least, the criticisms of private company accounting data frequently made can be overcome by the adoption of a careful multivariate modelling approach. This piece of work incidentally might constitute the first successful attempt at the development of such a strictly operational model for private companies reported on either side of the Atlantic[1]. Following on from this another of the author's students has been using the database to analyse the differences in financial structure in a multivariate context between matched samples of quoted and private manufacturing firms.

Another study in its preliminary stages is the use of the P-model to examine the extent to which the stockmarket valuation of a company in terms of its market relative price-earnings (P/E) ratio is related to its 'P-score'.

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[1]The only related study known to the author (Edmister, 1972) was comparatively unsuccessful, to a large extent due to the methodology adopted and the way in which the company data were selected (see pp91-93 above).

On the basis of his experiences in this study, the author concludes that the potential power of the multivariate approach for purposes of economic and financial analysis appears to have been very much neglected in the literature, particularly in the UK, and that the worries of the theoretical accountants and others regarding the informational content of historic accounting numbers are probably exaggerated in very many cases, particularly when a multivariate methodology is adopted.

COMPANY ACCOUNTS
DATA INPUT FORM

FUNDS FLOW - Sheet 3

Company _____

Note: The computer (at present) will not acknowledge commas, dashes, brackets or 'n/a. Data for the descriptions in brackets are not required by the computer.

	DESCRIPTION	£000					
	Year						
	[Net change in ord. cap. & Reserves]						
	[Less ret. in assoc. cos.]						
	[Less ret. earnings, operating earnings]						
	[Leaving direct b/s changes & exc. income items]						

CONSISTING OF:-

74	New equity money raised consisting of val. of ord. shares issued.						74
75	Profits (losses) on disposals of assets						75
	[Goodwill, written off]						
76	Tax adjustment						76
77	Revaluation of assets as per Co. a/c						77
78	Additional revaluation of assets						78
79	Capitalisation of expenses						79
80	Other *						80
81	Other *						81
82	Other *						82
	[Other]						
	Total = 74 thru 82 + [other] - [goodwill] - 78 ≡ direct b/s changes and exceptional inc. items						

83	Disposal of fixed assets (net book value)						83
84	Net fixed assets of cos. acquired						84
85	Cap. commitments contr. for next year						85
86	Cap. commitments auth. for next year						86

87	Number of employees U.K.						87
88	Number of employees Overseas						88
89	- optional - number of employees all						89

Appendix 4.3: concluded

Appendix 4.1: Rolls Royce Standardised Accounts 1965-1969

Profit & Loss A/c.

ROLLS ROYCE LTD — SUMMARY INCOME STATEMENT

YEAR ENDING: 31/ 12	1965	1966	1967	1968	1969
TOTAL SALES	126600	170276	263582	319536	299363
LESS TOTAL WAGES	49974	65889	104906	111986	114112
OTHER(C)	65226	90433	136296	182037	161863
GROSS TRADING PROFIT(C)	11400	13954	22380	25513	23388
LESS DEPRECIATION	3680	4613	7894	8876	10941
PROVISIONS	-0	-0	1933	2639	3605
INVESTMENT GRANT	0	0	0	0	0
NET TRADING PROFIT(C)	7720	9341	12553	13998	8842
ADD SHARE OF ASSOC. COS.	442	1030	1255	1602	1443
INVESTMENT INCOME	777	1082	1576	1412	1614
E.B.I.T.(C)	8939	11453	15384	17012	11899
LESS INTEREST:FIXED	2006	3224	7567	8959	9692
O/DRAFT	-0	-0	-0	-0	-0
TOTAL EARNINGS BEFORE TAX	6933	8229	7817	8053	2207
LESS TOTAL TAX	2379	3142	4575	7126	2272
EARNINGS AFTER TAX(C)	4554	5087	3242	927	-65
LESS PREF.DIVIDEND	-0	-0	-0	-0	-0
MIN.INTEREST	58	19	113	75	118
RETAINED IN ASSOC.COS.	-0	-0	-0	-0	-0
DISTRIBUTABLE EARNINGS(C)	4496	5068	3129	852	-183
LESS ORDINARY DIVIDEND	1633	3669	6108	7376	3973
RETAINED OP.EARNINGS(C)	2863	1399	-2979	-6524	-4156
EXCEPTIONAL ITEMS	-0	-0	-52	328	-10700
RETAINED EARNINGS TO B/S(C)	2863	1399	-3031	-6196	-14856

ROLLS ROYCE LTD — SUMMARY BALANCE SHEET

AS AT: 31/ 12	1965	1966	1967	1968	1969
NET FIXED ASSETS	21934	53029	62516	77495	89374
ASSOC. COS.	-0	-0	-0	-0	-0
TRADE INVEST.	-0	-0	-0	-0	-0
INTANGIBLE ASSETS	5263	30835	28404	24587	11760
CASH ETC.≤OTH.LIQU.ASS.	386	1041	710	1118	848
DEBTORS	40783	84056	98332	118026	110947
NET STOCKS ≤ W.I.P.	53683	108582	124603	115642	112101
CURRENT ASSETS(C)	94852	193679	223645	234786	223896
TOTAL ASSETS(C)	122049	277543	314565	336868	325030
CREDITORS	22180	78415	64244	63579	62305
FUTURE TAX,DIVS. PROG.PAY≤OTHER	5784	9333	13363	13771	3849
BANK O/D.≤LOANS	19311	41000	56284	46375	54027
CURRENT LIABILITIES(C)	47275	128748	133891	123725	120181
NET CAPITAL EMPLOYED(C1)	74774	148795	180674	213143	204849
REPRESENTED BY:					
FIXED INTEREST CAPITAL	14867	38597	48572	57163	56650
PREFERENCE CAPITAL	-0	-0	-0	-0	-0
TAX EQUALIZATION A/C	0	11783	5076	10330	13174
PROVISIONS	5424	6905	7295	7129	7029
MINORITY INTEREST	335	327	499	539	617
LONG TERM LIABILITIES(C)	20626	57612	61442	75161	77470
INVESTMENT GRANTS	-0	-0	-0	-0	-0
ORD.CAPITAL ≤ RESERVES	54148	91183	119231	137982	127379
NET CAPITAL EMPLOYED(C2)	74774	148795	180673	213143	204849

Appendix 4.1 (cont): Rolls Royce Standardised Accounts 1965-1969

Balance Sheet

ROLLS ROYCE LTD	FUNDS FLOW ANALYSIS			
YEAR ENDING: 31/ 12	1966	1967	1968	1969
SOURCES				
DIRECT B/S.CHANGES, EXCEPT.INCOME ITEMS ETC(A)	35636	29094	22636	-10052
RETAINED OP.EARNINGS	1399	-2979	-6524	-4156
ADD:DEPRECIATION	4613	7894	8876	10941
PROVISIONS	-0	1933	2639	3605
TRANSFER TO TAX EQU.A/C	668	2602	5226	2845
LESS INV.GRANT CREDIT	0	0	0	0
RETAINED CASH FROM OPS(B)	6680	9450	10217	13235
INCREASE IN:				
FIXED INT.CAPITAL	23730	9975	8591	-513
PREF.CAPITAL	0	0	0	0
TAX EQUALISATION A/C	11115	-9309	28	-1
PROVISIONS	1481	390	-166	-100
MINORITY INTEREST	-8	172	40	78
INCREASE IN L.TERM LIABS(C)	36318	1228	8493	-536
INVESTMENT GRANT RECD.(D)	0	0	0	0
TOTAL SOURCES(A+B+C+D)	78634	39772	41346	2647
APPLICATIONS				
INCREASE IN:				
CASH≤EQUIV.≤OTHER L.A.	655	-331	408	-270
DEBTORS	43273	14276	19694	-7079
STOCKS ≤ W.I.P	54899	16021	-8961	-3541
INCREASE IN CURR.ASS.(E)	98827	29965	11142	-10890
LESS INCREASE IN:				
CREDITORS	56235	-14171	-665	-1274
TAX,DIV.≤OTHER	3549	4030	408	-9922
BANK O/D	21689	15284	-9909	7652
INCREASE IN CURR.LIABS.(F)	81473	5143	-10166	-3544
INCR.IN WORK.CAP.(E-F)	17354	24822	21308	-7346
REVALUATION OF FIXED ASS.	-0	-0	-0	-0
INCR.IN N.F.A(INCL.COS.ACQ)	35708	17381	23855	22820
INCR.IN INTANGIBLES	25572	-2431	-3817	-12827
INCR.IN ASSOC.COS.	0	0	0	0
INCR.IN TRADE INV.	0	0	0	0
TOTAL APPLICATIONS	78634	39772	41346	2647

Appendix 4.1 (concluded): Rolls Royce Standardised Accounts

Appendix 4.2: Data items Collected for Failed firms
Together with the Laurence Prust & Co Databank Equivalent Definitions

Item Code (I)	Item	Laurence Prust databank definitions[1]
	PROFIT & LOSS ACCOUNT ITEMS	
1	Total sales	12 or 13+14+15
2	Total wages	16+17
3	Depreciation	21
4	Provisions	22
5	Investment grant credit (+ ve)	23
6	Share of Assoc. Cos.	24
7	Total investment income	25+26
8	Fixed interest	27
9	Overdraft interest	28
10	Total earnings before tax	30
11	Total tax	31+32+33-34+35+36+37
12	Preference dividend	38
13	Minority interest	39
14	Retained in Association Companies	40
15	Ordinary dividends (gross)	42
16	Retained operating earnings + depreciation[2]	$I_{10}-(I_{11}+I_{12}+I_{13}+I_{14}+I_{15}-I_3)$
17	Exceptional items	43
	BALANCE SHEET ITEMS	
18	Net fixed assets	48-69 or 44+45-47-69
19	Associated companies	49
20	Trade investments	50
21	Intangible assets	51
22	Cash and other liquid assets	52+53+54
23	Debtors	55
24	Net stocks and work in progress	56-57
25	Total current assets[2]	$I_{22}+I_{23}+I_{24}$
26	Creditors	59
27	Future tax and dividends etc	60+61+62
28	Short term loans (overdraft & bank loans etc)	63
29	Total current liabilities[2]	$I_{26}+I_{27}+I_{28}$
30	Fixed interest capital	64
31	Preference capital	65
32	Deferred tax (tax equalisation account)	66
33	Provisions	67
34	Minority interest	68
35	Investment grants[3]	set to zero
36	Ordinary capital and reserves	$I_{38}-(I_{30}+I_{31}+I_{32}+I_{33}+I_{34}+I_{35})$
37	Other liquid assets - other liabilities	set to zero
38	Net capital employed[2]	$I_{18}+I_{19}+I_{20}+I_{21}+I_{25}-I_{29}$
	OTHER ITEMS	
39	Total revaluation of assets over year	77+78
40	Profit and loss a/c, tax equalisation	32+36

Note: This appendix is to be read in conjunction with appendix 4.3
1 The numbers refer to the item code numbers in appendix 4.3
2 Items used for input check purposes for failed firms
3 In the case of the failed firms, item I_{35} was completed and subtracted from I_{18} to adjust for investment grants

COMPANY ACCOUNTS

DATA INPUT FORM - NEW COMPANY

INCOME STATEMENT - Sheet 1

Full name of company _____

Date of end of year _____

Note: The computer (at present) will not acknowledge commas, dashes, brackets or 'n/a'. Data for the descriptions in brackets are not required by the computer.

F.T. Act. Group No. _____ Stock Exch. Co. Code _____ Analyst Name _____

	DESCRIPTION	£'000					
10	Year						10
11	Monetary Units	1000	1000	1000	1000	.000	11
12	-optional- Total Sales**						12
13	Sales U.K.						13
14	Exports						14
15	Sales Overseas						15
16	Wages U.K.						16
17	Wages Overseas						17
18	Other*.....						18
19	Other*.....						19
20	Other*						20
***	[other]						***
21	Depreciation (positive value)						21
22	Provisions						22
23	Investment grant credit (positive value)						23
24	Share of assoc. companies						24
25	Investment income franked						25
26	Investment income other						26
27	Interest fixed						27
28	Interest overdraft						28
29	-optional- o/seas earnings before tax**						29
30	Total earnings before tax						30
31	U.K. tax charge						31
32	Tax equal.						32
33	A.C.T. (positive value) Relief to be negative						33
34	D.T.R. (positive value)						34
35	Overseas tax charge						35
36	Tax equal.						36
37	Associated Companies						37
	[Total Tax]						
38	Preference Dividend						38

Appendix 4.3: Laurence, Prust & Co. Databank Account Items

Company _____

	DESCRIPTION	£'000					
	Year						
39	Min. interest						39
40	Ret. in associated companies						40
41	Ord. dividends NET						41
42	Ord. dividends GROSS						42
	[Ret. operating E.]						
43	Exceptional items						43
***	[Retained earnings to b/s per L.P.]						***
	[Add ret. in associated cos.]						
	[Net earnings per co a/cs.]						

NOTES

* 'other' entries to include only specific items. The remaining 'all other' items will be calculated by the computer, except for other liabilities and liquid assets. The description of these items should be added as the computer will ask for them (maximum 24 characters).

** The overseas earnings will be assumed to be twice overseas tax charge if this entry is zero.

*** These items will be calculated when the data is read by the computer from this data sheet and provides a quick check.

\+ '-optional-' Complete these entries only if associated item(s) are incomplete.

++ 1. Enter number of shares of actual year ending value unless,

2. If there has been a rights issue or issue for acquisition enter the average number of shares over the year.

3. The machine will adjust the shares in years prior to the adjusting fraction.

4. If the adjusted number of shares are entered then enter '1.0' as the adjusting fraction.

+++ The first entry of investment grants deducted from fixed assets should include all grants deducted in the years prior to this year as well as for that year. When the computer reads this data it will calculate the cumulative value for each year.

Appendix 4.3: continued

COMPANY ACCOUNTS — BALANCE SHEET - Sheet 2

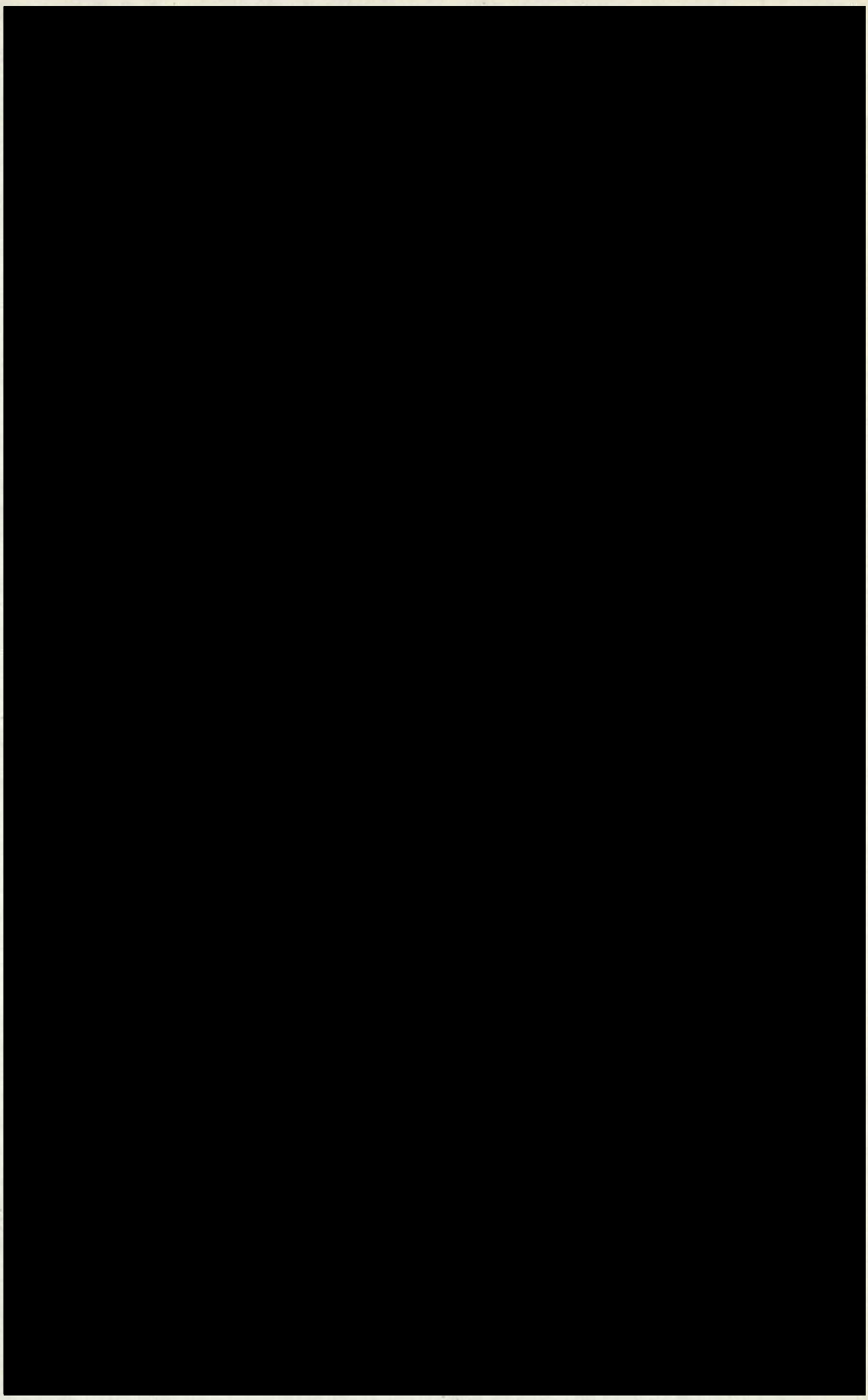
DATA INPUT FORM

Company _____

Note: The computer (at present) will not acknowledge commas, dashes, brackets or 'n/a'.
Data for the descriptions in brackets are not required by by the computer.

	DESCRIPTION	£'000					
	Year						
44	Gross fixed assets - property						44
45	Gross fixes assets - plant						45
46	Investment grants deducted from fixed asset+++						46
47	-optional- Depreciation (positive value) } one of these						47
48	-optional- Net fixed assets } must be completed						48
49	Associated companies						49
50	Trade investments						50
51	Intangible assets						51
52	Cash						52
53	Other*.....						53
54	Other liquid assets						54
55	Debtors						55
56	Gross stocks & w.i.p.						56
	[Current assets]						
57	Progress payments						57
58	If output/employee to incl. stocks enter '1'						58
59	Creditors						59
60	Tax						60
61	Other*.....						61
62	Other (including Dividend)						62
63	Bank overdraft						63
	[Current liabilities]						
64	Fixed interest capital						64
65	Preference capital						65
66	Deferred tax						66
67	Provisions						67
68	Minority interest						68
69	Investment grants						69
***	[Ordinary capital & reserves]						
70	Adjusting factor for rights & scrips++(1.0)						70
71	No. of ordinary shares in '000's ++						71
72	Goodwill written off reserves						72
73	Additional adj. to net trading capital						73

Appendix 4.3: continued



Appendix 4.5b (concluded): Dowty Group Standardised Accounts 1968-1972: Funds Flow - Uses Statement. (Source: Laurence, Prust & Co Databank.)

Company	Sequential financial year ends	Adjustments made to accounting items in income statement etc
Dansette	31. 3.66-31.12.66	For year to 31.12.1966, 9 months to 31.12.1966 + 3 months of results for year to 31.3.1966. Year to 31.3.66 called '1965' and year to 31.3.65 called '1964'.
Lawes Chemical	30. 6.65-30. 9.66	Pro-rata reduction in account items
Oldham Twist	14.12.64-26. 3.66	Pro-rata reduction in account items. P/L account 10.12.64 moved to 26.3.65.
W & J Sagar	31. 3.64-30. 6.65	Pro-rata reduction in account items
Wardle & Davenport	31.12.66-29. 2.68	Pro-rata reduction in account items
United Match	30. 9.64-31. 3.66	Pro-rata reduction in account items for year to 31.3.66. A pro-forma P/L account for 12 months to 31.3.65 was made up from '½' of the account to 30.9.64 and '1/3' of the 18 months account to 31.3.66.

Appendix 4.4: Adjustments Made to the Account Items of the Failed Firms for Changes in Year End

Appendix 4.6b: Definitions of the Numerators and Denominators of the Ratios Employed

The definitions of one or two items differed between the earlier and later stages of the analyses - see appendices 4.8 and 4.9.

Ratio numerator or denominator	Description	Computation (see appendix 4.2 for item code descriptors)
FF	funds flow (gross trading profit)	$I_{10}+I_9+I_8-I_7-I_6-I_5+I_4+I_3$
EBIT	earnings before interest and tax	$I_{10}+I_9+I_8$
CF	cash flow (a measure of retained operating earnings + depreciation)	$I_{10}-I_{11}-I_{12}-I_{13}-I_{14}-I_{15}+I_3+I_4-I_5+I_{40}$
S	turnover	I_1
TA	total assets (adjusted for investment grants)	$CA+I_{18}+I_{19}+I_{20}+I_{21}$
NW	net worth (shareholders' funds)	$I_{36}+I_{31}$
TL	total liabilities (current and long term)	CL+LTL
CL	current liabilities	$I_{29}=I_{26}+I_{27}+I_{28}$
NTC	net trading capital	$I_{38}+I_{28}-I_{22}-I_{19}-I_{20}$
NTC (adj)	adjusted net trading capital	$I_{38}+I_{28}-I_{22}$
NCE	net capital employed (shareholders' funds + long term liabilities)	I_{38}
Int.	interest paid	I_8+I_9
LTL	long term liabilities	$I_{30}+I_{31}+I_{32}+I_{33}+I_{34}$
FA	fixed assets[1]	$I_{18}+I_{21}$
WC	working capital (current assets-current liabilities)	CA-CL
CA	current assets	$I_{25}=I_{22}+I_{23}+I_{24}$
C	cash and equivalent	I_{22}
QA	quick assets (cash+ debtors)	$I_{22}+I_{23}$
Inv.	inventory	I_{24}
N.T.WC	net trading working capital	$WC+I_{28}-I_{22}$
Dr.	debtors	I_{23}
DA	defensive assets (cash+ 7 days debtors)	$I_{22}+(7xDr.)/Days\ Drs.$
Cr.	creditors	I_{26}
Debt		$I_{28}+I_{30}$
Equity		$I_{38}+I_{28}-I_{32}-I_{33}$
Days Debtors (Drs.)		$(Av.Dr.x365)/I_1$
Days creditors (Crs.)		$(Av.Cr.x365)/(I_1-I_2-FF)$

(continued overleaf)

Explanation to items

subscript $_{(t-1)}$ denotes opening balance sheet item
subscript $_{(t)}$ denotes closing balance sheet item
Av. denotes average of opening and closing balance sheet items.

Notes

[1] The inclusion of goodwill in this measure was suggested by the financial analysts as an attempt to obtain a more realistic valuation of the fixed assets. The most important componont in intangible assets in the accounts considered here is the excess of the price paid in a subsitiary over the net book value of the assets they represent. "It is common for acquiring companies to pay more for an acquisition than the 'victim's' book value and to deal with the surplus payment either by creating 'goodwill' or by revaluing tangible fixed assets." Meeks and Whittington (1975:831). Also see Lee (1974).

Appendix 4.7: The Computed Funds Flow Measures

Retained cash from operations ratios

1. B/ΔTA
2. B/ΔNW
3. B/ΔTL
4. B/ΔCL
5. B/ΔFA
6. B/Direct balance sheet changes etc
7. B/ΔWC
8. B/Total sources

Long term solvency flow ratios

9. ΔTL/ΔNW
10. ΔLTL/ΔNW
11. ΔFA/ΔNW
12. ΔFA/Direct balance sheet changes etc
13. ΔLTL/ΔWC
14. ΔTL/ΔCA
15. ΔCL/ΔTA
16. ΔLTL/ΔTA
17. ΔTL/ΔTA
18. Δdebt/(ΔEquity+ΔDebt)
19. ΔTL/Direct balance sheet changes etc
20. Direct balance sheet changes etc/ Total sources

Liquid asset flow ratios

21. ΔC/ΔCL
22. ΔQA/ΔCL
23. ΔCA ΔCL
24. ΔWC/ΔCL
25. ΔC/ΔTA
26. ΔQA/ΔTA
27. ΔCA/ΔTA
28. ΔWC/ΔTA
29. ΔC/ΔNW
30. ΔQA/ΔNW
31. ΔCA/ΔNW
32. ΔWC/ΔNW
33. ΔC/ΔLTL
34. ΔQA/ΔLTL
35. ΔCA/ΔLTL
36. ΔWC/ΔLTL
37. ΔC/ΔTL
38. ΔQA/ΔTL
39. ΔCA/ΔTL
40. ΔWC/ΔTL
41. ΔC/Total sources
42. ΔQA/Total sources
43. ΔCA/Total sources
44. ΔWC/Total sources

Other liquid asset flow ratios etc

45. ΔDr./ΔCr.
46. ΔInv./ΔWC
47. ΔDr./ΔWC
48. B/(ΔWC+ΔFA)

Computations:

Δ denotes change from one year to the next in the particular accounting item.

B denotes Retained Cash from operations.
Direct balance sheet changes etc is a "catch-all" item which is calculated by subtraction of items B, C and D (in appendices 4.1 or 4.5b) from the total applications' figure. It was not possible to compute it directly because of data collection problems.
The other items are as defined in appendix 4.6b.

Appendix 4.8: The Variables Used in the Initial Analyses (Incorporating trend measures)

Variable	Transformation Employed	FAILED42 Outliers 2.5σ–4σ	FAILED42 Outliers >4σ	GOOD47 Outliers 2.5σ–4σ	GOOD47 Outliers >4σ	Total Outliers
1. FF/S		1		1		2
2. FF/TA$_{t-1}$		1		2	1	4
3. Δ(FF/TA$_{t-1}$)		3	2	1		6
4. FF/NW$_{t-1}$				2	3	5
5. FF/TL$_{t-1}$		3	1	2		6
6. Δ(FF/TL$_{t-1}$)		3	2	1	1	5
7. FF/CL$_{t-1}$		2		2	1	5
8. Δ(FF/CL$_{t-1}$)		3	2	1	1	7
9. FF/NTC$_{t-1}$				1	1	2
10. FF/NCE$_{t-1}$				1	2	3
11. EBIT/S$_{t-1}$		1				1
12. EBIT/TA$_{t-1}$				2		2
13. EBIT/NW$_{t-1}$				1	2	3
14. Δ(EBIT/NW$_{t-1}$)		2	3	2	1	8
15. EBIT/TL$_{t-1}$		3		3	1	7
16. EBIT/CL$_{t-1}$		1		1	1	3
17. EBIT/NTC$_{t-1}$				1		1
18. Δ(EBIT/NTC$_{t-1}$)		2	3		1	6
19. EBIT/NCE$_{t-1}$					1	1
20. Δ(EBIT/NCE$_{t-1}$)		1	4	1	1	7
21. CF/S		1	2	3	1	7
22. CF/TA$_{t-1}$		2		2		4
23. Δ(CF/TA$_{t-1}$)		1	4	1	2	8
24. CF/NW$_{t-1}$		2		1	1	4
25. Δ(CF/NW$_{t-1}$)		1	4		2	7
26. CF/TL$_{t-1}$		1		2		3
27. Δ(CF/TL$_{t-1}$)		1	3	2	2	8
28. CF/CL$_{t-1}$		1	2		3	6
29. ΔCF/CL$_{t-1}$		1	4	1	7	13
30. CF/NTC$_{t-1}$		2		1		3
31. Δ(CF/NTC$_{t-1}$)		1	4	1	2	8
32. CF/NCE$_{t-1}$		1			1	2
33. Δ(CF/NCE$_{t-1}$)		1	4	2	2	9
34. TL/NW			2			2
35. Δ(TL/NW)		1	3	1	1	6
36. FA/NW	LOG_{10}		1		1	2
37. FA/NCE			1	1		2
38. Δ(FA/NCE)		1	3		2	6
39. TL/CA		1	1		2	4
40. Δ(TL/CA)				1	2	3
41. CL/TA						
42. Δ(CL/TA)		1		2		3
43. TL/TA				1	1	2
44. Δ(TL/TA)				1	3	4
45. TL/NCE		2		2		4
46. Debt/Equity		1		1		2
47. QA/CL	LOG_{10}	1	3			4
48. Δ(QA/CL)		1	3	1		5
49. CA/CL	RECIPROCAL		1	1		2
50. Δ(CA/CL)			2	1	2	5

(continued overleaf)

Appendix 4.8: continued

Variable	Trans-formation Employed	FAILED42 Outliers 2.5σ-4σ	FAILED42 Outliers >4σ	GOOD47 Outliers 2.5σ-4σ	GOOD47 Outliers >4σ	Total Outliers
51. QA/TA		1	1	2	1	5
52. Δ(QA/TA)		2	2	2	3	9
53. CA/TA						
54. Δ(CA/TA)				2	2	4
55. WC/TA		1		1	1	3
56. QA/NW	LOG_{10}	1	1		1	3
57. Δ(QA/NW)			1	3	3	7
58. CA/NW	LOG_{10}		1			1
59. Δ(CA/NW)		2	1	3	1	7
60. WC/NW		1	2			3
61. QA/TL	RECIPROCAL	2	2	2		6
62. CA/TL	RECIPROCAL	1	1	2		4
63. QA/NCE	LOG_{10}	1		1	1	3
64. Δ(QA/NCE)		1		3	3	7
65. CA/NCE	LOG_{10}			1		1
66. WC/NCE			1	1		2
67. Δ(WC/NCE)		1	4	2	3	10
68. Dr./Cr.		2	3	2		7
69. Δ(Dr./Cr.)		3	1			4
70. S/QA_{t-1}	LOG_{10}	1	1	1	1	4
71. S/CA_{t-1}	LOG_{10}			3		3
72. S/WC_{t-1}	LOG_{10}			2		2
73. S/NW_{t-1}	LOG_{10}					
74. S/TA_{t-1}	LOG_{10}					
75. S/FA_{t-1}	LOG_{10}	2				2
76. S/NTC_{t-1}	LOG_{10}					
77. S/av. inv.		1	2	1	2	6
78. days debtors				1		1

Notes: Δ indicates a trend variable

The definition for the ratios are the same as given in appendix 4.6b except that CF includes exceptional items (I_{17}), NTC includes the overdraft etc item (I_{22}) and ratio 72 in this appendix is equivalent to ratio 64 in appendix 4.6a.

LAURENCE, PRUST & CO

FUNDS FLOW ANALYSIS
(£000)

DOWTY GROUP LIMITED

YEAR ENDING: 31ST MARCH	1968	1969	1970	1971	1972	4 YEAR TOTAL
SOURCES						
NEW EQUITY/VAL: SHARES ISS:	-	625	-	-	-	625
RETAINED IN ASSOC. COS.	-	-	-	-	-	-
EXCEPTIONAL INCOME ITEMS*	-	333	677	(385)	365	990
OTHER RESERVE CHANGES*	-	(13)	(169)	6	3,861	3,685
DIRECT BALANCE SHEET CHANGES, EXCEPTIONAL INCOME ITEMS, ETC. (A)	-	945	508	(379)	4,226	5,300
RETAINED OPERATING EARNINGS	-	923	474	1,013	960	3,370
ADD: DEPRECIATION	-	973	1,056	1,101	1,120	4,250
PROVISIONS	-	-	-	-	-	-
TRANSFER TO TAX EQUALISATION A/C	-	23	323	248	150	744
LESS INVESTMENT GRANT CREDIT	-	(389)	(371)	(331)	(421)	(1,512)
RETAINED CASH FROM OPERATIONS (B)	-	1,530	1,482	2,031	1,809	6,852
INCREASE IN:						
FIXED INTEREST CAPITAL	-	-	-	-	5,300	5,300
PREFERENCE CAPITAL	-	-	-	-	-	-
DEFERRED TAX	-	-	-	-	1	1
PROVISIONS	-	-	-	-	-	-
MINORITY INTEREST	-	-	-	-	-	-
INCREASE IN LONG TERM LIABILITIES (C)	-	-	-	-	5,301	5,301
INVESTMENT GRANT RECEIVED (D)	-	605	751	499	96	1,951
TOTAL SOURCES (A+B+C+D)	-	3,080	2,741	2,151	11,432	19,404
RECONCILIATION OF OTHER RESERVE CHANGES AND EXCEPTIONAL INCOME ITEMS						
PROFITS (LOSSES) IN DISPOSALS OF ASSETS	-	32	144	-	(15)	
GOODWILL WRITTEN OFF	-	-	-	(100)	(404)	
TAX OF PRIOR YEARS	-	241	(98)	509	110	
REVALUATION OF ASSETS PER CO A/C	-	-	598	-	3,866	
OTHER REVALUATION OF ASSETS	-	-	-	-	-	
CAPITALISATION OF EXPENSES	-	-	-	-	-	
-	-	47	(301)	(788)	672	
-	-	-	-	-	-	
-	-	-	-	-	-	
OTHER	-	-	165	-	(3)	
	-	320	508	(379)	4,226	

Appendix 4.5b (cont): Dowty Group Standardised Accounts
1968-1972: Funds Flow - Sources Statement. (Source: Laurence, Prust & Co Databank.)

FUNDS FLOW ANALYSIS
(£000)

LAURENCE, PRUST & CO

DOWTY GROUP LIMITED

YEAR ENDING: 31ST MARCH		1968	1969	1970	1971	1972	4 YEAR TOTAL
APPLICATIONS							
INCREASE IN:							
CASH AND EQUIVALENT		-	310	(813)	84	332	(87)
-		-	-	-	-	-	-
OTHER LIQUID ASSETS		-	-	-	-	-	-
DEBTORS		-	2,435	3,241	1,494	(303)	6,867
STOCKS & W.I.P.		-	667	3,009	3,566	2,056	9,298
INCREASE IN CURRENT ASSETS	(E)	-	3,412	5,437	5,144	2,085	16,078
LESS INCREASE IN:							
CREDITORS		-	207	1,914	2,702	(190)	4,633
TAX		-	103	680	(1,562)	(180)	(959)
-		-	-	-	-	-	-
OTHER		-	37	9	-	278	324
BANK OVERDRAFT		-	2,103	2,966	3,010	(4,774)	3,305
INCREASE IN CURRENT LIABILITIES	(F)	-	2,450	5,569	4,150	(4,866)	7,303
INCREASE IN WORKING CAPITAL	(E-F)	-	962	(132)	994	6,951	8,775
ADDITION TO FIXED ASSETS		-	2,098	1,545	1,174	840	5,657
DISPOSALS OF FIXED ASSETS		-	-	-	-	-	-
REVALUATION OF FIXED ASSETS		-	-	598	-	3,866	4,464
NET FIXED ASSETS OF COS. ACQUIRED		-	-	-	-	-	-
INCREASE IN INTANGIBLES		-	-	725	(14)	(204)	507
INCREASE IN ASSOC. COS.		-	20	5	(3)	(21)	1
INCREASE IN TRADE INVESTMENT		-	-	-	-	-	-
TOTAL APPLICATIONS		-	3,080	2,741	2,151	11,432	19,404

	NEXT YEAR
CAPITAL COMMITMENTS:	
CONTRACTED	253
AUTHORISED	127
TOTAL	380

Appendix 4.5b (concluded): Dowty Group Standardised Accounts 1968-1972: Funds Flow - Uses Statement.
(Source: Laurence, Prust & Co Databank.)

1. FF/S
2. FF/TA_{t-1}
3. FF/NW_{t-1}
4. FF/TL_{t-1}
5. FF/CL_{t-1}
6. FF/NTC_{t-1}
7. FF/NCE_{t-1}
8. EBIT/S
9. $EBIT/TA_{t-1}$
10. $EBIT/NW_{t-1}$
11. $EBIT/TL_{t-1}$
12. $EBIT/CL_{t-1}$
13. $EBIT/NTC_{t-1}$
14. $EBIT/NCE_{t-1}$
15. CF/S
16. CF/TA_{t-1}
17. CF/NW_{t-1}
18. CF/TL_{t-1}
19. CF/CL_{t-1}
20. CF/NTC_{t-1}
21. CF/NCE_{t-1}
22. Int/EBIT
23. TL/NW
24. LTL/NW
25. FA/NW
26. FA/NCE
27. LTL/WC
28. TL/CA
29. CL/TA
30. LTL/TA
31. TL/TA
32. TL/NCE
33. Debt/Equity
34. Int./av.debt
35. C/CL
36. QA/CL
37. CA/CL
38. WC/CL
39. C/TA
40. QA/TA
41. CA/TA
42. WC/TA
43. C/NW
44. QA/NW
45. CA/NW
46. WC/NW
47. C/LTL
48. QA/LTL
49. CA/LTL
50. WC/LTL
51. C/TL
52. QA/TL
53. CA/TL
54. WC/TL
55. C/NCE
56. QA/NCE
57. CA/NCE
58. WC/NCE
59. Dr./Cr.
60. Int/N.T.WC
61. Dr./N.T.WC
62. S/QA_{t-1}
63 S/CA_{t-1}
64. $S/N.T.WC_{t-1}$
65. S/NW_{t-1}
66. S/TA_{t-1}
67. S/FA_{t-1}
68. S/NTC_{t-1}
69. S/av.inv.
70. Days Drs.
71. Days Crs.
72. DA/CL
73. DA/TA
74. DA/NW
75. DA/LTL
76. DA/TL
77. DA/NCE
78. S/DA_{t-1}
79. (Dr.+Inv.)/Cr.
80. N.T.WC/NTC

Appendix 4.6a: The 80 Financial Ratio Measures Calculated and Employed in Different Stages of the Study

(definitions are provided in appendix 4.6b)

5.1.3 - The Statistical Model - Extension to Multiple groups

In the general case for $g > 2$, the pooled dispersion matrix W is given by

$$W = \frac{1}{n_1+n_2+\text{--------}n_g-g} \; X_1'X_1 + X_2'X_2 + \text{- - -} X_g'X_g$$

and the within-group variation can be written as:

$$d'\{(n_1 + n_2 + \text{-----}n_g - g)W\}d$$

The between groups variation (sum of squares) is more complex.

Let the matrix of group means be given by $\bar{X}$ where $\bar{X}$ is $p \times (n_1 + n_2 + \text{---}n_g)$ with n_1 columns given by $\bar{x}_1$, n_2 columns given by $\bar{x}_2$ and so on, and the matrix of grand means be given by $\bar{\bar{X}}$ where $\bar{\bar{X}}$ is a $p \times (n_1+n_2+ \text{----}n_g)$ matrix with all columns given by the $p \times 1$ vector $\bar{\bar{x}}$ of grand means where $\bar{\bar{x}}_j = \frac{1}{g} \sum_{j=1}^{g} \bar{x}_j$

Then the between-group variation is given by

$$d'(\bar{X} - \bar{\bar{X}})\,(\bar{X} - \bar{\bar{X}})'d \; ^{1}$$

and λ is given by $\frac{1}{n_1+ n_2+\text{------}n_g- 2} \cdot \frac{d'(\bar{X} - \bar{\bar{X}})(\bar{X} - \bar{\bar{X}})'d}{d'W\,d}$

λ can then be maximized by calculus to yield the equation

$$(B - \lambda W)d = 0 \qquad \text{where } B = (\bar{X} - \bar{\bar{X}})(\bar{X} - \bar{\bar{X}})'$$

or $$(W^{-1}B - \lambda I)d = 0$$

with solution yielding $(g-1)$ eigenvalues λ_k, and associated $(p \times 1)$ eigen-vectors d_i, where $i = 1, 2, \text{-------}(g-1)$.[2]

Thus $(g - 1)$ uncorrelated discriminant functions can be computed of the form $z_i = d_i'x$.

---

1. See Tatsuoka (1971: 170-172) for a justification of the relationship given above for the two group case as being a special case of the general between-group variation expression.

2. The rank of $W^{-1}B$ is $(g - 1)$ or strictly speaking $\min\{(g - 1), p\}$.

5.1.4 - Tests of Statistical Significance in Discriminant Analysis

The following classes of tests of statistical significance in discriminant analyses are usually carried out

(i) to test the overall statistical significance of the discriminant function(s)

(ii) in the case of g>2 to test how many of the uncorrelated discriminant functions are significant

and (iii) to test the statistical significance of the variables included individually.

(i) The overall difference among several group centroids can be tested by the application of Wilks' Λ criterion [1] where

$$\Lambda = \frac{|W|}{|T|}$$ where T is total sum of squares cross product matrix of deviations from the grand mean and = W + B.

Rao's F - ratio approximation 'R' [2]

can then be utilized to test for equality of group means where

$$R = \frac{1 - \Lambda^{\frac{1}{s}}}{\Lambda^{1/s}} \quad \frac{ms + 1 - p(g - 1)/2}{p(g - 1)}$$

where $s = 1$ if $p^2 + (g - 1)^2 = 5$

or $= \sqrt{\frac{p^2(g - 1)^2 - 4}{p^2 + (g - 1)^2 - 5}}$ if $p^2 + (g - 1)^2 \neq 5$

and $m = n_1 + n_2 + \text{-------} n_g - 1 - \frac{1}{2}(p + g)$

R is then approximately distributed as an F-variate with degrees of freedom given by $p(g - 1)$ and $ms + 1 - p(g - 1)/2$.

Another approach using Bartlett's γ is also valid for reasonably large sample sizes [3]. Its application is illustrated in§ ii below for examining the significance of individual discriminant functions when $g > 2$.

---

1. See Tatsuoka, (pp85-89)
2. See Tatsuoka, (pp88-89 or 188-9)
3. See Tatsuoka, (pp86-88)

An alternative approach is to compute the Mahalanobis D^2 multivariate distance[1] between pairs of groups (1, m) where

$$D^2_{1,m} = (\bar{x}_1 - \bar{x}_m)' W^{-1} (\bar{x}_1 - \bar{x}_m)$$

and test for significance by using[2]:

$$F_{p,\, n_1 + n_2 + \cdots n_g - g - p + 1} = \frac{n_1 n_m}{p(n_1 + n_m)(n_1 + n_2 + \cdots n_g - g)} D^2_{1,m}$$

(ii) To test for significance of individual discriminant functions in the case of g>2, Wilks' Λ criterion can also be applied.

Where $\lambda_1, \lambda_2 \cdots \lambda k$ are the k non-zero eigen-values of $W^{-1}B$ above then

$\frac{1}{\Lambda} = (1 + \lambda_1)(1 + \lambda_2) \cdots (1 + \lambda_k)$ and Bartlett's γ statistic (Tatsuoka 1971:86) for testing the significance of an observed Λ value can be expressed as

$$\gamma = -(n_1 + n_2 + \cdots - n_g - 1 - (p + g)/2) \log_e \Lambda$$

$$= (n_1 + n_2 + \cdots - n_g - 1 - (p + g)/2) \sum_{m=1}^{k} \log_e (1 + \lambda_m)$$

and this is approximately distributed as a χ^2 with p(g - 1) d.f. for large values of the bracketed expression above.

Specifically the m'th component γ_m is approximately a χ^2 with p + g - 2m degrees of freedom. Thus the residual discrimination after removing successive functions can be tested for[3].

(iii) Bolch and Huang (1974: 238) suggest two approaches in the two group case to test for the significance of individual discriminant coeffecients viz: comparison of the coeffecients with their standard errors as in multiple

---

1. See Tatsuoka, (1971: §8.1 pp218-225) and the description of the discriminant package BMD07M in Dixon (1973:241).

2. In the 2 group case D^2 reduces to $d'(\bar{x}_1 - \bar{x}_2)$ and this test gives equivalent results to those under 5.1.4 §i above. Also see Singh, (1971: 96-98).

3. The discussion is given in more detail with an example in Tatsuoka (pp164-70)

regression or comparison of the Mahalanobis D^2 distance between group centroids (see 5.1.4 §i above) based upon p variables (D^2_p) and that based upon (p + q) variables (D^2_{p+q}). However in the former case they point out that problems arise as the coeffecient estimates d depend on the value of c in the expression of footnote 1 of page 2 above. In the latter case the null hypothesis that the q extra variables do not significantly increase the discriminating power of the function can be tested using:

$$F_{q,n_1+n_2-p-q-1} = \frac{n_1 + n_2 - p - q - 1}{q} \cdot \frac{n_1 n_2 (D^2_{p+q} - D^2_p)}{(n_1+n_2)(n_1+n_2-2)+n_1 n_2 D^2_p}$$

The approach taken in the computer package BMD07M for examining separately the significance of each of the p included variables for $g > 2$ groups is described in Dixon (1973: 243) and the results provided by it are those given in the chapter.

5.1.5 - The Mahalanobis D^2 Multivariate Distance for Classification Purposes

The D^2 - multivariate distance of a case k in group1 from group m is given by

$$D^2_{m1k} = (x_{1k} - \bar{x}_m)' \; W^{-1} \; (x_{1k} - \bar{x}_m)$$

using the notation previously.

This is a χ^2 statistic with p degrees of freedom and can be used for classification purposes viz: assign the company to the group to which it is nearest. This approach is taken in the package BMD07M (Dixon, 1973: 244 and 250)[1].

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1. Also see Tatsuoka (1971: 218-225).

Appendix 5.2: Discrimatory Ability of the Financial Measures Used in the Initial Runs on a Univariate Basis: GOOD47 and FAILED42 firms

Appendix 4.8 Variable no	Variable Description	Ranking	F-value
12	$EBIT/TA_{t-1}$	1	138.3
2	FF/TA_{t-1}	2	134.4
28	CF/CL_{t-1}	3	132.3
9	FF/NTC_{t-1}	4	125.7
17	$EBIT/NTC_{t-1}$	5	125.7
16	$EBIT/CL_{t-1}$	6	123.6
13	$EBIT/NW_{t-1}$	7	121.9
5	FF/TL_{t-1}	8	121.6
7	FF/CL_{t-1}	9	120.5
22	CF/TA_{t-1}	10	117.5
21	CF/S	11	114.2
24	CF/NW	12	111.4
30	CF/NTC_{t-1}	13	108.3
15	$EBIT/TL_{t-1}$	14	107.9
11	EBIT/S	15	106.7
4	FF/NW	16	105.9
19	$EBIT/NCE_{t-1}$	17	98.8
1	FF/S	18	97.1
26	CF/TL	19	95.8
10	FF/NCE_{t-1}	20	83.3
32	CF/NCE	21	81.3
23	$\Delta(CF/TA_{t-1})$	22	56.4
31	$\Delta(CF/NTC_{t-1})$	23	55.7
25	$\Delta(CF/NW_{t-1})$	24	55.0
33	$\Delta(CF/NCE_{t-1})$	25	53.2
27	$\Delta(CF/TL_{t-1})$	26	50.8
29	$\Delta CF/CL_{t-1})$	27	48.8
68	$Dr./Cr._{t-1}$	28	30.2
47	QA/CL	29	24.4
3	$\Delta(FF/TA_{t-1})$	30	24.0
18	$\Delta(EBIT/NTC_{t-1})$	31	23.4
14	$\Delta(EBIT/NW_{t-1})$	32	21.5
8	$\Delta(FF/CL_{t-1})$	33	21.2
57	$\Delta(QA/NW)_{t-1}$	34	18.1
20	$\Delta(EBIT/NCE_{t-1})$	35	18.0
35	$\Delta(TL/NW)_{t-1}$	36	16.7
50	$\Delta(CA/CL)$	37	16.3
38	$\Delta(FA/NCE)$	38	16.2
40	$\Delta(TA/CA)$	39	15.7
45	TL/NCE	40	14.5
44	$\Delta(TL/TA)$	41	14.4
42	$\Delta(CL/TA)$	42	13.8
41	CL/TA	43	13.0
64	$\Delta(QA/NCE)$	44	12.9
6	$\Delta(FF/TL_{t-1})$	45	12.3
59	$\Delta(CA/NW)_{t-1}$	46	10.7
49	CA/CL	47	10.1
67	$\Delta(WC/NCE)$	48	9.4
77	S/av.inv.	49	9.1
37	FA/NCE	50	8.6

(continued overleaf)

Appendix 5.2 (concluded)

Appendix 4.8 Variable no	Variable Description	Ranking	F-value
60	WC/NW	51	8.4
65	CA/NCE	52	8.0
61	QA/TL	53	6.0
34	TL/NW	54	5.7
55	WC/TA	55	5.5
46	Debt/Equity	56	5.1
48	Δ(QA/CL)	57	4.4
66	WC/NCE)	58	3.9
72	S/WC_{t-1}	59	2.4
78	days debtors	60	2.0
43	TL/TA	61	1.8
58	CA/NW	62	1.7
52	Δ(QA/TA)	63	1.2
51	QA/TA	64	1.2
63	QA/NCE	65	1.0
71	S/CA_{t-1}	66	.7
54	$\Delta(CA/TA)_{t-1}$	67	.6
56	QA/NW	68	.6
70	S/QA_{t-1}	69	.5
36	FA/NW_{t-1}	70	.5
53	CA/TA	71	.3
62	CA/TL	72=	.2
39	TL/CA	72=	.2
74	S/TA_{t-1}	74	.2
76	S/NTC_{t-1}	75	.2
73	S/NW_{t-1}	76	.2
75	S/FA_{t-1}	77	.0
69	$\Delta(Dr./Cr.)_{t-1}$	78	.0

Note: All the first 57 ranked measures are statistically significant discriminators at $\alpha = 0.05$ ($F_{1,87} \simeq 3.96$ for $\alpha = 0.05$).

APPENDIX 5.1: The Statistical Classification Models Employed

5.1.1 - The Linear Discriminant Model

The best way of conceptualising the approach is to consider the case of two variables only, V_1 and V_2. If we plot the values of these for companies which have 'failed' and for those classified as 'good' we arrive at the diagram shown in figure A1 (V_1 and V_2 are slightly positively correlated) where the ellipses define the region within which say 95% of each set of observations lie.

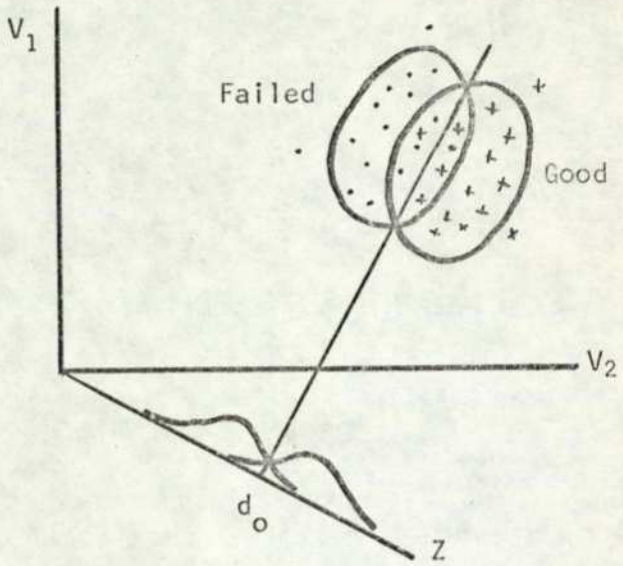


Fig. A1
The two variable, two group discriminant model
. denotes a 'failed' company
x denotes a 'good' company

Where the two ellipses intersect a straight line is drawn and a second line in the two-dimensional space is constructed perpendicular to this first line as shown and intersects Z at d_o. When the observations in the two groups are projected onto Z the overlap between the distributions of the groups will be smaller than for any other line drawn. A company with a score on Z to the left of d_o would indicate membership of the 'failed' group with high probability and a score to the right, a membership of the 'good' group with high probability.

In this way we have transformed two-dimensional data relating to a company into a single discriminant score and this approach can be generalised to any number of groups and any number of variables.

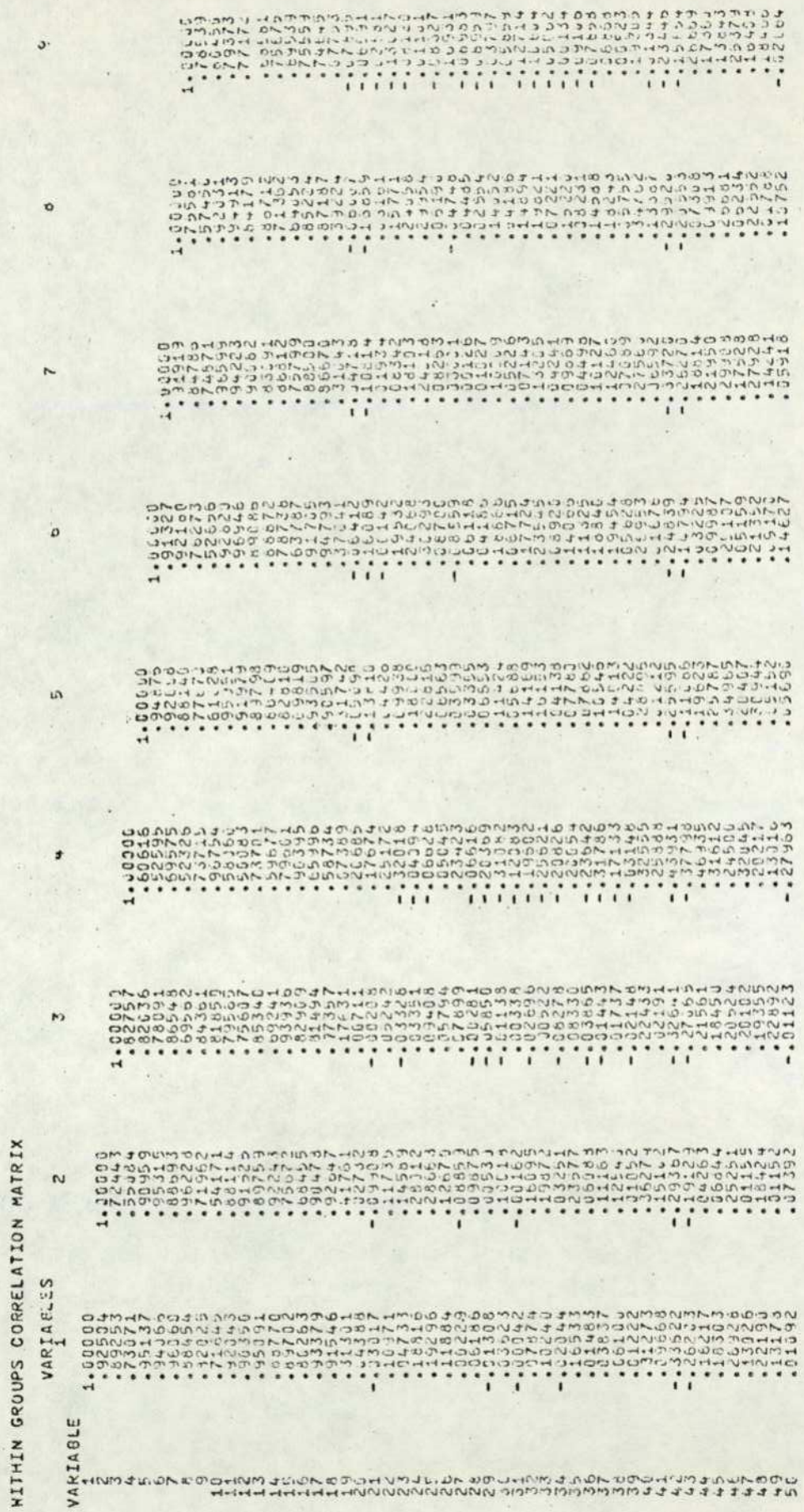
In general terms the transformation is effected by a discriminant function of the following form -

$$z = d_1 v_1 + d_2 v_2 + \text{-------} d_p v_p$$

where z is the discriminant score for a company and v_1, v_2 ---------v_p are the p variables selected for the analysis and d_1 -------d_p are the optimal coefficients. d_o is the cut-off criteria.

In Linear Discriminant Analysis the probability of an observation (in our case a company) being ciassified to the wrong group is minimised when the ratio λ where

$$\lambda = \frac{\text{between-group variation}}{\text{within-group variation}}$$ is maximised.



Appendix 5.3.2: Within Groups Correlation Matrix for the GOOD45 and FAILED23 Companies

(the 50 variables are those of appendix 4.9)

(continued overleaf)

Appendix 5.3.2 (continued)

VARIABLE	VARIABLES 10	11	12	13	14	15	16	17	18
10	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000	1.000000
11	.664117	.962570	.839659	.941540	.774683	.865400	.798654	.739566	.742442
12	.554980	.853080	.831460	.932710	.759220	.880894	.735566	.721051	.733552
13	.716600	.811370	.751120	.866320	.943660	.841132	.721051	.716526	.711074
14	.576510	.798140	.596460	.975220	.955400	.241191	.716526	.713545	.707615
15	.786480	.657520	.868030	.957440	.351890	.040358	.713545	.711390	.705615
16	.871720	.886090	.897610	.306910	.667590	-.064350	.711390	.709961	.704176
17	.643020	.862370	.351130	.066730	.064350	-.064350	.709961	.708976	.703176
18	.574560	.302970	-.131360	-.019220	-.064350	-.064350	.708976	.708276	.702476
19	.711260	-.117280	-.228160	.138860	.126220	-.064350	.708276	.707776	.701976
20	.115130	-.197890	-.061070	.000958	.063771	-.064350	.707776	.707376	.701576
21	.110860	-.031730	.119985	.206093	.229862	-.064350	.707376	.707076	.701276
22	.154990	.123850	.224950	.168336	.171133	-.064350	.707076	.706876	.701076
23	.270600	.182466	.323118	.120925	.092611	-.064350	.706876	.706676	.700876
24	.043447	.270223	.055292	.047455	.017557	-.064350	.706676	.706576	.700776
25	.020881	.045083	-.046007	.009515	-.027613	-.064350	.706576	.706476	.700676
26	.006823	.055935	-.061607	.017977	-.063726	-.064350	.706476	.706376	.700576
27	.098555	-.024953	-.227390	.017066	-.088465	-.064350	.706376	.706276	.700476
28	.169160	-.087453	-.211566	.022664	-.126015	-.064350	.706276	.706176	.700376
29	.250600	-.166779	-.166830	.061480	-.129465	-.064350	.706176	.706076	.700276
30	.086199	-.107554	-.247224	.052410	-.093381	-.064350	.706076	.706076	.700276
31	.193780	-.132810	-.146774	.055165	-.015588	-.064350	.706076	.705976	.700176
32	.232490	-.180063	-.066814	.198866	-.024755	-.064350	.705976	.705876	.700076
33	.165230	-.111114	-.227390	.000386	.014980	-.064350	.705876	.705876	.700076
34	.136770	-.011378	-.211566	.015402	.000463	-.064350	.705876	.705776	.699976
35	.191890	-.103880	-.125140	.021715	.062141	-.064350	.705776	.705776	.699976
36	.252660	-.152970	-.217990	.022255	.349248	-.064350	.705776	.705676	.699876
37	.202970	-.207554	-.251310	.030548	.160780	-.064350	.705676	.705676	.699876
38	.017610	-.088050	-.087532	.122944	.229762	-.064350	.705676	.705576	.699776
39	.301150	-.238838	-.234022	.305117	.149960	-.064350	.705576	.705576	.699776
40	.229955	-.096330	-.160513	.194230	.122414	-.064350	.705576	.705476	.699676
41	.427780	-.257411	-.245737	.176075	.146018	-.064350	.705476	.705476	.699676
42	.301240	-.125596	-.155287	.170869	.247356	-.064350	.705476	.705376	.699576
43	.490320	-.101271	-.055332	.241110	.064955	-.064350	.705376	.705376	.699576
44	.357980	-.255852	-.122683	.107990	.175312	-.064350	.705376	.705376	.699576
45	.576420	-.333330	-.263697	.194920	.218911	-.064350	.705376	.705276	.699476
46	.370110	-.208080	-.088337	.050530	.155443	-.064350	.705276	.705276	.699476
47	.267480	-.322650	-.241040	.032601	.020028	-.064350	.705276	.705176	.699376
48	.127460	-.085710	-.106210				.705176	.705176	.699376
49	.236320	-.164030	-.179100				.705176	.705176	.699376

(continued overleaf)

Appendix 5.3.2 (continued)

(continued overleaf)

VARIABLE	VARIABLES 28	29	30	31	32	33	34	35	36
28	1.00000								
29	-.09961	1.00000							
30	-.40222	.57040	1.00000						
31	-.88511	.32380	.71324	1.00000					
32	.01036	.79257	.58614	.23138	1.00000				
33	-.16224	.40202	.80247	.42314	.68049	1.00000			
34	-.72051	.39046	-.74961	-.85437	.45990	.70125	1.00000		
35	.40678	-.56263	-.38477	-.50306	-.21166	-.01950	-.32128	1.00000	
36	-.06145	.83412	.66148	.23961	.65110	.56795	.30670	-.39263	1.00000
37	-.11160	.57116	.93354	.42959	.60181	.83324	.54580	-.24415	.74702
38	-.73868	.43223	.84430	.91604	.41806	.58810	.86628	-.28802	.94225
39	.19420	-.37167	-.05929	-.21952	-.20770	.03487	.13625	.34933	.39394
40	.63743	-.13560	-.35879	-.65765	-.08537	.09950	.45706	-.44883	.03677
41	-.00848	-.09839	-.41967	-.61179	-.03415	-.18034	.31444	-.36374	.02121
42	-.25006	.58860	.31421	.35655	.44361	.11348	.06046	-.23883	.07679
43	-.19982	.22357	-.10919	.22555	.04260	-.17445	.23656	.10195	.04744
44	-.29352	.00142	-.28837	.06846	-.17445	-.09550	.22047	.33055	.02747
45	-.13416	.22486	-.05979	.04114	.09550	.37410	.22514		
46	-.03361	.26868	.16147	.03604	.37410	.07208	.22552		
47	-.26777	.17545	-.24457	.15120	.07208	.34995	.11688		
48	.01253	-.42870	.27321	.03753	.34995	.11449	.14124		
49	-.36657	-.00942	.27501	.60342	.11449	.49445			
50	-.09693	.91013	.89946	.77942	.49445	.03765			

VARIABLE	VARIABLES 37	38	39	40	41	42	43	44	45
37	1.00000								
38	.62039	1.00000							
39	.05095	-.15049	1.00000						
40	-.14450	-.50797	.29059	1.00000					
41	-.24700	-.49394	.06764	.80185	1.00000				
42	.21883	.31376	-.45321	-.53250	-.48773	1.00000			
43	.00692	.17892	-.22235	-.49727	.44563	.62332	1.00000		
44	-.38010	-.06619	.04948	.10559	.14182	-.24088	-.36254	1.00000	
45	-.07810	.00678	.15211	.12331	.12069	-.17637	.00037	.09722	1.00000
46	.20942	.11239	.18486	.30293	.23444	-.28037	-.12560	.65743	.81327
47	-.11583	.07729	.06693	.28085	.05520	-.14166	-.02394	.90402	.88997
48	.35404	.13286	.19370	.27445	.19004	-.19012	-.12360	.64934	.81948
49	.06184	.44883	-.32882	-.59283	-.55049	.26777	-.00497	-.09241	-.23179
50	.75840	.85767	-.22378	-.47059	-.48914	.36863	.10558	-.36027	-.24343

VARIABLE	VARIABLES 46	47	48	49	50
46	1.00000				
47	.64210	1.00000			
48	.88986	.76445	1.00000		
49	-.36688	-.06739	-.33505	1.00000	
50	-.09355	-.17264	.00478	.53223	1.00000

regression or comparison of the Mahalanobis D^2 distance between group centroids (see 5.1.4 §i above) based upon p variables (D^2_p) and that based upon (p + q) variables (D^2_{p+q}). However in the former case they point out that problems arise as the coeffecient estimates d depend on the value of c in the expression of footnote 1 of page 2 above. In the latter case the null hypothesis that the q extra variables do not significantly increase the discriminating power of the function can be tested using:

$$F_{q,n_1+n_2-p-q-1} = \frac{n_1 + n_2 - p - q - 1}{q} \cdot \frac{n_1 n_2 (D^2_{p+q} - D^2_p)}{(n_1+n_2)(n_1+n_2-2)+n_1 n_2 D^2_p}$$

The approach taken in the computer package BMD07M for examining separately the significance of each of the p included variables for $g > 2$ groups is described in Dixon (1973: 243) and the results provided by it are those given in the chapter.

5.1.5 - The Mahalanobis D^2 Multivariate Distance for Classification Purposes

The D^2 - multivariate distance of a case k in group1 from group m is given by

$$D^2_{mlk} = (x_{lk} - \bar{x}_m)' \; W^{-1} \; (x_{lk} - \bar{x}_m)$$

using the notation previously.

This is a χ^2 statistic with p degrees of freedom and can be used for classification purposes viz: assign the company to the group to which it is nearest. This approach is taken in the package BMD07M (Dixon, 1973: 244 and 250)[1].

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1. Also see Tatsuoka (1971: 218-225).

Appendix 5.2: Discrimatory Ability of the Financial Measures Used in the Initial Runs on a Univariate Basis: GOOD47 and FAILED42 firms

Appendix 4.8 Variable no	Variable Description	Ranking	F-value
12	$EBIT/TA_{t-1}$	1	138.3
2	FF/TA_{t-1}	2	134.4
28	CF/CL_{t-1}	3	132.3
9	FF/NTC_{t-1}	4	125.7
17	$EBIT/NTC_{t-1}$	5	125.7
16	$EBIT/CL_{t-1}$	6	123.6
13	$EBIT/NW_{t-1}$	7	121.9
5	FF/TL_{t-1}	8	121.6
7	FF/CL_{t-1}	9	120.5
22	CF/TA_{t-1}	10	117.5
21	CF/S	11	114.2
24	CF/NW	12	111.4
30	CF/NTC_{t-1}	13	108.3
15	$EBIT/TL_{t-1}$	14	107.9
11	EBIT/S	15	106.7
4	FF/NW	16	105.9
19	$EBIT/NCE_{t-1}$	17	98.8
1	FF/S	18	97.1
26	CF/TL	19	95.8
10	FF/NCE_{t-1}	20	83.3
32	CF/NCE_{t-1}	21	81.3
23	$\Delta(CF/TA_{t-1})$	22	56.4
31	$\Delta(CF/NTC_{t-1})$	23	55.7
25	$\Delta(CF/NW_{t-1})$	24	55.0
33	$\Delta(CF/NCE_{t-1})$	25	53.2
27	$\Delta(CF/TL_{t-1})$	26	50.8
29	$\Delta CF/CL_{t-1})$	27	48.8
68	Dr./Cr.	28	30.2
47	QA/CL	29	24.4
3	$\Delta(FF/TA_{t-1})$	30	24.0
18	$\Delta(EBIT/NTC_{t-1})$	31	23.4
14	$\Delta(EBIT/NW_{t-1})$	32	21.5
8	$\Delta(FF/CL_{t-1})$	33	21.2
57	$\Delta(QA/NW)_{t-1}$	34	18.1
20	$\Delta(EBIT/NCE_{t-1})$	35	18.0
35	$\Delta(TL/NW)$	36	16.7
50	$\Delta(CA/CL)$	37	16.3
38	$\Delta(FA/NCE)$	38	16.2
40	$\Delta(TA/CA)$	39	15.7
45	TL/NCE	40	14.5
44	$\Delta(TL/TA)$	41	14.4
42	$\Delta(CL/TA)$	42	13.8
41	CL/TA	43	13.0
64	$\Delta(QA/NCE)$	44	12.9
6	$\Delta(FF/TL_{t-1})$	45	12.3
59	$\Delta(CA/NW)_{t-1}$	46	10.7
49	CA/CL	47	10.1
67	$\Delta(WC/NCE)$	48	9.4
77	S/av.inv.	49	9.1
37	FA/NCE	50	8.6

(continued overleaf)

****

STEP NUMBER 6
VARIABLE ENTERED 41

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM 1 63

7	53.6451	25	59.8083	29	12.2944	41	5.1463

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM 1 62

1	3.9391	9	.0854	16	.6131	23	.9499	32	.6616	39	.0071	47	.1043
2	.8947	10	.0015	17	3.7658	24	.1600	33	1.5893	40	4.4295	48	.0756
3	.4903	11	.2315	18	2.8261	26	.0458	34	8.9662	42	1.5141	49	1.1253
4	.1478	12	.0115	19	.9217	27	.9910	35	.4320	43	.2789	50	1.1090
5	2.0681	13	4.1500	20	.6278	28	8.6643	36	1.2210	44	.4815		
6	2.0272	14	2.8443	21	4.6293	30	2.2784	37	.4557	45	.0139		
8	.0590	15	2.2826	22	.8921	31	6.6061	38	2.7542	46	.5336		

U-STATISTIC .18949 DEGREES OF FREEDOM 4 1 66
APPROXIMATE F 67.36913 DEGREES OF FREEDOM 4 63.00

F MATRIX - DEGREES OF FREEDOM 4 63

GROUP	GOOD
GROUP FAILED	67.36913

****

STEP NUMBER 7
VARIABLE ENTERED 34

VARIABLES INCLUDED AND F TO REMOVE - DEGREES OF FREEDOM 1 62

7	40.4881	25	68.1101	29	4.4455	34	8.9662	41	11.9023

VARIABLES NOT INCLUDED AND F TO ENTER - DEGREES OF FREEDOM 1 61

1	2.1414	9	.3765	16	.1450	23	.0289	32	1.5539	40	.7134	48	.1097
2	1.1023	10	.0258	17	2.6130	24	.0004	33	.7040	42	1.8279	49	.0181
3	.0000	11	.3912	18	2.6319	26	.2132	35	.1007	43	.2844	50	.4368
4	.3459	12	.3215	19	1.7076	27	.1642	36	.1653	44	.1102		
5	.9732	13	2.5088	20	.0872	28	.3836	37	.0090	45	.0061		
6	1.7654	14	2.6184	21	.0613	30	.0629	38	1.4031	46	.0061		
8	.0360	15	.7768	22	.0311	31	.0005	39	.0064	47	.0950		

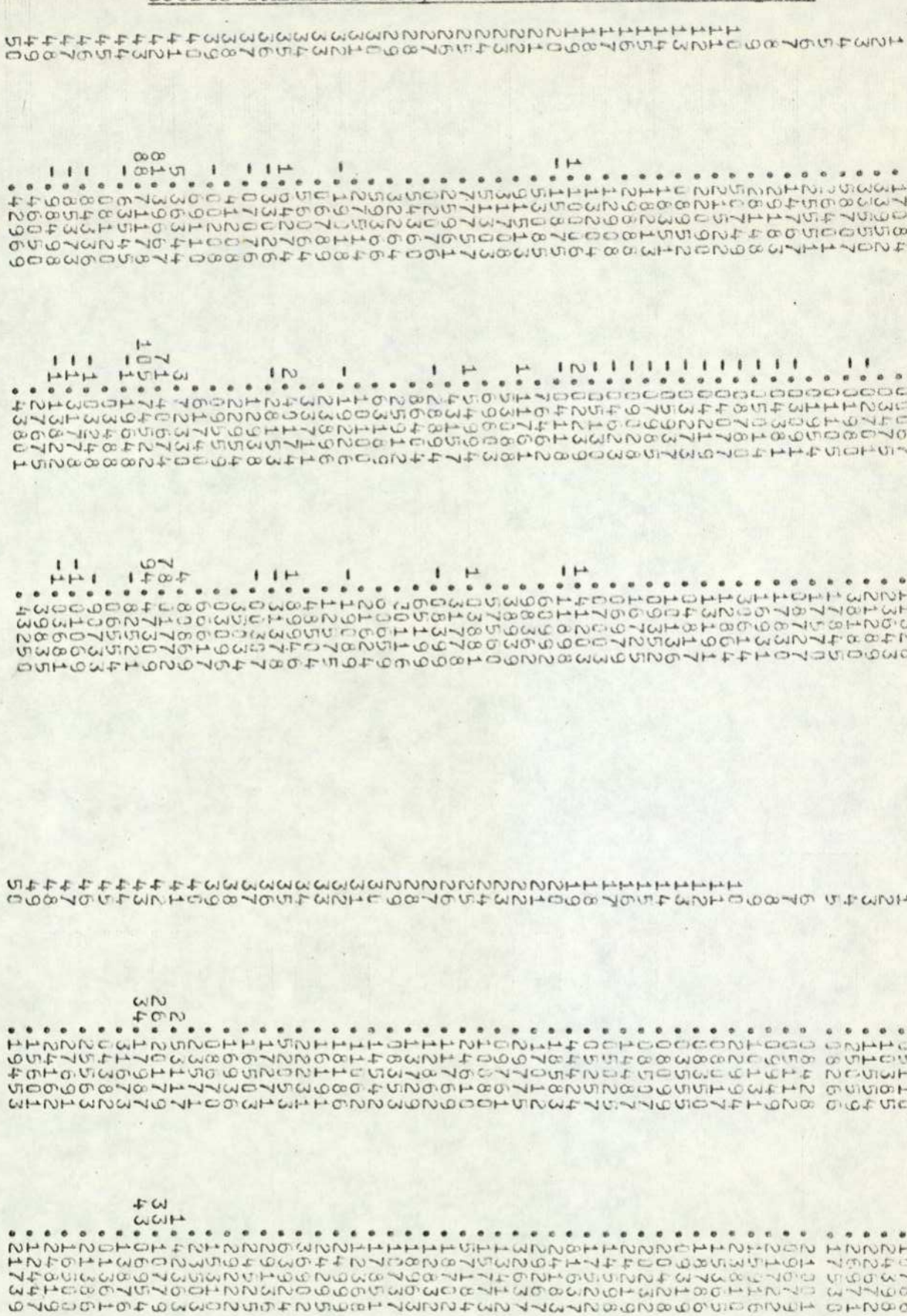
U-STATISTIC .16555 DEGREES OF FREEDOM 5 1 66
APPROXIMATE F 62.50345 DEGREES OF FREEDOM 5 62.00

F MATRIX - DEGREES OF FREEDOM 5 62

GROUP	GOOD
GROUP FAILED	62.50345

VARIABLE	FUNCTION GOOD	FAILED
7	27.60562	-24.06998
25	12.45968	8.79389
29	30.77029	17.47694
34	9.96246	1.89541
41	1.60877	.70703
CONSTANT	-14.60546	-12.07559

Appendix 5.3: The Computer Results of the GOOD45-FAILED23 Stepwise Discriminant Analysis



Appendix 5.3.1: The Means and Standard Deviations of the 50 Ratios of Appendix 4.9 for the GOOD45 and FAILED23 Groups.

Appendix 5.4: The Multivariate Normality of The Company Data

5.4.1 - The Algorithm of the 'Identification of Outliers' package BMD10M[1]

(i) For all cases k compute separately the Mahalanobis D^2 multivariate distance d_k from the centroid of all other cases where $d_k = (x_k - \bar{x})' W^{-1} (x_k - \bar{x})$ if $\bar{x}$ is the mean vector and W is the dispersion matrix of all cases except k.

(ii) If $d_1 = \max \{d_k\}$ then under the hypothesis that case 1 is from the same multivariate normal population as the remaining cases,

$$F = \frac{n - p - 1}{p} \quad \frac{d_1}{1 - 1/n - d_1}$$

has an F-distribution with p and n-p-1 degrees of freedom where n is the total number of cases including 1 and p is the number of variables.

(iii) The associated probability P of an F-value this large or larger is computed, if $P > P_c$ (0.05, 0.01 etc) the case is removed and the algorithm returns to (i) above and computations continue on the reduced matrix with case 1 removed.

(iv) The above sequence continues until no more cases have a probability of an F-value $> P_c$.

---

1. Taken from Dixon (1973: 278-281).

5.4.2 - Industrial Classification of Outlying Companies

Company code no:	Company	Industry*	Outside of 99% contour
42	J. B. Eastwood	General Food Manufacturing (49)	Yes
32	Rank Hovis McDougall	Milling and Flour Confectionary (50)	
19	Associated Biscuits	" "	
20	United Biscuits	" "	
25	Scotcros Ltd	General Food Manufacturing (49)	
28	Associated British Foods	Milling and Flour Confectionary (50)	
1	London Brick	Bricks and Roofing Tiles (12)	
2	Aberthaw & Bristol Cement	Cement and Concrete (15)	

GOOD45 Companies Outside 95%-Contour of the Remaining cases

*Note: Numbers in brackets refer to Stock Exchange sub-group code number.

The only FAILED23 company outside the 95% - contour was Hupfield Brothers which was classified to industry 22-Industrial Plant, Engines and Compressors and would appear to be of outlier status by virtue of its WC/NW ratio being 2.2.σ from the mean.

Appendix 5.4.3: The BMDIOM Program Run to test for the Multivariate Normality of the GOOD45 Companies - 95% Probability Contour.

VARIABLE	MEAN	STANDARD DEVIATION
1	.14767	.05112
2	.77757	.24610
3	.32264	.08353
4	.55064	.22231
5	5.36344	2.53117

CASE NUMBER	F STATISTIC	PROBABILITY	INPUT DATA EBIT/TA$_{t-1}$	TL/NCE	QA/TA	WC/NW	S/av. inv.
42	3.801	.0067	.2434	1.2420	.2381	.4744	7.8960
32	2.674	.0363	.1170	.7082	.3160	.5511	10.7200
19	3.649	.0088	.1689	.7103	.3101	.5233	11.2600
20	2.781	.0313	.1435	.7467	.2346	.1942	11.3400
25	3.252	.0163	.0805	1.3030	.3307	.6105	9.6750
28	4.129	.0049	.1685	.9610	.1887	.2571	10.4600
1	2.697	.0377	.2006	.4076	.3400	.2040	5.2280
2	2.533	.0486	.2272	.6908	.1578	.1015	7.6290

THE REST OF THE CASES PASS

VARIABLE	MEAN	STANDARD DEVIATION
1	.14312	.04988
2	.76274	.23432
3	.33521	.08175
4	.60278	.20677
5	4.51749	1.66750

(CASES DELETED)

Appendix 5.5. The Bartlett-Box Test Criterion for Equality of Dispersion Matrices[1]

5.5.1 - The Theory

The Box-Bartlett test criterion M is given by

$$M = (n - g) \log_e |W| - \sum_{i=1}^{g} (n_i - 1) \log_e |W_i|$$

where n_i is the number of observations in group i and there are g groups, W is the variance-covariance matrix pooled over all the groups and W_i the variance-covariance matrix for group i. Where p is the number of variables,

$$A_1 = \left(\sum_{i=1}^{g} \frac{1}{n_i - 1} - \frac{1}{n-g} \right) \frac{2p^2 + 3p - 1}{6(g - 1)(p + 1)}$$

$$A_2 = \left(\sum_{i=1}^{g} \frac{1}{(n_i-1)^2} - \frac{1}{(n-g)^2} \right) \frac{(p - 1)(p + 2)}{6(g - 1)}$$

The degrees of freedom of the appropriate F-test for a null hypothesis are given by:

$$n_1' = \frac{(g-1)\, p(p+1)}{2} \quad \text{and} \quad n_2' = \frac{n_1 + 2}{\left| A_2 - A_1^2 \right|}$$

Then if $A_2 - A_1^2 > 0$

$$F_{n_1', n_2'} = \frac{M(1 - A_1 - n_1/n_2)}{b}$$

and if $A_2 - A_1^2 < 0$

$$F_{n_1', n_2'} = \frac{n_2 M}{n_1 \left(\frac{n_2}{1 - A_1 + \frac{2}{n_2}} \right) - M}$$

---

1. Reference: Cooley and Lohnes (1971:229).

5.5.2 - The Results of the Test for the FAILED23 and GOOD45 Firms

In this study the dispersion matrices for the FAILED23 group W_1, GOOD45 group W_2 and the pooled dispersion matrix W are given by

$$W_1 = \begin{bmatrix} .0094 & .0232 & .00083 & .0057 & -.0138 \\ .0232 & .3270 & .0184 & .0591 & .0651 \\ .00083 & .0184 & .0115 & .0067 & .0199 \\ .0057 & .0591 & .0067 & .1362 & -.2626 \\ -.0138 & .0651 & .0199 & -.2626 & 2.0266 \end{bmatrix}$$

$$W_2 = \begin{bmatrix} .0026 & -.002 & .0003 & -.0017 & .022 \\ -.0020 & .0606 & .0094 & .0126 & .1869 \\ .0003 & .0094 & .007 & .0117 & -.0402 \\ -.0017 & .0126 & .0117 & .0494 & -.2926 \\ .022 & .1869 & -.0402 & -.2926 & 6.407 \end{bmatrix}$$

$$W_3 = \begin{bmatrix} .0049 & .0065 & 0.00007 & 0.00083 & .0102 \\ .0065 & .1494 & .0124 & .028 & .144 \\ 0.00007 & .0124 & .0085 & .0101 & -.0202 \\ 0.00083 & .028 & .0101 & .0783 & -.2849 \\ .0102 & .144 & -.0202 & -.2849 & 4.9468 \end{bmatrix}$$

and $|W_1| = 4.3756 \times 10^{-6}$, $|W_2| = 8.1761 \times 10^{-8}$ and $|W| = 1.1462 \times 10^{-6}$

$\therefore$ $M = 86.69$, $A_1 = .09428$, $A_2 = .01098$

Thus $n_1' = 15$, $n_2' = 8134$

and since $A_2 - A_1^2 > 0$

$$F_{calc.} = 5.22$$

But $F_{15,8134}$ $(\alpha = 0.001) \simeq 2.70$, hence the null hypothesis of no significant differences in dispersion matrices must be strongly rejected if the underlying assumptions of multivariate normality of the dispersion matrices hold.

Appendix 6.1: Principal Component Analysis

6.1.1 : The Theory

Principal component analysis is a method for dealing with intercorrelated data by constructing uncorelated vector variables by appropriate transformation of the data.

Consider an nxp observation matrix X and associated pxp correlation matrix R.

For the first principal component i.e. the dimension in the observation space along which the variance of the observations is maximized, the first column v_1 of the pxp matrix V that carries the observation matrix X into the new reference axes is given by

$$(R - \lambda_1 I)\, v_1 = 0$$ where λ_i $(i = 1,2...p)$ are the p eigenvalues of R in descending magnitude.

The second principal component is that dimension in the observation space orthogonal to the first which accounts for the next largest amount of variance and v_2 is given by

$$(R - \lambda_2 I)\, v_2 = 0$$ and so on with

$$\sum_{i=1}^{p} \lambda_i = p .$$

The original observation matrix X can be transformed into the new set of variables by

$$C = ZVE^{-\frac{1}{2}}$$

where Z is X in standardized form and $E^{\frac{1}{2}}$ is the diagonal matrix whose diagonal elements are the square roots of the latent roots (eigenvalues) of R. The nxp matrix C termed the component scores matrix contains the co-ordinates of the original observations in the new variable space.

The p x p component loadings matrix L is given by

$$L = E^{\frac{1}{2}} V$$

with element l_{ij} denoting the correlation between variable i in X with component j. The columns of L are the new reference axes othogonal to each other, note

$$\lambda_j = \sum_{i=1}^{p} l_{ij}^2 .$$

If a good description of the data is obtained by ignoring the components explaining little variance then the data can be projected from p-space into m-space defined by the first m axes (m<p) and only these need be considered i.e. the information contained in the originai n x p observation matrix is summarized into an n x m matrix.

Different approaches for the number of components to retain are provided in the literature (see Tatsuoka, 1971: 146-8). Two such were considered here. Bartlett's sphericity test (Cooley and Lohnes, 1971: 103-5) seeks to test the null hypothesis that the determinant of the population residual matrix after extraction of m components is zero, indicating that factoring should stop by

$$\chi^2_{.5(p-m)(p-m-1)} = -\{(n-1)-\tfrac{1}{6}(2p+5)-\tfrac{2}{3}n\} \log_e \tilde{R}$$

$$\text{where } \tilde{R} = \frac{|R|}{\prod_{j=1}^{m} \lambda_j \{(p - \sum_{i=1}^{j} \lambda_i)/(p-m)\}^{p-m}}$$

however it is only applicable for small samples and when applied to the data here produced meaningless results because of the minute size of the majority of the λ_i's making computation of $\tilde{R}$ impossible.

The rule of thumb of Kaiser was consequently adopted viz: select the number of components with eigenvalues $\lambda_i > 1$. However for certain of the analyses including the varimax rotations (see below) an additional component was also included on the basis of considerations of the additional variance explained by it and the size of n - see Cooley and Lohnes p104.

6.1.2: Varimax rotation

To improve the principal component transformations to aid interpretation, varimax rotation of the component loadings was undertaken which tends to result in high loadings for a few variables on each factor and near zero loadings for the others.

The varimax criterion is construct L′ such that U is maximized where

$$U = \sum_{i=1}^{m} U_i = \sum_{i=1}^{m} \left\{ \frac{p \sum_{j=1}^{p} (l_{ji}^2)^2 - (\sum_{j=1}^{p} l_{ji}^2)^2}{p^2} \right\}$$

and l_{ji} is the new factor loading for variable j on component i.

U is maximized by iterative application of orthogonal rotation matrices M. The final mxm rotation matrix M′ which maximizes U produces L′ thus -

$$L' = LM'.$$

The new loadings l'_{ij} can be interpreted as the simple correlations between variable j and new component i.

The approach is discussed in detail in Lawley and Maxwell (1971: 72-76) ; see also Cooley and Lohnes (1971: 144-149) and the write-up of the computer package employed - Taylor and Peksa (1971).

Appendix 6.2: Varimax Rotated Principal Component Analysis of the 50 Variable Data of Appendix 4.9 - 8 Factor Loadings Matrices for:

appendix 6.2.1 : The 68 GOOD45 + FAILED23 Companies

6.2.2 : The 45 GOOD45 Companies

6.2.3 : The 23 FAILED23 Companies

Note: The Constituent ratios of the final z-model are ringed.

Ratio	Component							
	1	2	3	4	5	6	7	8
1	-.96	-.08	.14	.13	-.03	-.02	-.09	-.04
2	-.96	-.10	.03	.05	-.04	-.02	-.06	.14
3	-.90	-.07	.22	.15	-.02	.00	-.12	-.21
4	-.80	.02	.36	.25	.03	-.15	-.23	-.20
5	-.95	-.11	.11	.18	-.04	.03	.02	.04
6	-.97	-.14	-.00	.06	-.02	.07	.00	.03
(7)	-.94	-.14	.18	.17	-.02	.00	-.10	-.03
8	-.94	-.16	.12	.10	-.04	.00	-.09	.15
9	-.87	-.12	.34	.15	-.01	.01	-.05	-.07
10	-.80	-.02	.37	.28	.02	-.10	-.22	-.18
11	-.93	-.17	.14	.20	-.04	.04	-.01	.04
12	-.95	-.20	.07	.11	-.03	.06	-.02	.08
13	-.97	-.03	.12	.11	-.04	-.04	-.05	-.03
14	-.95	-.05	.08	.08	-.04	-.05	-.02	.12
15	-.92	-.04	.14	.16	-.01	-.02	-.08	-.20
16	-.87	.04	.24	.17	-.02	-.12	-.20	-.15
17	-.97	-.05	.10	.12	-.04	-.04	.04	.02
18	-.97	-.08	.04	.05	-.00	-.01	.05	.07
19	.12	.15	-.91	-.03	.08	-.13	-.02	.06
20	.09	.73	-.17	-.07	.30	-.50	-.01	.07
21	.28	.90	-.10	-.11	.15	.02	-.07	-.09
22	.05	.77	-.29	-.08	.13	-.48	-.06	.10
23	.35	.02	-.80	-.12	-.19	.41	-.04	.05
24	.17	.21	-.88	-.02	-.01	-.20	.03	.04
(25)	.27	.10	-.89	-.01	-.06	.15	.00	-.04
26	.18	.24	-.74	-.09	-.02	-.50	.04	-.15
27	-.41	-.26	.62	.38	-.35	-.22	.05	-.10
28	.34	.70	-.50	-.21	-.01	.25	-.03	.08
(29)	-.15	-.34	-.04	.28	-.84	.09	.05	.01
30	.06	-.77	-.48	.00	-.26	.30	.02	-.02
31	-.31	-.86	.31	.13	-.09	-.11	.07	-.06
32	-.06	-.28	-.48	.14	-.72	-.08	-.06	.21
33	.15	-.44	-.84	-.01	-.11	-.04	.00	.09
(34)	-.18	-.88	-.10	.17	-.10	-.29	.12	.04
35	.15	.45	-.52	-.31	.42	-.17	-.15	.04
36	.06	-.24	-.41	.11	-.78	.33	-.04	.04
37	.24	-.42	-.72	-.04	-.24	.39	-.03	-.02
38	-.24	-.94	.03	.08	-.15	.02	.05	.07
39	.22	.15	-.33	.14	.58	.39	-.04	.28
40	-.34	.55	-.11	.16	-.04	.07	-.53	.43
(41)	-.27	.44	.12	.20	-.15	-.20	-.60	.38
42	.13	-.30	.24	-.16	-.67	-.07	.49	-.03
43	.25	-.06	.01	-.05	-.16	-.05	.88	.11
44	-.44	-.06	.52	.70	.02	-.15	-.06	-.04
45	-.34	-.03	.26	.87	-.05	-.02	.02	-.01
46	-.34	-.08	-.20	.88	-.05	-.13	-.09	.12
47	-.39	-.14	.52	.72	-.06	.10	-.06	-.02
48	-.26	-.07	-.14	.89	-.18	.23	-.12	.03
49	-.35	-.56	.40	-.20	.01	-.12	-.07	-.48
50	.01	-.84	-.28	-.22	-.28	.17	-.02	-.11

Appendix 6.2.1: Varimax Rotated Loadings Matrix:

GOOD45 + FAILED23 Companies

Ratio	Component 1	2	3	4	5	6	7	8
1	-.94	.05	.15	.11	.04	.06	.20	.02
2	-.87	.17	-.15	-.07	-.23	.09	.11	-.02
3	-.62	.02	.40	.15	.48	-.11	.30	.09
4	-.35	.24	.67	.29	.11	-.22	.38	-.11
5	-.91	-.02	-.01	.23	.09	.12	-.10	.06
6	-.93	-.02	-.23	-.04	.08	.11	.09	.11
(7)	-.95	.01	.17	.13	.07	-.02	.09	.11
8	-.92	.14	-.08	-.05	-.17	.01	.02	.08
9	-.67	-.04	.39	.10	.35	-.20	.23	.15
10	-.41	.21	.65	.31	.14	-.27	.30	-.04
11	-.93	-.02	.01	.18	.10	.02	-.11	.14
12	-.94	-.04	-.17	-.02	.11	.01	.01	.19
13	-.84	.14	.20	.13	.00	-.01	.18	-.41
14	-.82	.18	-.04	.07	-.33	.08	.13	-.34
15	-.66	.05	.40	.21	.36	-.08	.18	-.30
16	-.41	.28	.56	.19	-.02	-.15	.34	-.39
17	-.89	.11	.06	.18	.03	.03	.02	-.38
18	-.91	.08	-.10	.02	.03	.05	.13	-.32
19	.01	.29	-.60	.00	-.72	.01	.05	-.00
20	.00	.81	.20	.01	-.46	-.00	.12	.03
21	-.08	.89	.25	-.06	-.05	.11	.16	.08
22	.01	.85	.12	-.02	-.46	.01	.01	-.12
23	-.11	-.02	-.93	-.26	-.02	.14	-.02	.08
24	.03	.28	-.61	-.03	-.71	.01	.05	-.08
(25)	-.02	.19	-.85	-.12	-.44	.06	.07	.01
26	.09	.29	-.25	-.02	-.85	-.11	.09	.04
27	.09	-.32	.22	.61	.17	-.57	-.11	-.17
28	-.16	.77	-.46	-.27	-.05	.22	-.05	.05
(29)	-.03	-.35	-.71	.34	.01	-.34	-.17	-.11
30	-.03	-.77	-.62	-.07	.04	.02	-.01	.03
31	.05	-.97	-.00	.12	.04	-.09	-.01	-.05
32	-.03	-.12	-.85	.22	-.31	-.28	-.13	-.08
33	-.02	-.41	-.79	-.06	-.43	-.00	-.00	.02
(34)	.08	-.83	-.31	.16	-.35	-.14	-.03	-.05
35	.04	.55	.26	-.36	-.54	.36	.20	.03
36	-.07	-.28	-.90	.15	.06	-.23	-.13	-.04
37	-.06	-.56	-.80	-.15	.00	.06	.01	.07
38	.03	-.92	-.33	.03	.08	-.06	-.02	-.03
39	-.36	.36	.13	.13	.13	.74	-.05	-.06
40	-.32	.78	-.13	.11	-.14	.06	.30	-.08
(41)	-.18	.76	-.11	.11	-.17	-.09	.39	-.24
42	.33	-.44	-.35	-.10	.08	-.34	-.60	.05
43	.38	-.14	-.22	.07	.12	.04	-.82	.01
44	-.07	.03	.42	.89	.04	-.08	.06	-.04
45	-.15	.04	.09	.95	.04	.04	-.07	-.03
46	-.14	.11	-.19	.93	-.25	.02	.03	-.01
47	-.16	-.10	.24	.90	.27	-.01	.03	.03
48	-.20	.01	-.22	.94	.01	.03	.05	.00
49	-.05	-.73	.37	-.23	.13	-.04	.24	.25
50	.05	-.85	-.41	-.26	.02	-.02	.06	.01

Appendix 6.2.2: Varimax Rotated Loadings Matrix: GOOD45 Companies

Ratio	Component							
	1	2	3	4	5	6	7	8
1	-.99	-.01	-.12	-.01	-.04	-.02	-.06	-.01
2	-.98	-.11	.02	.09	-.01	.03	-.03	.01
3	-.93	.03	-.26	-.08	-.10	.00	-.13	-.07
4	-.94	.08	-.17	-.07	-.09	-.06	-.12	-.12
5	-.97	-.06	-.10	.10	-.03	-.01	-.05	.04
6	-.97	-.10	-.05	.08	-.03	.08	-.01	.07
(7)	-.96	-.10	-.13	.07	-.11	.05	-.04	-.03
8	-.93	-.19	.06	.17	-.06	.06	-.05	-.00
9	-.92	-.01	-.03	.09	.01	-.06	.07	.13
10	-.93	.01	-.15	.03	-.18	.02	-.06	-.14
11	-.94	-.17	-.11	.18	-.08	.02	-.01	.01
12	-.94	-.20	-.06	.14	-.06	.09	-.00	.05
13	-.99	.02	-.05	-.03	-.02	.00	.02	-.01
14	-.97	-.04	.15	.03	.03	.01	.04	.02
15	-.93	.04	-.24	-.09	-.10	.05	-.06	-.08
16	-.94	.11	-.10	-.05	-.13	-.02	-.05	-.13
17	-.98	-.03	-.06	.05	.03	-.04	.06	.03
18	-.97	-.07	.00	.03	.06	.06	.07	.07
19	-.46	-.09	-.59	.01	-.20	.32	-.30	.19
20	.02	.49	-.43	-.26	.64	.08	-.07	.16
21	.16	.95	-.10	-.09	.20	.05	.03	-.01
22	-.12	.56	-.59	-.22	.41	-.07	-.10	-.12
23	-.06	-.00	-.20	.19	-.88	.29	-.13	.00
24	-.32	.07	-.78	.08	-.19	.20	.07	.13
(25)	-.25	-.07	-.55	.35	-.62	.23	.15	-.09
26	-.17	.03	-.84	-.37	-.06	.03	.12	-.13
27	-.07	-.14	.13	.16	.11	-.89	.13	-.05
28	-.02	.94	-.07	.08	-.11	.15	-.12	-.09
(29)	-.02	-.10	.06	.00	-.72	-.64	.01	-.08
30	-.10	-.68	-.10	.11	-.68	.12	-.06	.02
31	-.08	-.98	.08	-.05	-.03	-.14	.06	.03
32	-.16	-.28	-.11	-.25	-.68	-.33	-.34	.07
33	-.17	-.57	-.50	-.03	-.43	.27	-.25	.13
(34)	-.03	-.92	-.25	-.04	-.12	-.00	.13	.09
35	-.29	.26	-.23	-.28	.07	.61	-.10	-.16
36	-.04	-.04	.07	-.07	-.92	-.32	-.07	.01
37	-.07	-.37	-.18	.14	-.84	.22	-.09	.06
38	-.16	-.95	.09	.09	-.21	-.06	-.04	-.00
39	.19	-.05	.02	.08	-.14	.73	-.05	.54
40	-.30	.53	.19	.17	-.25	.23	-.58	-.04
(41)	.14	.45	.13	.31	-.17	.00	-.34	-.67
42	.19	-.08	.20	-.40	-.21	-.72	.95	.15
43	.01	-.17	.01	-.07	.21	-.36	.77	.09
44	-.20	.03	.16	.84	.31	-.21	.08	-.01
45	-.22	-.03	-.06	.90	-.32	.04	-.07	-.07
46	-.32	-.23	-.47	.55	-.31	.26	-.32	.10
47	.01	.01	.49	.80	-.20	-.11	-.02	-.09
48	-.17	.02	-.11	.64	-.70	.17	-.09	.02
49	-.20	-.50	-.01	-.58	.12	-.20	.20	-.49
50	-.15	-.75	.04	-.14	-.56	-.02	-.00	-.22

Appendix 6.2.3: Varimax Rotated Loadings Matrix:

FAILED23 Companies

Table 2: Ratios and Factor Loadings Defining Seven Classifications of Financial Ratios (1969)

Number	Variable	Factor Loading 1	2	3	4	5	6	7	
2	Total income/Sales	.71							
27	Cash flow/Total assets	.85							
28	Cash flow/Net worth	.91							
30	Total income/Total assets	.89							
31	Net income/Total assets	.89							
32	Net income/Net worth	.96							
38	Earnings before interest and taxes/Total assets	.91							Return on investment
39	Earnings before interest and taxes/Sales	.77							
43	Cash flow/Total capital	.88							
44	Total income/Total capital	.97							
1	Cash flow/Sales		-.78						
14	Current assets/Total assets		.81						
18	Quick assets/Total assets		.77						
34	Net worth/Sales		-.88						Capital turnover
36	Sales/Total assets		.89						
42	Sales/Net plant		.95						
45	Sales/Total capital		.85						
22	Current assets/Sales			.73					
23	Inventory/Sales			.97					Inventory turnover
35	Sales/Working capital			-.77					
37	Cost of goods sold/Inventory			-.97					
6	Debt/Net plant				.73				
7	Debt/Total capital				.99				
8	Total liabilities/Net worth				.76				Financial leverage
10	Total assets/Net worth				.76				
47	Debt/Total assets				.97				
48	Total liabilities/Total assets				.76				
11	Receivables/Inventory					-.99			
16	Inventory/Current assets					.76			Receivable
20	Receivables/Sales					-.82			turnover
24	Quick assets/Sales					-.73			
5	Current liabilities/Net worth						-.71		
15	Current assets/Current liabilities						.91		Short-term
17	Inventory/Working capital						-.76		liquidity
19	Quick assets/Current liabilities						.81		
46	Current liabilities/Total assets						-.78		
12	Cash/Total assets							.91	
13	Cash/Current liabilities							.83	Cash
21	Cash/Sales							.90	position
26	Cash/Fund expenditures							.91	

Appendix 6.3: The Dimensionality of US Financial Ratio Data: Oblique Factor Analysis Loadings

Source: Pinches et al (1974)

(Note: this working paper has recently been published in the Journal of Business Research vol 3 no 4, October 1975 from which this table (p299) was reproduced.)

5.5.2 - The Results of the Test for the FAILED23 and GOOD45 Firms

In this study the dispersion matrices for the FAILED23 group W_1, GOOD45 group W_2 and the pooled dispersion matrix W are given by

$$W_1 = \begin{bmatrix} .0094 & .0232 & .00083 & .0057 & -.0138 \\ .0232 & .3270 & .0184 & .0591 & .0651 \\ .00083 & .0184 & .0115 & .0067 & .0199 \\ .0057 & .0591 & .0067 & .1362 & -.2626 \\ -.0138 & .0651 & .0199 & -.2626 & 2.0266 \end{bmatrix}$$

$$W_2 = \begin{bmatrix} .0026 & -.002 & .0003 & -.0017 & .022 \\ -.0020 & .0606 & .0094 & .0126 & .1869 \\ .0003 & .0094 & .007 & .0117 & -.0402 \\ -.0017 & .0126 & .0117 & .0494 & -.2926 \\ .022 & .1869 & -.0402 & -.2926 & 6.407 \end{bmatrix}$$

$$W_3 = \begin{bmatrix} .0049 & .0065 & 0.00007 & 0.00083 & .0102 \\ .0065 & .1494 & .0124 & .028 & .144 \\ 0.00007 & .0124 & .0085 & .0101 & -.0202 \\ 0.00083 & .028 & .0101 & .0783 & -.2849 \\ .0102 & .144 & -.0202 & -.2849 & 4.9468 \end{bmatrix}$$

and $|W_1| = 4.3756 \times 10^{-6}$, $|W_2| = 8.1761 \times 10^{-8}$ and $|W| = 1.1462 \times 10^{-6}$

$\therefore$ $M = 86.69$, $A_1 = .09428$, $A_2 = .01098$

Thus $n_1' = 15$, $n_2' = 8134$

and since $A_2 - A_1^2 > 0$

$F_{calc.} = 5.22$

But $F_{15,8134}$ $(\alpha = 0.001) \simeq 2.70$, hence the null hypothesis of no significant differences in dispersion matrices must be strongly rejected if the underlying assumptions of multivariate normality of the dispersion matrices hold.

Appendix 6.1: Principal Component Analysis

6.1.1 : The Theory

Principal component analysis is a method for dealing with intercorrelated data by constructing uncorelated vector variables by appropriate transformation of the data.

Consider an nxp observation matrix X and associated pxp correlation matrix R.

For the first principal component i.e. the dimension in the observation space along which the variance of the observations is maximized, the first column v_1 of the pxp matrix V that carries the observation matrix X into the new reference axes is given by

$$(R - \lambda_1 I)\, v_1 = 0$$

where λ_i $(i = 1,2 \ldots p)$ are the p eigenvalues of R in descending magnitude.

The second principal component is that dimension in the observation space orthogonal to the first which accounts for the next largest amount of variance and v_2 is given by

$$(R - \lambda_2 I)\, v_2 = 0 \quad \text{and so on with}$$

$$\sum_{i=1}^{p} \lambda_i = p \, .$$

The original observation matrix X can be transformed into the new set of variables by

$$C = ZVE^{-\frac{1}{2}}$$

where Z is X in standardized form and $E^{\frac{1}{2}}$ is the diagonal matrix whose diagonal elements are the square roots of the latent roots (eigenvalues) of R. The nxp matrix C termed the component scores matrix contains the co-ordinates of the original observations in the new variable space.

The p x p component loadings matrix L is given by

$$L = E^{\frac{1}{2}} V$$

with element l_{ij} denoting the correlation between variable i in X with component j. The columns of L are the new reference axes othogonal to each other, note

$$\lambda_j = \sum_{i=1}^{p} l_{ij}^2 .$$

If a good description of the data is obtained by ignoring the components explaining little variance then the data can be projected from p-space into m-space defined by the first m axes (m<p) and only these need be considered i.e. the information contained in the original n x p observation matrix is summarized into an n x m matrix.

Appendix 6.5:Classification Models

6.5.1: Probability of Group Membership

Let us assume the GOOD45 and FAILED23 sets of companies, from which the final discriminant function was derived, are separately distributed multivariate normal over the p(p = 5) ratios included in the final model, and that they have identical variance - covariance (dispersion) matrices W[1](estimated by pooling over the two samples - see appendix 5.1.2) which is the sample based estimate of the true common dispersion matrix.

Also let the mean column vectors $\bar{x}_1$ and $\bar{x}_2$ respectively represent the underlying population parameters.

The following Ladd (1966:875) the probability density functions for the "well-solvent" and "insolvent" populations are given by[2]

$$f_1(x) = (2\pi)^{-5/2}|W|^{-\frac{1}{2}} e^{-\frac{1}{2}(x-\bar{x}_1)'W^{-1}(x-\bar{x}_1)} \quad ---(6.1)$$

$$f_2(x) = (2\pi)^{5/2}|W|^{-\frac{1}{2}} e^{-\frac{1}{2}(x-\bar{x}_2)'W^{-1}(x-\bar{x}_2)} \quad ---(6.2)$$

where x is the p element vector of ratio values for the firm.

Thus by expansion and rearrangement of terms:

$$\frac{f_1(x)}{f_2(x)} = e^{x' W^{-1}(\bar{x}_1-\bar{x}_2) - \frac{1}{2}.(\bar{x}_1+\bar{x}_2)' W^{-1}(\bar{x}_1-\bar{x}_2)} \quad ---(6.4)$$

---

1. It was pointed out in chapter V §6.1 that the GOOD45 set of companies was probably not multivariate normally distributed and that the hypothesis of no significant differences in the dispersion matrices may not have been tenable. This will be discussed in more detail in § 6.4.3 here

2. These are equivalent to

$$f_1(x) = ke^{-\frac{1}{2}\chi_1^2} \text{ and } f_2(x) = ke^{-\frac{1}{2}\chi_2^2} \quad ---(6.3)$$

where $k = (2\pi)^{-5/2}|W|^{-\frac{1}{2}}$

and χ_i, $i = 1,2$ is a measure of the multivariate distance from the individual firm to the centroid of group i (see appendix 5.1.5).

Appendix 6.2: Varimax Rotated Principal Component Analysis of the 50 Variable Data of Appendix 4.9 - 8 Factor Loadings Matrices for:

appendix 6.2.1 : The 68 GOOD45 + FAILED23 Companies

6.2.2 : The 45 GOOD45 Companies

6.2.3 : The 23 FAILED23 Companies

Note: The Constituent ratios of the final z-model are ringed.

However taking into account the differential costs of misclassification let us rewrite $\frac{p_2}{p_1}$ as

$$\ell = \frac{p_2}{p_1} \times \frac{c_{12}}{c_{21}} \qquad \text{---(6.7)}$$

where ℓ is the a priori likelihood ratio taking into account misclassification costs.

Thus the posterior 'probability' estimators used to classify a firm to the "good" or "failed" groups taking into account differential misclassification costs can be written as

$$P(H_1/x)^* = \frac{e^z}{e^z + \ell} \qquad \text{---(6.8a)}$$

and by $P(H_2/x)^* = 1 - P(H_1/x)$,

$$P(H_2/x)^* = \frac{e^z}{e^{-z} + \frac{1}{\ell}} \qquad \text{---(6.8b)}$$

Thus for a given value of ℓ computation of a firm's z-score allows the 'probabilities' of the firm belonging to each of the two groups, taking into account the differential misclassification costs, to be calculated. The decision rule is then to assign the firm to the population for which its posterior 'probability' is greater.

Note: This approach can be readily generalized to handle the classification problem with more than two groups.

6.5.2: The χ^2 Classification Rule

Taksuoka (1971: 218) states the generalized classification scheme - "the chi-square rule"- which has the property of minimizing the probability of misclassification when the k populations have multivariate normal distributions with equal dispersion matrices thus: "Compute the χ^2 value of the unclassified individual with respect to each of the k groups, and assign him to that group for which his χ^2 value is the smallest".

This, however, is exactly equivalent in our case to the decision rule of assigning a firm to a particular group on the basis of the distance of its computed z-score to the group mean z-score since, as we have seen from expressions (6.1)-(6.5) above and using the same notation, $z = \chi_1^2 - \chi_2^2$ hence the decision rule assign a firm with computed z-score >0 to group 1 and to group 2 otherwise, is strictly equivalent to the "chi-square rule" above.

Note: The "chi-square rule" can be readily modified to handle unequal sample dispersion matrices - see §6.5.3 below, differential prior probabilities and misclassification costs etc (see above and Tatsuoka, 1971: 218-236).

6.5.3: Unequal Dispersion Matrices

Tatsuoka (1971: 222) discusses the situation in which population dispersion matrices are not (or cannot be assumed to be) equal. In this case the respective sample dispersion matrices W_1 and W_2 are used in place of the dispersion matrix pooled across samples, and the expression for $\chi^2_{i,\ i=1,\ 2}$ in (6.3) above becomes

$$\chi_i'^2 = (x - \bar{x}_i)' W_i^{-1} (x - \bar{x}_i) \qquad ---(6.9)$$

The χ^2 classification rule of §6.5.2 above can then be applied using an adjusted quantity $\chi^2_{i,adj}$ given by

$$\chi^2_{i,adj} = \chi_i'^2 + \log_e |W_i| \qquad ---(6.10)$$

Taking into account prior probabilities and differential costs of misclassification, the expression for probability of group membership $P(H_1/x)$ can thus be expressed (after Tatsuoka 1971: 229) as

Ratio	Component 1	2	3	4	5	6	7	8
1	-.99	-.01	-.12	-.01	-.04	-.02	-.06	-.01
2	-.98	-.11	.02	.09	-.01	.03	-.03	.01
3	-.93	.03	-.26	-.08	-.10	.00	-.13	-.07
4	-.94	.08	-.17	-.07	-.09	-.06	-.12	-.12
5	-.97	-.06	-.10	.10	-.03	-.01	-.05	.04
6	-.97	-.10	-.05	.08	-.03	.08	-.01	.07
(7)	-.96	-.10	-.13	.07	-.11	.05	-.04	-.03
8	-.93	-.19	.06	.17	-.06	.06	-.05	-.00
9	-.92	-.01	-.03	.09	.01	-.06	.07	.13
10	-.93	.01	-.15	.03	-.18	.02	-.06	-.14
11	-.94	-.17	-.11	.18	-.08	.02	-.01	.01
12	-.94	-.20	-.06	.14	-.06	.09	-.00	.05
13	-.99	.02	-.05	-.03	-.02	.00	.02	-.01
14	-.97	-.04	.15	.03	.03	.01	.04	.02
15	-.93	.04	-.24	-.09	-.10	.05	-.06	-.08
16	-.94	.11	-.10	-.05	-.13	-.02	-.05	-.13
17	-.98	-.03	-.06	.05	.03	-.04	.06	.03
18	-.97	-.07	.00	.03	.06	.06	.07	.07
19	-.46	-.09	-.59	.01	-.20	.32	-.30	.19
20	.02	.49	-.43	-.26	.64	.08	-.07	.16
21	.16	.95	-.10	-.09	.20	.05	.03	-.01
22	-.12	.56	-.59	-.22	.41	-.07	-.10	-.12
23	-.06	-.00	-.20	.19	-.88	.29	-.13	.00
24	-.32	.07	-.78	.08	-.19	.20	.07	.13
(25)	-.25	-.07	-.55	.35	-.62	.23	.15	-.09
26	-.17	.03	-.84	-.37	-.06	.03	.12	-.13
27	-.07	-.14	.13	.16	.11	-.89	.13	-.05
28	-.02	.94	-.07	.08	-.11	.15	-.12	-.09
(29)	-.02	-.10	.06	.00	-.72	-.64	.01	-.08
30	-.10	-.68	-.10	.11	-.68	.12	-.06	.02
31	-.08	-.98	.08	-.05	-.03	-.14	.06	.03
32	-.16	-.28	-.11	-.25	-.68	-.33	-.34	.07
33	-.17	-.57	-.50	-.03	-.43	.27	-.25	.13
(34)	-.03	-.92	-.25	-.04	-.12	-.00	.13	.09
35	-.29	.26	-.23	-.28	.07	.61	-.10	-.16
36	-.04	-.04	.07	-.07	-.92	-.32	-.07	.01
37	-.07	-.37	-.18	.14	-.84	.22	-.09	.06
38	-.16	-.95	.09	.09	-.21	-.06	-.04	-.00
39	.19	-.05	.02	.08	-.14	.73	-.05	.54
40	-.30	.53	.19	.17	-.25	.23	-.58	-.04
(41)	.14	.45	.13	.31	-.17	.00	-.34	-.67
42	.19	-.08	.20	-.40	-.21	-.72	.95	.15
43	.01	-.17	.01	-.07	.21	-.36	.77	.09
44	-.20	.03	.16	.84	.31	-.21	.08	-.01
45	-.22	-.03	-.06	.90	-.32	.04	-.07	-.07
46	-.32	-.23	-.47	.55	-.31	.26	-.32	.10
47	.01	.01	.49	.80	-.20	-.11	-.02	-.09
48	-.17	.02	-.11	.64	-.70	.17	-.09	.02
49	-.20	-.50	-.01	-.58	.12	-.20	.20	-.49
50	-.15	-.75	.04	-.14	-.56	-.02	-.00	-.22

Appendix 6.2.3: Varimax Rotated Loadings Matrix:

FAILED23 Companies

Appendix 6.6.1: Constituent Ratios of the Recent Failed Company Z-Scores of Table 6.8

Company	$EBIT/TA_{t-1}$	TL/NCE	QA/TA	WC/NW	Stockturn	Z-score
A.D.M. Business Systems	0.932 *	2.8830	0.5085	0.3725	4.1708	-15.099
Anglian Food Group Ltd	0.0416	0.9192	0.1916	0.0028	6.7095	- 0.981
Bear Brand	-0.0421	2.9083 *	0.1644	-0.5115 *	6.8889	-31.752
British Leyland Motor Corporation	0.0424	2.0592	0.2619	0.3826	3.4966	-12.968
British Steel Constructions (Birmingham) Ltd	-0.0365	2.1569	0.3159	-0.0072	4.4143	-19.034
Budge Brothers	0.0982	2.9083 *	0.0659	-0.5115 *	1.2366	-32.908
Business Computers Ltd	0.1583 *	2.1870	0.5099	0.1528	5.0169	- 5.058
CBR Jersey (Holdings) Ltd	0.0194	1.3105	0.3069	0.0626	5.1772	- 5.737
Cohen & Wilkes (Holdings) Ltd	-0.2946 *	2.9083 *	0.2283	-0.5115 *	4.0463	-45.880
J. Collett Ltd	-0.1350 *	0.4348	0.1180	0.0077	4.6345	- 7.543
Court Line	0.0500 *	1.5304	0.2320	0.2222	2.8886	- 9.164
John E. Dallas & Sons Ltd	0.0353	1.7719	0.2933	0.8690	3.2363	- 5.840
Fairfax Jersey Group	-0.0252	1.4524	0.2270	0.1971	2.6282	-12.454
Ferranti Ltd	0.0201	1.2208	0.2843	0.5340	3.0941	- 3.465
Fodens Ltd	0.0576	1.2273	0.1740	0.3999	2.7754	- 5.013
Heenan Spark Ltd	0.0754	1.2958	0.3111	0.1442	4.6112	- 2.780
Alfred Herbert Ltd	-0.0725	1.0873	0.2757	0.7776	2.0196	- 5.695
A. H. Meltzer (Holdings) Ltd	0.0475	2.2814	0.3191	0.0003	6.8796	-13.587
McIntyre & Sons Ltd	0.0574**	1.7717	0.3316	-0.2281	8.0667	- 7.909
Metal Products Co. (Willenhall) Ltd	0.0515	1.5443	0.3267	0.4864	5.9168	- 2.186
T & A Naylor Ltd	-0.2218	1.4276	0.1951	0.6662	2.2556	-18.598
Norbury Insulation Group Ltd	0.1426 *	2.0604	0.4245	-0.1158	8.5731	- 4.084
Rosedale Industries Ltd	0.0392 *	2.2688	0.2391	-0.3411	3.2464	-22.098
L. Ryan (Holdings) Ltd	0.0045	1.3924	0.1538	-0.4150	3.0650	-16.135
Charles Spreckley Industries Ltd	0.0564	1.1123	0.1450	0.2295	2.5767	- 5.876
G. Stibbe & Co Ltd	0.0526	1.8030	0.2825	0.2353	2.1974	-11.926
Tan Sad Holdings Ltd	-0.1365	0.6847	0.2041	0.2454	4.1682	- 7.435
Venesta International	0.0043	2.9083 *	0.3009	-0.5115 *	3.9390	-30.563
W. Wood & Son Ltd	-0.2854 *	2.9083 *	0.2542	-0.5115 *	4.6402	-44.307

Notes (1) * denotes (a) in the case of $EBIT/TA_{t-1}$, that average total assets are used in ratio computation because growth in total assets exceed 30%
(b) in the case of other ratios that the calculated ratio was more than 3 standard deviations from the mean and was replaced by the appropriate limit for computation of the z-score.

(2) ** denotes that the growth in total assets over the year was greater than 150% and the $EBIT/TA_{t-1}$ ratio was replaced by the mean.

Appendix 6.6.2: Notes Associated with the Analysis of Recent Failed Companies

Company	Comments
A.D.M. Business Systems Ltd	Converted into public company 3 Dec. 1970. 68% growth in total assets. 51% of ordinary capital owned by, or controlled by, directors and their families.
Anglian Food Group	Converted into public company 23 January 1969. 56% of ordinary capital owned by directors and family trusts, the remainder by an investment company.
Bear Brand	TL/NCE = 3.2693 replaced by limit, WC/NW = -0.8308 replaced by limit, Z_{1973} = -25.99, Z_{1972} = 16.97, Z_{1971} = -29.41 (see comments in chapter VII §4).
British Leyland Motor Corporation	Z_{1973} = -2.63, Z_{1972} = -3.11, Z_{1971} = -5.43, Z_{1970} = -8.59, Z_{1969} = -1.48, Z_{1968} = 0.23 Note: Classified as 'failed' by virtue of its nationalisation considered in conjunction with Stock Exchange listing suspension and subsequent cancellation.
Budge Brothers	15 months accounts taken pro-rata. Large growth in total assets. TL/NCE = 3.2585 replaced by limit, WC/NW = -2.0425 replaced by limit. Converted into public company in July 1973 when the issue was obersubscribed three times. Z_{1972} computed from consolidated pro-forma accounts as at 30.9.1972 given in the offer for sale document = -25.4. Because of its large property development activities etc this company is not strictly suitable for application of the model.
Business Computer Ltd	Converted into public company 30.5.69. 81% growth in total assets. 47% of ordinary capital owned or controlled by directors or families. It made a total loss before tax in 1971 of 110% of its total fixed assets (excluding intangibles).
C.B.R.Jersey (Holdings) Ltd	45% growth in total assets due to large acquisition. The accounts are adjusted for the acquisition when computing the z-score. 69% of capital owned by directors and families.
Cohen & Wilkes (Holdings) Ltd	57% of ordinary capital controlled by directors and family trusts. 28% decline in TA over year. TL/NCE = 5.332 set to limit, WC/NW = 5.415 set to limit.
J. Collett Ltd	Subsidiary of Lyon Group Ltd (61% of ordinary capital). Revaluation of property assets taken into account in computations.
Court Line	41% growth in total assets due to acquisition of Clarksons etc. Z_{1972} = -6.87, Z_{1971} = 5.38, Z_{1970} = 3.12, Z_{1969} = -5.03. (See comments in text).
John E. Dallas & Sons Ltd	57% of ordinary capital owned or controlled by the directors.
Fairfax Jersey Group	Converted into public company 10.7.1970. 57.5% of ordinary capital controlled by joint managing directors or their families. Z_{1974} = -5.83, Z_{1973} = 6.25, Z_{1972} = 13.38, Z_{1971} = 12.80. (See comments in chapter VII §4).

Ferranti Ltd	Private company; preference shares only are listed on the London Stock Exchange. $Z_{1972} = 3.01$, $Z_{1971} = 0.36$. Classified as 'failed' by virtue of Government subscription of £15m share and loan capital agreed on 10.9.1975, taken together with suspension of Stock Exchange listing of preference shares.
Fodens	This company was classified as 'failed' by virtue of temporary suspension of Stock Exchange listing and request by company to Government for support to overcome liquidity problems (see comments in text).
Heenan Spark Ltd	Its subsidiary, Rosedale accounted for 12% of its net capital employed and 8.3% of its turnover.
Alfred Herbert Ltd	$Z_{1973} = 2.38$, $Z_{1972} = -0.85$, $Z_{1971} = 0.31$. Company classified as 'failed' by virtue of suspension of Stock Exchange listing and State Aid culminating with the provision of equity finance to be vested in the National Enterprise Board. (See comments in text).
McIntyre & Sons Ltd	217% growth in assets due to acquisitions. $EBIT/TA_{t-1}$, mean ratio -0.05740 used.
Metal Products Co (Willenhall) Ltd	Change in year end. Z-score computed from the accounts for 9 months to 31.12.74 + 3 months pro-rata of accounts to 31.3.74.
T & A Naylor Ltd	58% owned by directors' families and family trusts. $Z_{1974} = 2.82$.
Norbury Insulation Group Ltd	Converted into public company 2.10.1969. 89% growth in total assets due to acquisitions. Goodwill of £1 million accruing during year from acquisitions is written off in line with receiver's comments. Using uncorrected data z-score is 0.93.
Rosedale Industries Ltd	69% growth in total assets. 58% of capital owned by Heenan Spark Ltd. Converted into public company 13.3.1969. It made a rights issue in August 1973. $Z_{31.12.73} = -27.71$, $Z_{31.4.1973} = -22.40$.
Charles Spreckley Industries Ltd	Subsidiary of Cambourne Securities Ltd.
G. Stibbe & Co Ltd	$Z_{1972} = -0.56$, $Z_{1971} = 5.04$.
Venesta International	TL/NCE = 3.0438 set to limit, WC/NW = -1.6927 set to limit.
W. Wood & Son Ltd	53% growth in total assets partly due to revaluations. TL/NCE = 3.2951 set to limit and WC/NW = -0.9140 set to limit. Accounts very heavily qualified. EBIT figure includes exceptional items not shown separately. Receiver appointed to main operating subsidiaries although not to company itself.

Company	Z-score	Date of last accounts	Reasons for non-inclusion in "prime" failed Set
E.J. Austin International	- 7.38	30. 4.69	Not a public company for 5 years; doubled total assets over year through acquisitions, 2 ratios outside limits, suspect accounts, suspect fraud.
S. Collier	6.64	31.12.72	Suspect fraud-receiver appointed after appointment of Customs and Excise inspectors; accounts qualified.
Egas Ltd	- 8.65	30. 8.68	Not a public company for five years.
Fir View Furniture Holdings	13.04	31. 7.69	Not a public company for five years; change in year end in last accounts; 65% growth in total assets over year due to acquisitions; family firm with negligible equity base.
Howarth of Burnley	- 18.85	31. 3.68	Not a public company for five years; one ratio outside limit.
Humphreys Ltd	- 21.87	30.11.68	Accounts consolidated for two years only; one ratio outside limit.
Industrial and Thermal Engineers	- 15.10	31.12.67	Subsidiary of Linsram Securities Ltd; accounts consolidated for two years only.
John Loveys	14.72	31.12.71	Subsidiary of Portsea Investments. Chairman stated on 11.6.74 that company was unable to solve liquidity problems caused by collapse of parent co. It also experienced problems through the purchase of a large chain of department stores in April 1972 (subsequent to date of last accounts). One ratio outside limit; 52% growth in total assets. Liquidation notified subsequent to date of analysis.

Appendix 6.7: Z-Scores for Firms with Turnover Figures Failing prior to 31.12.1973 and not Included in the "Prime Failed" Set for Various Reasons

Company	Z-score	Date of accounts	Stock Exchange Industry Description	Stock Exchange Industry Code no.
Armstrong Equipment	7.245	30. 6.72	Motor Components	41
Cadbury Schweppes	9.057	31.12.72	General Food Manufacturing	49
Chloride Electrical	11.528	31. 3.74	Motor Components	41
Dobson Park	19.484	30. 9.72	Miscellaneous Engineering	27
Duport	12.552	31. 1.73	Miscellaneous Engineering	27
Hollis Bros. & E.S.A. Ltd.	15.973	31. 3.73	Timber	17
Manbré & Garton	12.912	31. 9.73	General Food Manufacturing	49
H. Samuel	15.547	31. 1.73	Multiple Stores activities (including manufacturing)	58
Spillers	6.098	31. 1.73	Milling and Flour confectionary	50
Wedgwood	11.534	31. 3.73	Kitchen and Tableware	40

Appendix 6.8: The Well-solvent Validation Set of Companies

Appendix 6.9: Prior Year Z-Scores

Appendix 6.9.1: FAILED23 Company Prior Year Z-scores

No.	Company	Date of last Accounts	Prior accounting year z-scores			
			4	3	2	last
1	Amalgamated Transport	31. 3.70	8.76	- 2.89	11.25	- 0.08
2	B.S.A.	31. 7.72	5.64	6.40	-10.46	- 7.13
3	Byard Manufacturing	31.12.67	11.93	6.04	- 2.71	- 5.91
4	Bydand	31. 3.71*	4.71	9.20	-14.73	-31.70
5	Dansette	31.12.68	8.04	- 2.31	0.35	- 8.59
6	Dickson & Mann	31. 3.68	- 1.07	- 1.26	1.73	- 8.86
7	John Galloway	30. 9.70	6.00	- 0.15	- 8.97	- 8.51
8	Hartley Crosland Group	31. 3.70	- 4.19	- 2.13	- 7.22	- 8.69
9	Headquarters & General Supplies	31. 3.67	7.80	0.64	3.87	- 8.02
10	Hupfield Bros.	31.12.69	2.07	8.51	3.34	-13.45
11	Lawes Chemical	30. 9.68	10.00	-15.74	- 8.09	-20.65
12	Lines Bros.	31.12.69	- 2.09	1.22	- 1.21	- 3.17
13	Mansell Thorpe	31.12.69	-10.36	-12.58	- 9.43	-10.16
14	Mitchell Construction	31.12.71	-17.07	-18.72	-17.91	-12.42
15	Pearson & Foster (Bradford) Ltd	31. 3.70	- 3.89	- 8.73	- 6.68	-29.45
16	Robert Pickles	31. 3.69	5.99	- 0.23	0.12	-10.15
17	Rippingilles	31. 3.69	-10.28	-13.12	- 5.62	-11.27
18	Rolls Royce	31.12.69	- 1.30	1.18	4.27	2.91
19	W & J Sagar Holdings	30. 6.68	- 7.32	-13.21	-22.42	- 5.58
20	United Match Industries	31. 3.69	- 6.72	- 3.22	- 1.75	- 6.19
21	Wardle & Davenport	29. 2.69	12.72	11.49	-12.29	-19.83
22	Wilson Lovatt & Sons	31.12.69	-24.35	-15.04	- 9.86	-18.85
23	Wilson Mandleburg	31.12.69	- 0.38	-10.39	- 6.30	-12.97

* The accounts for the 9 months to 31.12.71 were not used.

Note (1) Companies with non-reported turnover data in the earlier years have the missing stockturn ratios replaced by the earliest computed ratio.

Note (2) Bydand — TL/NCE set to limit in 1971, WC/NW set to limit (-ve) in 1971.

Hupfield Bros. — WC/NW set to limit in 1969.

Headquarters & General Supplies — QA/TA is set to limit in 1964 and 1965, TL/NCE is set to limit in 1965, S/av.inv. is set to limit in 1964 and 1965.

W & J Sagar — WC/NW set to limit (-ve) in 1967, S/av.inv. is set to limit in 1965, 1966, 1967 and 1968.

Amalgamated Transport — S/av.inv. is set to limit in 1970.

Pearson & Foster (Bradford) Ltd — TL/NCE is set to limit in 1970.

Appendix 6.9.2: GOOD45 Company Prior Year Z-scores

No.	Company	Date of last Accounts	Prior accounting year z-scores			
			4	3	2	last
1	Aberthaw & Bristol Cement	31.12.72	1.00	7.45	12.21	11.71
2	Acrow Engineers	31. 3.72	8.38	6.42	7.28	11.91
3	Amalgamated Power Eng.	31.12.72	8.39	7.51	10.55	10.52
4	Associated Biscuits	31.12.72	12.25	11.69	14.67	18.47
5	Associated British Foods	31. 3.73	6.57	7.74	7.60	10.87
6	Associated Portland Cement	31.12.72	8.02	7.56	9.73	7.28
7	Beecham Group	31. 3.73	16.64	17.56	14.32	15.94
8	BICC	31.12.72	8.51	8.51	9.50	10.46
9	Peter Brotherhood	31. 3.72	8.60	8.07	2.11	3.71
10	Courtney Pope	31. 5.73	9.20	11.08	8.90	8.31
11	Daniel Doncaster	31. 3.73	9.91	13.33	13.08	16.40
12	Ductile Steels	30. 6.73	12.89	17.08	11.03	16.20
13	Dunford Elliott	31. 7.72	0.65	3.61	11.84	8.78
14	J B Eastwood	31. 3.73	4.16	1.53	2.90	10.99
15	E.M.I.	30. 6.73	3.99	1.57	3.52	6.23
16	General Electric Co.	31. 3.73	5.20	5.99	8.20	11.82
17	Glaxo Group	30. 6.73	13.15	10.22	13.06	15.21
18	Hawker Siddeley	31.12.72	4.21	3.34	6.42	9.35
19	Hopkinsons Holdings	31. 1.73	14.07	13.39	12.72	16.24
20	Howden Group	30. 4.72	11.73	6.07	3.37	4.40
21	Kitson's Insulations	31. 3.73	13.28	2.49	13.98	19.26
22	Lamson Industries	31.12.72	9.11	8.94	9.25	7.44
23	London Brick	31.12.72	14.68	17.72	20.54	21.22
24	Martin-Black Ltd	31.12.72	7.29	7.52	7.58	11.24
25	Mather & Platt	31.12.72	11.53	10.05	9.20	7.59
26	Muirhead	30. 9.73	5.02	8.63	6.19	9.72
27	Norcros Limited	30.11.72	8.41	8.78	11.07	12.99
28	Pegler-Hattersley	31. 3.73	16.05	10.39	15.84	16.82
29	Plessey	30. 6.73	9.95	7.08	5.71	8.69
30	Rank Hovis McDougall	31. 8.73	10.12	11.39	14.10	15.96
31	Reckitt & Coleman	31.12.72	9.12	8.26	9.78	11.81
32	Rugby Portland Cement	31.12.72	13.20	12.73	12.67	12.41
33	Scapa Group	31. 3.73	6.76	5.66	3.53	7.46
34	Scotcros Limited	31. 3.73	11.37	10.48	9.52	7.14
35	Serck	30. 9.72	3.34	3.52	9.69	8.07
36	S.G.B. Group	30. 9.72	9.71	6.49	9.57	14.10
37	Sheffield Steel & Twist Co	31.12.72	6.71	7.97	3.87	1.39
38	Smiths Industries	31. 7.73	6.49	9.52	11.39	11.80
39	Stone Platt Industries	31.12.72	6.01	5.34	7.84	10.08
40	Tunnel Cement	31. 3.73	1.19	4.41	11.26	14.01
41	Turner & Newall	30. 9.72	8.23	8.51	9.39	9.26
42	United Biscuits	31.12.72	9.37	8.79	11.06	12.90
43	Weir Group	31.12.72	5.29	1.44	3.11	7.16
44	Westinghouse	30. 9.72	6.35	8.46	8.74	6.88
45	Yorkshire Chemicals	31. 3.73	8.59	10.24	15.06	18.58

Note (1) These z-scores are not adjusted for growth in total assets over a year if greater than 30%

Note (2) Associated Biscuits, Kitson's Insulations: S/av.inv. set to limit in 1972 should not have been included in the sample QA/TA set to limit in 1970, 1971, 1972 and 1973. S/av.inv. was replaced by mean in 1970 and 1971 and set to limit in 1972 and 1973

London Brick: S/av.inv. set to limit in 1969, 1970 1971 and 1972

United Biscuits: S/av.inv. set to limit in 1972

Appendix 6.9.3: POOR16 Company Prior Year Z-scores

No.	Company	Date of last Accounts	Prior accounting year z-scores			
			4	3	2	last
1	Associated Engineering	30. 9.72	4.88	2.45	5.65	6.40
2	Avon Rubber	30. 9.73	4.15	4.69	2.79	4.02
3	British Oxygen Co.	30. 9.72	4.74	2.90	4.63	3.54
4	Brooke Bond Liebig	30. 6.73	7.22	6.00	5.65	8.47
5	John Brown	31. 3.73	1.08	-3.35	-2.73	-1.19
6	Dowty Group	31. 3.73	9.03	7.63	10.63	13.71
7	Ever Ready	28. 2.73	7.50	3.85	6.44	7.77
8	Flight Refuelling	31.12.72	9.36	8.34	7.79	6.75
9	George Kent	31. 3.73	3.33	0.95	2.14	0.83
10	J Lucas	31. 7.73	5.12	8.54	11.05	11.08
11	M K Electric	31. 3.73	9.09	9.23	12.36	15.10
12	Morgan Crucible	31.12.72	8.83	7.01	6.22	8.43
13	Reyrolle Parsons	31.12.72	10.06	5.00	-3.07	-1.73
14	Royal Worcester Limited	31.12.72	1.46	3.17	4.29	10.81
15	Strong & Fisher	31. 5.72	3.22	-2.79	0.47	-0.63
16	Wilmot-Breeden	31.12.72	4.01	2.78	6.49	10.25

Note: These z-scores are not adjusted for growth in total assets over a year if greater than 30%.

Prior Accounting Years:	4		3		2		last	
Measure	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Z-Score	- .2320	9.4661	-3.2627	8.7102	-5.2479	7.8422	-11.2484	8.2890
$EBIT/TA_{t-1}$	.0621	.0966	.0258	.1011	.0070	.0871	- .0309	.0968
TL/NCE	1.1412	.7110	1.2714	.6638	1.3153	.5673	1.6158	.6466
QA/TA	.2785	.1171	.2837	.1017	.2701	.1082	.2591	.1074
WC/NW	.4485	.2573	.4113	.3982	.3970	.3576	.3130	.4362
Stockturn	4.5359	2.6097	4.6706	2.6840	4.2980	2.2160	4.4279	2.6146

Appendix 6.10.1: FAILED23 Group Prior Year Results

Prior Accounting Years:	4		3		2		last	
Measure	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Z-Score	8.5488	3.8306	8.3229	3.8935	9.6201	3.9585	11.3049	4.3741
$EBIT/TA_{t-1}$	.1194	.0492	.1170	.0438	.1266	.0450	.1482	.0525
TL/NCE	.7897	.2491	.8194	.2782	.7889	.2492	.7803	.2531
QA/TA	.3203	.0929	.3200	.0919	.3176	.0902	.3291	.0935
WC/NW	.4940	.2524	.5175	.2365	.5466	.2317	.5606	.2223
Stockturn	5.0862	2.4858	5.1136	2.5725	5.3808	2.7589	5.6131	2.7755

Appendix 6.10.2: GOOD45 Group Prior Year Results

Appendix 6.10: Mean and Standard Deviation Results for the Z-scores and Constituent Ratios for the FAILED23 and GOOD45 sets of Firms for Prior Accounting Years

Appendix 7.1: Company Z-Score, Ratio and Other Information 1969-1975

KEY

UNDER DESCR.HEADING

* DENOTES OVER 50PC. EQUITY CONTROLLED BY DIRECTORS
** DENOTES COMPANY IS A SUBSIDIARY OF ANOTHER
A DIGIT DENOTES THE NUMBER OF COMPLETED FINANCIAL YEARS PUBLICALLY QUOTED IF LESS THAN 5

FOLLOWING A RATIO

* DENOTES ORIGINAL RATIO OUTSIDE 3*SD OF MEAN AND IS REPLACED BY LIMIT
** DENOTES TOTAL ASSET GROWTH.GT.30PC.AND AVERAGE TOTAL ASSETS USED IN EBIT/TA COMPUTATION

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1969

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
1	BATH + PORTLAND GROUP	31 10 69		73	.0530	1.7214	.3284	.5441	5.1951	-4.388	INSOLVENT
2	BRITISH PRINTING CORP.	31 12 69		53	.0486	.8644	.2936	.4346	6.7771	5.273	SOLVENT
3	CADBURY SCHWEPPES	31 12 69		49	.0934	.7196	.2231	.3055	4.1361	3.905	GRAY AREA
4	FRANCIS INDUSTRIES	31 12 69		73	.0668	1.0051	.2976	.5573	3.7356	2.294	GRAY AREA
5	ILLINGWORTH,MORRIS + CO.	31 3 69		61	.0905	1.1295	.2529	.4968	2.5273	-.528	GRAY AREA
6	LAPORTE INDUSTRIES (HOLDINGS)	30 3 69		68	.1128	.5726	.2309	.4064	5.1019	3.506	SOLVENT
7	LESNEY PRODUCT + CO	26 1 69	*	65	.4094	* .6869	.4571	.3928	10.9014	31.327	SOLVENT
8	SCRAGG (ERNEST) + SONS	30 9 69		22	.4094	1.4333	.5831	.6505	5.3933	21.079	SOLVENT

KEY

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** DENOTES TOTAL ASSET GROWTH.GT.30PC.AND AVERAGE TOTAL ASSETS USED IN EBIT/TA COMPUTATION

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1970

COMPANY	A/CS ENDING	DESCR. IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
1 BATH + PORTLAND GROUP	31 10 70	73	.0506	1.6509	.3054	.6496	3.6383	-4.932	INSOLVENT
2 BRITISH PRINTING CORP.	31 12 70	53	-.0040	1.0723	.2639	.1702	6.4280	-2.615	INSOLVENT
3 CADBURY SCHWEPPES	31 12 70	49	.0896	.7548	.2424	.3516	4.0098	3.890	GRAY AREA
4 FRANCIS INDUSTRIES	31 12 70	73	-.0150	.9960	.3174	.4580	4.2607	-1.425	GRAY AREA
5 ILLINGWORTH,MORRIS +CO	31 3 70	61	.0787	1.0890	.2724	.4956	2.4672	-.396	GRAY AREA
6 LAPORTE INDUSTRIES (HOLDINGS)	29 3 70	68	.1066	.6334	.2138	.3268	5.3497	6.862	SOLVENT
7 LESNEY	1 2 70 *	65	.2407 **	.7084	.3426	.2899	7.8074	16.918	SOLVENT
8 SCRAGG (ERNEST) + SONS	30 9 70	22	-.0658	.9215	.5463	.6674	3.4909	1.556	GRAY AREA

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** DENOTES TOTAL ASSET GROWTH.GT.30PC.AND AVERAGE TOTAL ASSETS USED IN EBIT/TA COMPUTATION

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1971

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	CA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
1	BATH + PORTLAND GROUP	31 10 71		73	.0591	1.4666	.3473	.7385	3.4373	-1.263	GRAY AREA
2	BEAR BRAND	31 12 71		59	-.1355	2.5222	.2043	-.4636	8.1798	-29.412	INSOLVENT
3	BEMROSE	31 12 71		54	.1262	.9002	.3122	.4263	4.0795	5.837	SOLVENT
4	BRITISH PRINTING CORP.	31 12 71		53	.0455	.9977	.3294	.5106	6.4548	4.491	SOLVENT
5	DEXION-COMINO INTERNATIONAL	31 10 71	* 4	27	.0199	1.4208	.3549	.3071	5.8951	-3.355	INSOLVENT
6	FAIRFAX JERSEY GROUP	30 6 71	* 1	60	.3623	.6721	.4866	.6376	4.5416	24.744	SOLVENT
7	FRANCIS INDUSTRIES	31 12 71		73	.0519	1.0251	.3046	.4694	5.4126	2.597	GRAY AREA
8	GLYNWED	31 12 71		14	.1658	.9310	.3217	.7552	5.1632	11.448	SOLVENT
9	ILLINGWORTH,MORRIS +CO.	31 3 71		61	.0622	.9248	.2967	.4853	2.6779	1.202	GRAY AREA
10	LAPORTE INDUSTRIES	28 3 71		68	.0755	.6585	.1996	.4230	4.5670	4.802	SOLVENT
11	LESNEY	31 1 71	*	65	-.0590	.7179	.3387	.3714	5.1635	.222	GRAY AREA
12	RANK ORGANISATION	31 10 71		69	.1887	.5937	.1833	.2380	6.5716	11.340	SOLVENT
13	SCRAGG (ERNEST) + SONS	30 9 71		22	.0760	.5569	.5124	.7697	3.5460	12.800	SOLVENT
14	TURNER MANFACTURING CO.	30 9 71	3	41	.2023	.6576	.3717	.4341	7.3550	16.823	SOLVENT
15	WARD (THOS.W)LTD.	30 6 71		27	.0793	.6289	.2947	.3758	4.7210	6.642	SOLVENT

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COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1972

COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
1 ALLIED POLYMER GROUP	31 12 72		1 66	.1542	1.2544	.4464	.7411	6.9815	11.187	SOLVENT
2 ARMSTRONG EQUIPMENT	30 6 72		41	.1633	.9592	.3064	.4874	3.9798	7.245	SOLVENT
3 BAKER PERKINS	31 12 72		22	.0775	.7545	.4295	.6685	3.7254	8.670	SOLVENT
4 BATH AND PORTLAND GROUP	31 12 72		73	.0833	1.2551	.3459	.6437	3.6419	1.678	GRAY AREA
5 BEAR BRAND	31 12 72		59	.0141	1.9826	.2406	-.2257	5.1896	-16.967	INSOLVENT
6 BEHROSE	31 12 72		54	.1266 **	1.0882	.3177	.2855	4.4056	3.034	GRAY AREA
7 BRITISH PRINTING CORP.	31 12 72		53	.0915	.9703	.3586	.5833	7.3036	9.002	SOLVENT
8 BROCKS GROUP	31 12 72		75	.1843	1.0328	.1978	.1197	2.7718	1.283	GRAY AREA
9 B T R LTD.	31 12 72		66	.1420	.8520	.3266	.5037	4.6832	8.669	SOLVENT
10 CADBURY SCHWEPPES	31 12 72		49	.1347	.8279	.3389	.4651	5.2129	9.057	SOLVENT
11 CARAVAN INTERNATIONAL	31 8 72		43	.1097	1.1044	.2786	.4118	4.6200	2.689	GRAY AREA
12 COPE SPORTSWEAR	31 12 72	*	59	.1554	1.8143	.3654	.4388	4.1788	-1.933	INSOLVENT
13 CRANE FRUEHAUF	31 12 72		43	.1028	1.2772	.3362	.2440	6.0675	1.570	GRAY AREA
14 DELTA METAL	30 12 72		32	.1480	.8055	.2942	.6105	4.3345	9.512	SOLVENT
15 DEXION-COMINO INTERNATIONAL	31 10 72	*	27	.0660	1.4252	.3869	.3521	7.7450	1.728	GRAY AREA
16 DOBSON PARK	30 9 72		27	.2453	.6460	.4452	.6125	5.3652	19.484	SOLVENT
17 FAIRFAX JERSEY	30 6 72	*	60	.2735 **	.7272	.2598	.5215	2.8497	13.376	SOLVENT
18 FRANCIS INDUSTRIES	31 12 72		73	.0895	.9604	.3051	.4934	5.9146	5.871	SOLVENT
19 GLYNHED	31 12 72		14	.1784 **	1.0642	.3520	.7455	5.0544	11.732	SOLVENT
20 HEAD WRIGHTSON + CO.LTD	31 1 72		25	.0663 **	.9047	.4281	.4408	8.5411	9.855	SOLVENT
21 ILLINGWORTH,MORRIS + CO.	31 3 72		61	.0680 **	1.4246	.2925	.3475	2.7140	-5.290	INSOLVENT
22 LAPORTE INDUSTRIES	31 12 72		68	.0780	.5820	.2465	.6184	3.4480	6.924	SOLVENT
23 LESNEY	30 1 72		65	.0744	.5766	.3533	.4586	5.7128	9.727	SOLVENT
24 PETBOW HOLDINGS LTD.	31 12 72	*	0 19	.1274	.5928	.3705	.5528	3.5481	10.746	SOLVENT
25 RANK ORGANISATION	31 10 72		69	.2015	.5925	.2270	.3041	7.0658	13.765	SOLVENT
26 ROWNTREE-MACKINTOSH	31 12 72		49	.1224	.6060	.3207	.5137	6.7292	10.492	SOLVENT
27 SCRAGG (ERNEST)	30 9 72		22	.0542	.4036	.3902	.7323	3.0318	10.614	SOLVENT
28 SIDLAW INDUSTRIES	30 9 72		62	.0311 **	1.1574	.2465	.6564	3.7388	-1.123	GRAY AREA
29 TRIANCO GROUP	31 12 72		27	.0156	1.0512	.4123	.6561	4.1451	2.474	GRAY AREA
30 TURNER MANUFACTURING	30 9 72		41	.1168	.4920	.4110	.4573	5.9791	13.919	SOLVENT
31 WARD (THOS.W)	30 6 72		27	.0988	.5043	.2913	.4240	4.7021	9.290	SOLVENT

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1973

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
1	AARONSON BROTHERS	30 9 73		17	.2436 **	.8559	.3828	.2311	7.6706	15.421	SOLVENT
2	ABERTHAW AND BRISTOL CEMENT	31 12 73		15	.1298 **	.9433	.1346	-.1321	6.6352	.828	GRAY AREA
3	ACROW ENGINEERS	31 3 73		23	.0727 **	.8134	.2180	.5450	2.0116	1.427	GRAY AREA
4	ADWEST GROUP	30 6 73		27	.1927	.7235	.3103	.3999	4.4593	11.155	SOLVENT
5	ALBRIGHT + WILSON	31 12 73		68	.0829	.8166	.4163	1.0671	5.1424	12.874	SOLVENT
6	ALLIED INSULATORS LTD.	31 12 73		19	.0959	.6025	.2967	.3443	4.7823	7.569	SOLVENT
7	ALLIED POLYMER GROUP	31 12 73	2	66	.1542	1.3655	.3564	.3385	6.5195	4.640	SOLVENT
8	ALLIED TEXTILE COS. LTD	30 9 73		61	.1962 **	1.2356	.2109	.6420	3.4072	4.808	SOLVENT
9	AMALGAMATED POWER ENGINEERING	31 12 73		24	.1186	.9093	.4232	.8380	3.6151	10.072	SOLVENT
10	A.P.V. HLDGS	31 12 73		22	.1404 **	.8031	.4104	.7177	4.5481	12.124	SOLVENT
11	APENSON(A) HOLDINGS	31 7 73	2	69	.1638 **	.9258	.3533	.1492	6.4460	8.326	SOLVENT
12	ARMSTRONG EQUIPMENT	30 6 73		41	.1901	.9407	.2857	.4092	4.0644	8.499	SOLVENT
13	ASS. BISCUITS	31 12 73		50	.1328	.6647	.2765	.4191	11.0432	15.818	SOLVENT
14	ASSOCIATED ENGINEERING	30 9 73		41	.1244	1.0531	.3111	.7449	3.7549	6.296	SOLVENT
15	ASSOC. FISHERIES LTD	30 9 73		49	.1686	.9406	.3148	.4154	11.0685	15.058	SOLVENT
16	ASSOCIATED PORTLAND CEMENT	31 12 73		15	.1244	.5159	.1892	.1996	6.9257	9.314	SOLVENT
17	ASS.SPRAYERS	31 8 73	3	39	.1561 **	1.3120	.2876	.0183	6.5151	1.559	GRAY AREA
18	AULT + WIBORG GROUP LTD	31 12 73		53	.1099	.7808	.3620	.4115	4.4997	7.550	SOLVENT
19	AURORA GEAR AND ENGINFERING	30 6 73		27	.0653	.9074	.3571	.6751	4.2104	5.785	SOLVENT
20	AVANA GROUP	31 3 73		50	.1119	.5625	.2815	.2615	9.1047	12.611	SOLVENT
21	AVERYS LTD	31 12 73		31	.1833 **	.4773	.3520	.5885	3.5073	14.654	SOLVENT
22	BABCOCK + WILCOX	31 12 73		20	.0808	1.6779	.5361	.4613	5.5521	.520	GRAY AREA
23	BAIRD (WILLIAM)AND CO.	31 12 73		73	.0784	1.0520	.3059	.2218	5.3512	1.466	GRAY AREA
24	BAKER PERKINS	31 12 73		22	.0825	.8989	.3907	.8636	3.6046	8.145	SOLVENT
25	BARGET(I) LTD	30 9 73	*	38	.1989 **	1.1547	.4571	.6738	6.7742	13.827	SOLVENT
26	BARROW HEPBURN	31 12 73		64	.1209	1.5897	.3319	.2428	6.8315	-.306	GRAY AREA
27	BARTON + SONS	31 12 73		27	.1756	.7863	.3929	.5337	5.1523	12.852	SOLVENT
28	BATH + PORTLAND CEMENT	31 10 73		73	.0891 **	1.4910	.3909	.4451	5.2469	.172	GRAY AREA
29	BBA GROUP	31 12 73		41	.1529	.3837	.2889	.3055	5.4861	6.823	SOLVENT
30	BEAR BRAND	31 12 73		59	-.0525	2.4958	.2139	-.3845	6.6863	-25.994	INSOLVENT

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1973

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
31	BEAUFORD GROUP	31 12 73	* 1	27	.1843 **	1.4121	.3518	.7201	3.7944	5.631	SOLVENT
32	BEMROSE	31 12 73		54	.0653	1.2510	.3198	.3333	4.4921	-1.189	GRAY AREA
33	BENSONS INTERNATIONAL SYSTEMS	31 12 73		69	.1890	1.0194	.3257	.5082	5.2917	9.727	SOLVENT
34	BERWICK TIMPO LTD	31 12 73		65	.2212 **	.9719	.3478	.2424	6.9026	11.733	SOLVENT
35	BESTOBELL LTD.	31 12 73		27	.1636	1.0820	.4659	.7512	4.5226	11.262	SOLVENT
36	BIBBY (J) + SONS	31 12 73		49	.0762 **	1.4407	.3188	.2909	8.5468	1.308	GRAY AREA
37	BIFURCATED ENGINEERING LTD	31 12 73		27	.1411	.7937	.2888	.2317	4.6471	6.373	SOLVENT
38	BIRMID QUALCAST LTD.	31 7 73		27	.1801	.5907	.5474	.8440	7.9680	23.443	SOLVENT
39	BLACK + EDGINGTON	30 9 73		48	.1443 **	1.0529	.2239	.2151	3.4493	1.107	GRAY AREA
40	BLACKMAN + CONRAD LTD.	30 9 73		59	.2020 **	1.1335	.2104	.0193	5.0805	2.915	GRAY AREA
41	BOND ST FABRICS	30 9 73	*	62	.1247 **	1.0236	.2561	.3437	5.9113	4.802	SOLVENT
42	BOOTH(INTERNATIONAL MLDGS)LTD.	31 12 73	*	59	.1394	2.0999	.5274	.5631	12.2943 *	5.368	SOLVENT
43	BOWATER GROUP	31 12 73		73	.1190 **	1.0999	.2929	.2980	9.8131	8.198	SOLVENT
44	BRAMMER (H).) + CO.	31 12 73		23	.1592	1.0899	.3817	.4845	3.7557	6.542	SOLVENT
45	BRIDON	31 12 73		26	.1614	.5270	.5142	1.3248	4.4856	22.860	SOLVENT
46	BR.INSUL.CALLENDER'S CABLES	31 12 73		19	.1403	.8050	.3354	.5131	6.1450	10.964	SOLVENT
47	BRITISH OXYGEN	30 9 73		68	.1297	.9646	.2550	.4853	4.4671	5.263	SOLVENT
48	BRITISH PRINTING CORPORATION	31 12 73		53	.1019	1.0594	.4190	.7972	7.1456	11.078	SOLVENT
49	BRITISH ROLLMAKERS CORP.LTD.	31 12 73		25	.1046	.4749	.3349	.5775	3.8472	10.936	SOLVENT
50	BR. STEEL CONSTRUCTIONS	31 10 73		27	-.0365	2.1569	.3159	.0072	4.4143	-19.034	INSOLVENT
51	BRITISH VITA CO. LTD.	31 12 73	*	66	.1494	1.1125	.3662	.3201	8.1113	9.009	SOLVENT
52	BROCKHOUSE (J) + CO.LTD	30 9 73		21	.0977	1.1515	.3599	.3460	5.6298	3.482	GRAY AREA
53	BROCKS GROUP	31 12 73		75	.1710 **	.9485	.2085	.1476	2.9790	2.223	GRAY AREA
54	BROOKE TOOL ENG.(HOLDINGS)LTD.	30 9 73		25	.0178	1.0530	.2304	.3057	2.0158	-5.649	INSOLVENT
55	BROTHERHOOD(PETER)	31 3 73		22	.1012	.5153	.2875	.5381	2.5092	7.748	SOLVENT
56	BROWN+TAWSE LTD	31 3 73		33	.1811	.6997	.3805	.5720	5.9177	15.040	SOLVENT
57	BRUNTONS(MUSSELBURGH) LTD.	31 12 73		26	.2884	.4885	.5618	.8155	5.2974	26.806	SOLVENT
58	B S R	31 12 73		35	.3605 **	.6242	.4411	.7302	6.8366	27.750	SOLVENT
59	B T R	31 12 73		66	.1376	.9519	.3174	.4771	4.5814	6.856	SOLVENT
60	BULLOUGH LTD.	31 10 73		27	.1799 **	.8712	.3425	.3142	5.4324	9.780	SOLVENT

COMPANY	A/CS ENDING	DESCR.	IND.	ERIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
61 BUNZL PULP + PAPER LTD.	31 12 73		54	.1769	.3991	.4168	.5832	7.8341	14.283	SOLVENT
62 BURCO DEAN LTD.	30 9 73		39	.2163 **	.6902	.3497	.5220	5.9745	15.976	SOLVENT
63 BURGESS PRODUCTS CO(HLDGS)LTD.	31 7 73		27	.2171	.5522	.3482	.6363	4.2844	16.618	SOLVENT
64 BURY + MASCO(HLDGS) LTD.	31 12 73		62	.1620 **	.6172	.3287	.6780	4.8739	13.938	SOLVENT
65 CADBURY SCHWEPPES	31 12 73		49	.1201 **	.8357	.2842	.3193	5.8639	6.891	SOLVENT
66 CAMFORD ENGINEERING	30 9 73	1	41	.2330 **	1.1924	.3004	.2089	8.0985	10.094	SOLVENT
67 CAMREX(HOLDINGS)LTD.	31 12 73		16	.1184	1.2000	.5866	.4658	10.5246	14.005	SOLVENT
68 CANNING TOWN GLASS WORKS LTD	31 12 73		54	.0032	.9024	.3114	.1368	8.2503	2.136	GRAY AREA
69 CARAVAN INTERNATIONAL	31 8 73		43	.1713	1.2904	.2590	.4012	4.9715	3.525	GRAY AREA
70 CARPETS INTERNATIONAL LTD	29 12 73		37	.1907	.9176	.3119	.5329	4.2783	9.813	SOLVENT
71 CARRINGTON VIYELLA	31 3 73		60	.1158	.9051	.2615	.6391	3.4453	5.520	SOLVENT
72 CARRON CO.(HLDGS)LTD.	31 12 73		14	.1578 **	1.3946	.3722	.3314	4.6995	2.491	GRAY AREA
73 CENTRAL MANUFACTURING+TR.GP.	31 7 73		27	.1603	1.2307	.4166	.3146	6.8012	7.537	SOLVENT
74 CENTRAL WAGON	31 12 73		33	.1419	1.3210	.4176	.4331	8.2302	8.214	SOLVENT
75 CLARK + FENN (HOLDINGS)LTD.	31 12 73		14	.1589 **	1.2352	.5316	.4537	7.5277	11.242	SOLVENT
76 CLARKE CHAPMAN-JOHN THOMPSON	31 12 73		20	.0870	1.4044	.4679	.8517	4.3361	4.656	SOLVENT
77 CLARKE (T.) + CO.	31 12 73	**	19	.1568	1.1278	.4905	.7916	7.0514	13.944	SOLVENT
78 CLAY(RICHARD)+ CO.	31 3 73		53	.1692	.3570	.3390	.3152	9.0107	18.925	SOLVENT
79 CLAYTON DEWANDRE HOLDINGS LTD.	31 12 73		41	.1595	.8116	.3283	.6821	3.7549	10.437	SOLVENT
80 COATES BROS	31 12 73		53	.2375	.6623	.3825	.4230	6.5731	17.675	SOLVENT
81 COLLINS (WILLIAM) + SONS	30 12 73		53	.1767	.6898	.3822	.6226	3.4465	12.666	SOLVENT
82 COMPAIR	30 9 73		22	.1616	.8266	.3753	.8271	3.0792	11.586	SOLVENT
83 COMPTON SONS + WEBB	31 12 73		59	.1627	.5058	.2533	.6692	3.6691	12.593	SOLVENT
84 CONCENTRIC	30 9 73		27	.1527	1.0920	.3356	.3731	6.1595	7.183	SOLVENT
85 COPE ALLMAN INTERNATIONAL	30 6 73		73	.1407	1.0483	.3075	.2825	5.8910	5.600	SOLVENT
86 CORAH (N) (ST. MARGARET)	31 12 73		59	.1659	.4696	.1178	.3911	4.1854	9.209	SOLVENT
87 CORNERCROFT	30 9 73		27	.1138	.7826	.3887	.6378	3.5574	8.983	SOLVENT
88 COSALT	31 12 73		75	.1593 **	1.1024	.3559	.7531	4.5758	9.111	SOLVENT
89 COWAN, DE GROOT	30 4 73		65	.1950	1.1699	.4723	.8594	6.7992	15.278	SOLVENT
90 CRANE FRUEHAUF	31 12 73		43	.1082 **	1.3914	.2940	.1834	5.2331	-1.558	GRAY AREA

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1973

COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	OA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
91 CRITTALL-HOPE ENGINEERING	31 3 73	**	14	.1512 **	.9511	.4367	.6809	6.4636	13.693	SOLVENT
92 CRODA INTERNATIONAL	31 12 73		68	.1820 **	1.1209	.4419	.6781	7.6801	14.183	SOLVENT
93 CROYDEX RUBBER PRODUCTS	31 12 73		3 39	.3132 **	.8340	.4778	.8289	7.7865	25.604	SOLVENT
94 CUMMINS ENGINE CO.	31 12 73		41	.1304	.3766	.2589	.6256	5.6487	8.808	SOLVENT
95 DALE ELECTRIC INTERNATIONAL	29 12 73	*	1 19	.2883 **	2.3436	.3957	.4427	3.8750	-1.336	GRAY AREA
96 DAVENPORT KNITWEAR	31 12 73	**	59	.2812	.4795	.2494	.2401	6.9959	18.589	SOLVENT
97 DELTA METAL CO	31 12 73		32	.1437 **	1.1826	.2973	.4283	4.6522	3.789	GRAY AREA
98 DESOUTER BROTHERS	31 12 73		28	.2729	.4890	.3815	.7987	2.3288	19.717	SOLVENT
99 DEXION-COMINO INTERNATIONAL	31 10 73	*	27	.1388	1.7732	.3746	.1423	7.6933	-.695	GRAY AREA
100 DICKINSON ROBINSON GROUP	31 12 73		54	.1837	.8296	.3492	.7136	5.4318	13.834	SOLVENT
101 DOBSON PARK INDUSTRIES	29 9 73		27	.2269	.7919	.3676	.5713	5.1069	15.084	SOLVENT
102 DUNLOP	31 12 73		41	.0921	.9291	.2774	.6297	4.3843	5.338	SOLVENT
103 DUPONT	31 1 73		27	.1431	.8078	.3482	.5702	6.8941	12.552	SOLVENT
104 EAST SUSSEX ENGINEERING	31 12 73		22	.1338	.8844	.3383	.3242	4.4447	6.360	SOLVENT
105 E. C. CASES	30 9 73	*	17	.1716	.4875	.1565	.1232	6.8997	10.689	SOLVENT
106 ELECTRICAL + INDUSTRIAL SEC.	31 12 73		73	.1166	.6762	.3838	.6584	3.5857	10.428	SOLVENT
107 EVERED AND CO. HOLDINGS	31 12 73		14	.0731	.8171	.4817	.6674	5.5188	10.575	SOLVENT
108 EVODE HOLDINGS	30 9 73		14	.2117 **	.8527	.3914	.3349	8.2895	15.615	SOLVENT
109 EXPANDED METAL CO.	31 12 73		27	.2024	.6021	.2898	.3543	5.4506	13.364	SOLVENT
110 FAIREY CO.LTD.	31 3 73		27	.0870 **	1.1762	.2580	.3665	2.5059	-2.428	INSOLVENT
111 FAIRFAX JERSEY GROUP	30 6 73	*	3 60	.1703 **	.9130	.2774	.4991	2.6436	6.250	SOLVENT
112 FEB INTERNATIONAL	31 12 73	*	68	.1261	1.9549	.4092	.0744	10.0949	-.686	GRAY AREA
113 FISONS	31 12 73		68	.1094	.8922	.3132	.3528	5.3993	5.985	SOLVENT
114 FLIGHT REFUELLING (HOLDINGS)	31 12 73		11	.1253	.6555	.2410	.6595	2.4913	7.550	SOLVENT
115 FOLKES (JOHN) HEFO	31 12 73		27	.1365 **	1.9228	.3107	.0924	4.7283	-7.202	INSOLVENT
116 FOSECO MINSEP	31 12 73		32	.1823	.8431	.4613	.5296	8.8290	17.664	SOLVENT
117 FOX'S BISCUITS	25 5 73		50	.1487	.8932	.3052	.1302	11.5390 *	12.131	SOLVENT
118 FRANCIS INDUSTRIES	31 12 73		73	.0920 **	1.1742	.3388	.5181	5.0725	3.423	GRAY AREA
119 FRANCIS(G.R) GROUP LTD.	31 3 73	*	1 14	.1765 **	1.3972	.4836	.5000	6.8617	9.135	SOLVENT
120 FRENCH (THOMAS) + SONS	30 6 73		62	.2398 **	1.8690	.3837	.1524	6.9259	2.436	GRAY AREA

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
121	GASKELL + CO.(BACUP) LTD	31 12 73		37	.2001	.9788	.3239	.4986	5.3981	10.719	SOLVENT
122	G E I(A/CS.FOR 18MTSH.PRORATA)	31 3 73		27	.0986 **	.9693	.3882	.5583	6.8512	9.129	SOLVENT
123	GESTETNER HOLDINGS LTD.	31 10 73		69	.2204	.5294	.4875	.6775	5.1390	20.580	SOLVENT
124	GLAXO	30 6 73		67	.2185	1.0441	.4279	.9009	4.7356	15.155	SOLVENT
125	GLYNWED LTD.	29 12 73		14	.1648 **	1.2445	.3647	.5895	5.7545	7.868	SOLVENT
126	GRIPPERRODS HOLDINGS	30 4 73	*	37	.3379 **	.8622	.5915 *	.5150	10.8834	29.107	SOLVENT
127	GROSS CASH REGISTERS	30 9 73		69	.1209	1.1297	.3271	.6930	2.7661	4.014	GRAY AREA
128	GUEST KEEN + NETTLEFOLD	31 12 73		27	.1491	.8241	.3231	.4422	4.9580	9.056	SOLVENT
129	HADEN CARRIER	31 12 73		30	.0660	1.9323	.3510	.0892	6.9796	-7.604	INSOLVENT
130	HAIGHTON + DEWHURST	30 6 73		60	.0505	.8239	.3366	.7173	3.1856	4.902	SOLVENT
131	HALL (MATTHEW) +CO.	31 12 73		25	.1150 **	1.8246	.3248	.5258	6.3764	-1.496	GRAY AREA
132	HALL-THERMOTANK	30 9 73		30	.1119	1.1206	.4673	.8280	4.5699	9.075	SOLVENT
133	HARMO INDUSTRIES	31 12 73		41	.2008	.5648	.2730	.3388	4.3903	12.132	SOLVENT
134	HARRIS + SHELDON GROUP.	31 12 73		73	.2358	.7038	.3343	.4214	5.9003	15.598	SOLVENT
135	HARTLEY BAIRD	30 4 73		73	.0497	.7620	.2463	.2133	4.9823	1.837	GRAY AREA
136	HAWKER SIDDELEY GROUP	31 12 73		27	.1450	1.0673	.4451	.5910	4.8840	9.272	SOLVENT
137	HEAD WRIGHTSON + CO	31 1 73		25	.0609	.7979	.4352	.4701	7.4266	9.923	SOLVENT
138	HEPWORTH CERAMIC HOLDINGS	31 12 73		14	.1248	.5846	.3150	.5260	6.1467	12.452	SOLVENT
139	HICKSON + WELCH (HOLDINGS)	30 9 73		68	.1492 **	.7522	.2620	.2887	5.0343	7.688	SOLVENT
140	HOLLIS BROTHERS + F.C.A.	31 3 73		17	.2157	.8444	.4210	.6677	5.4220	15.973	SOLVENT
141	HOMFRAY AND CO.	30 6 73		37	.1676	.3634	.2739	.5837	3.6235	14.000	SOLVENT
142	HOOVER	31 12 73		39	.2352	.5498	.5772	.7868	6.4081	25.775	SOLVENT
143	HOWARD MACHINERY	31 10 73		27	.1404 **	1.3864	.3270	.5058	4.1215	2.011	GRAY AREA
144	I.C.I	31 12 73		68	.1540	.6871	.3230	.5421	5.4502	12.749	SOLVENT
145	I C L	30 9 73		19	.0965	.8277	.3025	1.2253	3.2196	10.733	SOLVENT
146	ILLINGWORTH,MORRIS + CO.	31 3 73		61	.1522	2.0113	.2812	.3459	3.3156	-7.386	INSOLVENT
147	I.M.I	31 12 73		32	.1343	.6911	.2709	.6191	3.9904	9.386	SOLVENT
148	INTERNATIONAL COMBUSTION	31 12 73		20	.1020	.6703	.5308	.5655	4.1935	12.098	SOLVENT
149	INVERESK PAPER CO.	31 12 73		54	.1385	.6170	.5156	.6647	7.4404	18.599	SOLVENT
150	JAMESONS CHOCOLATES	31 12 73		49	.2416	.3935	.5322	.7266	12.9896 *	30.786	SOLVENT

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCF	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
151	JOHNSON + FIRTH BROWN	30 6 73		26	.0468	.8770	.3159	.8553	3.3701	5.139	SOLVENT
152	JEROME(S) + SONS	31 12 73		61	.1363	.7880	.2815	.5941	3.7164	8.062	SOLVENT
153	JEVONS COOPER	30 4 73		28	.0781 **	1.2772	.3192	-.2440	4.6875	-13.282	INSOLVENT
154	JUDGE INTERNATIONAL	26 6 73		40	.1185 **	.8037	.1868	.1409	3.4813	1.488	GRAY AREA
155	KLEEMAN INDUSTRIAL HOLDINGS	31 12 73		27	.2086	.6713	.4396	.6302	5.4766	17.629	SOLVENT
156	LAIRD GROUP	31 12 73		27	.1447	1.0469	.4189	.5354	6.2966	10.156	SOLVENT
157	LAKE + ELLIOT	31 1 73		21	-.0373	.7328	.3023	.3235	2.8126	-2.490	INSOLVENT
158	LAMSON INDUSTRIES	31 12 73		69	.1115	.8476	.3097	.3195	5.2560	6.095	SOLVENT
159	LANCASTER CARPETS + ENG	31 12 73		37	.2220	.8003	.2567	.1766	7.9693	12.841	SOLVENT
160	LANE (PERCY) GROUP	31 12 73	* 1	41	.1731	1.0731	.4065	.5436	6.6785	11.503	SOLVENT
161	LAPORTE INDUSTRIES	31 12 73		68	.1321	.6102	.3138	.6599	4.5618	11.856	SOLVENT
162	LAURENCE SCOTT LTD	31 12 73	4	19	.1031 **	.5647	.3952	.7752	4.1174	12.771	SOLVENT
163	LEAD INDUSTRIES GROUP	31 12 73		32	.1943	.5806	.3061	.5072	7.3835	16.871	SOLVENT
164	LEE (ARTHUR) + SONS LTD.	30 9 73		33	.1388	.6240	.3298	.5645	4.2029	11.095	SOLVENT
165	LESNEY PRODUCTS AND CO.	28 1 73		65	.1544	.4994	.4555	.6198	7.1792	19.020	SOLVENT
166	LEY'S FOUNDRIES + ENGINEERING	30 9 73		33	.0692	.3406	.3639	.5396	5.4884	12.719	SOLVENT
167	LINCROFT KILGOUR GROUP	30 9 73		59	.2001	.8358	.3668	.6334	6.3944	15.235	SOLVENT
168	LINDUSTRIES LTD	30 9 73		73	.1396	.7856	.2886	.4572	4.4161	8.001	SOLVENT
169	LINREAD LTD	31 7 73		27	.1309 **	.6840	.3638	.6528	5.2560	12.491	SOLVENT
170	LONDON BRICK CO.	31 12 73		12	.2230	.4819	.2642	.1421	15.3516 *	19.710	SOLVENT
171	LONSDALE UNIVERSAL	30 9 73		53	.1536 **	1.2533	.3179	.3796	6.5510	5.618	SOLVENT
172	LUCAS (JOSEPH) INDS.	31 7 73		41	.1125	.6140	.3695	.6098	5.1480	12.018	SOLVENT
173	MCCORQUODALE + CO.	30 9 73		19	.1418	.5598	.3721	.5753	6.3795	15.136	SOLVENT
174	MACKAY HUGH + CO.	31 12 73		37	.2291	.4238	.4167	.7613	5.4246	21.986	SOLVENT
175	MCKECHNIE BROTHERS	31 7 73		32	.2370	.6448	.3251	.5408	4.9513	16.097	SOLVENT
176	MACPHERSON (DONALD) GROUP	31 10 73		16	.1580	.8238	.4250	.7779	5.9164	14.943	SOLVENT
177	MALLINSON (WILLIAM) + DENNY	31 12 73		17	.2256	1.8706	.4069	.7018	5.8423	5.466	SOLVENT
178	MANBRE + GARTON	30 9 73		49	.1285	.5501	.1157	.0704	9.9462	10.188	SOLVENT
179	MARLEY	31 10 73		14	.2109	.7076	.3184	.4082	7.4261	15.717	SOLVENT
180	MARSHALL(THOMAS)+CO.(LOXLEY)	31 12 73		25	.0913	1.0192	.3743	.3512	4.8734	4.103	GRAY AREA

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1973

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	CA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
181	MARSHALL, MORGAN + SCOTT	31 12 73		53	.1571 **	1.6818	.4063	.2230	5.9558	.283	GRAY AREA
182	MARSHALL'S UNIVERSAL	31 12 73		73	.2115	.7147	.3156	.5708	8.0220	17.575	SOLVENT
183	MARTIN(ALBERT) HOLDINGS	31 12 73		59	.1406 **	.0722	.2273	.3583	4.5866	4.330	GRAY AREA
184	MARTIN-BLACK	31 12 73		26	.1516	.9017	.3393	.3997	5.0368	8.305	SOLVENT
185	MARTONAIR INTERNATIONAL	31 7 73		24	.2268 **	.8020	.3724	.7610	3.0870	14.387	SOLVENT
186	MATHER + PLATT	31 12 73		22	.0771	1.2687	.3752	.8030	2.4830	1.749	GRAY AREA
187	MATTHEWS (BERNARD) LTD.	31 12 73	* 2	43	.2434 **	1.1549	.3152	.2972	5.6293	9.276	SOLVENT
188	MEGGITT HOLDINGS	31 10 73		28	.1361	1.0819	.3594	.6735	5.1039	8.212	SOLVENT
189	METAL CLOSURES GROUP	31 12 73		54	.2155	.6217	.3866	.5296	6.6818	18.148	SOLVENT
190	METTOX CO.	31 12 73		65	.1487	.7913	.4086	.4765	9.4895	16.078	SOLVENT
191	M K REFRIGERATION	31 10 73		30	.3337	.5527	.4182	.7416	3.8660	23.719	SOLVENT
192	MORGAN CRUCIBLE CO.	31 12 73		27	.1585	.8931	.2843	.2889	5.2785	7.185	SOLVENT
193	MORRIS(HERBERT) LTD	31 10 73		22	.0633	.8347	.3425	.5441	2.9452	3.790	GRAY AREA
194	MUIRHEAD	30 9 73		35	.1046	.6151	.3164	.7995	2.7707	9.714	SOLVENT
195	NAIRN AND WILLIAMSON	31 12 73		37	.1841	.5481	.4018	.6119	5.4913	17.091	SOLVENT
196	NEEPSEND	31 3 73		27	.0427	.8371	.3433	.3498	4.2853	2.662	GRAY AREA
197	NEGRETTI + ZAMBRA	31 3 73		31	.1099	.5797	.3463	.6771	3.3150	10.442	SOLVENT
198	NEIL + SPENCER HOLDINGS	30 11 73		22	.1784	.9001	.3254	.6109	3.5361	9.469	SOLVENT
199	NEWALL MACHINE TOOL CO.	31 3 73		28	-.0768	1.2886	.2982	.8222	1.6912	-7.779	INSOLVENT
200	NEWEY + TAYLER	31 12 73		75	.1091	.6054	.3253	.7215	3.0775	9.874	SOLVENT
201	NEWMAN INDUSTRIES	31 12 73		19	.0893	1.6094	.4133	.2461	3.8124	-4.005	INSOLVENT
202	NORCROS LTD.	30 11 73		73	.2058	1.1861	.3758	.3330	9.1358	12.264	SOLVENT
203	NORTH BRITISH STEEL GROUP	28 9 73		21	.0317	.4483	.3865	.4953	4.9284	9.110	SOLVENT
204	NOTTINGHAM MANUFACTURING CO.	31 12 73		59	.1827	.6194	.3564	.7005	7.9243	18.899	SOLVENT
205	OFREX GROUP	31 12 73		59	.1862	.8399	.4018	.5626	4.1683	12.057	SOLVENT
206	OSBORN (SAMUEL) AND CO.	30 9 73		33	.0614	.8526	.2572	.7102	2.7044	3.215	GRAY AREA
207	OXLEY PRINTING GROUP	31 12 73		53	.1019	1.4935	.4167	.1283	11.6404 *	4.976	SOLVENT
208	OZALID GROUP HOLDINGS	31 12 73		69	.1721 **	.9271	.3500	.7093	4.6660	11.325	SOLVENT
209	PLAXTON'S (SCARBOROUGH)	31 8 73		43	.3654	.9724	.3881	.7505	6.1811	22.662	SOLVENT
210	PICKLES (WILLIAM + CO.	31 12 73		62	.1217	.9177	.3141	.6665	5.0114	11.832	SOLVENT

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1973

	COMPANY	A/CS ENDING		DESCR.	IND.	EBIT/TA(T-1)		TL/NCE		OA/TA	WC/NW	STOCKTURN		Z-SCORE	CLASSIF.
211	PLESSEY TELECOMMUNICATIONS	30	6 73		19	.1138		.5987		.2976	.5432	3.4791		8.689	SOLVENT
212	P.M.A. HOLDINGS	30	9 73		73	.0600	**	.9733		.3337	.3744	7.1166		5.128	SOLVENT
213	PORTALS HOLDINGS	31	12 73		73	.1226		.9214		.4196	.5333	6.6252		10.867	SOLVENT
214	PRATT (F.) ENGINEERING	31	10 73		27	.1343		.7019		.2959	.6932	3.2212		9.455	SOLVENT
215	RANSOMES, SIMS + JEFFERIES	31	12 73		27	.1047		.5217		.2331	.6100	2.1605		7.168	SOLVENT
216	RANK ORGANISATION	31	10 73		69	.1836		.6949		.1969	.2902	7.8871		12.066	SOLVENT
217	RANKS HOVIS MCDOUGALL	31	8 73		50	.1150		.7283		.3120	.5233	10.7248		15.347	SOLVENT
218	RANSOME HOFFMANN POLLARD	30	9 73		27	.0570		.8323		.2461	.7228	2.6849		3.134	GRAY AREA
219	R.C.F. HOLDINGS	31	7 73		28	.1196		.8140		.2819	.5242	2.9765		5.589	SOLVENT
220	RECKITT + COLEMAN	31	12 73		67	.1801		.7122		.3263	.4870	5.1626		12.437	SOLVENT
221	RECORD RIDGWAY LTD.	30	9 73		28	.1263		.5174		.2407	.3217	3.8473		7.845	SOLVENT
222	REDFEARN NATIONAL GLASS	30	9 73		54	.1887		.7405		.4038	.5340	12.0599	*	20.693	SOLVENT
223	REDLAND LTD	31	3 73		12	.2481		1.0154		.2907	.4665	10.8938		17.844	SOLVENT
224	REDNOR	31	12 73	**	27	.1633	**	1.0613		.5236	.9980	8.0930		18.391	SOLVENT
225	REVERTEX HOLDINGS	31	12 73		68	.1323		.9879		.3135	.3171	5.3548		5.667	SOLVENT
226	REYROLLE PARSONS	31	12 73		19	.0549		.9747		.3999	.7243	3.6712		5.519	SOLVENT
227	RICHARDS LTD.	30	9 73		60	.1383		.5753		.2940	.7085	4.3121		12.347	SOLVENT
228	ROCKWARE GROUP	31	12 73		54	.0856		.8501		.2494	.2967	6.7600		5.322	SOLVENT
229	ROLLS ROYCE MOTORS(HLDGS) LTD.	31	12 73	1	43	.1466		.9624		.2019	.7030	2.7517		5.141	SOLVENT
230	ROTAFLEX (GREAT BRITAIN)	31	12 73	*	19	.2176	**	1.8557		.3884	.5814	4.6468		2.637	GRAY AREA
231	ROTORK	31	12 73		24	.0922		1.5405		.4103	.2996	4.9637		-1.435	GRAY AREA
232	ROWTREE MACKINTOSH	31	12 73		49	.1405		1.3013		.2397	-.0928	7.2358		.029	GRAY AREA
233	ROYAL SOVEREIGN PENCIL CO.	31	12 73		69	.1806		.7772		.3560	.4900	6.1918		13.374	SOLVENT
234	ROYAL WORCESTER	31	12 73		73	.1731	**	.7768		.4709	.9143	4.4309		16.462	SOLVENT
235	RUGBY PORTLAND CEMENT CO.	31	12 73		15	.1723		.5263		.3031	.2936	7.6588		14.919	SOLVENT
236	SANGAMO WESTON	31	12 73	**	35	.1324		.7262		.3172	.5111	3.5212		8.248	SOLVENT
237	SCRAGG (ERNEST) + SONS	30	9 73		22	.1600	**	1.2489		.4936	.8395	3.1820		8.872	SOLVENT
238	SEARS HOLDINGS	31	1 73		73	.1467	**	.5940		.1738	.2405	6.9641		9.727	SOLVENT
239	SELINCOURT	31	1 73		59	.1392	**	1.2318		.3180	.8726	4.7823		7.299	SOLVENT
240	SENIOR ENGINEERING GROUP	31	12 73		20	.1633		.6795		.2555	.2831	5.4078		9.435	SOLVENT

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1973

COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
241 SEROK	30 9 73		27	.0977	.9279	.3129	.5588	3.8506	5.023	SOLVENT
242 SHAW (FRANCIS) AND CO. LTD.	31 12 73		22	.0702	1.7853	.3889	.9314	2.2283	-3.363	INSOLVENT
243 SHEFFIELD TWIST DRILL + STEEL	31 12 73		28	.1450	.7245	.2457	.6200	2.5492	7.533	SOLVENT
244 SIDLAW INDUSTRIES	30 9 73		62	.0724	1.0201	.2707	.5665	3.9336	2.252	GRAY AREA
245 SILENTBLOC HOLDINGS	30 9 73		41	.0724	.4609	.3000	.3590	4.9604	8.409	SOLVENT
246 SIMON ENGINEERING	31 12 73		25	.0995	1.3303	.5304	.4763	16.1208 *	11.418	SOLVENT
247 SMITH + NEPHEW	29 12 73		67	.1780	.8627	.3873	.5395	5.4564	12.400	SOLVENT
248 SPEAR + JACKSON INTERNATIONAL	31 12 73		28	.1386	.9692	.3451	.6983	3.7329	5.059	SOLVENT
249 SPENCER CLARK METAL INDUSTRIES	30 9 73		28	.1159	.7827	.3271	.6457	3.5154	8.095	SOLVENT
250 SPILLERS	31 1 73		50	.0761	.8432	.1676	.0379	10.9575	6.098	SOLVENT
251 SPIRAX-SARCO ENGINEERING	31 12 73		24	.2181	.8591	.3684	.6841	4.0821	13.726	SOLVENT
252 SPIRELLA GROUP	30 11 73		62	.1521	.9187	.2736	.7684	3.5310	8.456	SOLVENT
253 STAFLEX INTERNATIONAL	31 12 73		59	.1439 **	1.4780	.3658	1.0794	3.2564	5.573	SOLVENT
254 STAG FURNITURE HOLDINGS	31 12 73	* 2	38	.2594 **	1.0323	.3889	.3711	8.0793	15.904	SOLVENT
255 STAVELEY INDUSTRIES	30 9 73		28	.0945	.8718	.3627	.5480	5.4271	7.958	SOLVENT
256 STEEL BROTHERS HOLDINGS	31 12 73	** 3	73	.1096 **	1.4373	.3111	.2060	6.0555	-.634	GRAY AREA
257 STEETLEY COMPANY	31 12 73		25	.1785	.8660	.3556	.6316	8.4398	15.921	SOLVENT
258 STONE-PLATT INDUSTRIES	31 12 73		22	.1178 **	1.2097	.4897	1.0208	3.6227	9.272	SOLVENT
259 STOREY BROTHERS AND CO.	31 12 73		66	.1595 **	1.0978	.3338	.4408	4.1802	5.793	SOLVENT
260 TATE + LYLE	30 9 73		49	.1011	.9767	.2937	.3231	10.3012	9.560	SOLVENT
261 THOMSON T-LINE CARAVANS	31 12 73		43	.2096 **	.7655	.4083	.6355	5.0735	15.713	SOLVENT
262 THURGAR BARDEX	31 12 73		68	.0106	.9083	.3954	.2282	8.7598	5.110	SOLVENT
263 TILLING (THOMAS)	31 12 73		73	.1400 **	1.1136	.3024	.4431	5.6746	5.841	SOLVENT
264 TOMKINSONS (HOLDINGS)	30 9 73		37	.2010	.6160	.2816	.5859	5.0386	14.462	SOLVENT
265 TRIANCO GROUP	31 12 73		27	-.0869	1.7920	.3453	.4417	3.7595	-14.001	INSOLVENT
266 TRUTEX LTD.	31 12 73		59	.2001	.7395	.2202	.6991	4.6250	12.517	SOLVENT
267 TUBE INVESTMENTS	31 3 73		27	.1221	.7863	.3336	.7136	4.1728	9.741	SOLVENT
268 TURNER + NEWALL	31 12 73		14	.1322	.6149	.2676	.5378	3.9838	9.407	SOLVENT
269 TURNER MANUFACTURING CO.	30 9 73		41	.1658	.5728	.3793	.4373	6.3624	15.090	SOLVENT
270 UNICORN INDUSTRIES	31 12 73		27	.1662	.6500	.2742	.6295	2.7402	10.131	SOLVENT

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1973

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
271	UNILEVER	31 12 73		49	.1840	.8072	.3579	.6739	7.0000	15.643	SOLVENT
272	UNITED BISCUITS (HOLDINGS)	31 12 73		50	.1446	.7927	.2133	.2082	10.9836	12.191	SOLVENT
273	UNITED GAS INDUSTRIES	31 3 73		39	.0416	1.1243	.2966	.9232	3.4560	2.457	GRAY AREA
274	UNITED GLASS	31 12 73		54	.1464	.7948	.3792	.4590	6.7850	12.322	SOLVENT
275	UNITED SPRING + STEEL GROUP	30 9 73		27	.1868 **	.9533	.4169	.4662	7.7257	14.183	SOLVENT
276	UNITED SCIENTIFIC HOLDINGS LTD	31 12 73		31	.1196	.9708	.2221	.2543	2.4126	.003	GRAY AREA
277	UNITED WIRE GROUP LTD	30 9 73		26	.1948 **	.6477	.2833	.4669	3.9795	11.690	SOLVENT
278	UNOCHROME INTERNATIONAL	30 6 73		27	.0392	1.1902	.3272	.0128	3.8661	-4.972	INSOLVENT
279	VANTONA LTD	31 3 73		62	.1552	1.1427	.2675	.6890	3.7545	5.586	SOLVENT
280	VICKERS	31 12 73		27	.0738 **	.8507	.3333	.3746	4.1138	3.857	GRAY AREA
281	VOSPER	31 10 73	**	29	.0688	2.4348	.2694	-.0162	3.5285	-19.058	INSOLVENT
282	WADKIN LTD.	31 12 73		28	.1162 **	.8037	.3850	.7583	2.9729	9.150	SOLVENT
283	WAGON REPAIRS LTD.	31 3 73		27	.1544	1.2254	.4328	.5406	5.5152	8.029	SOLVENT
284	WARD AND GOLDSTONE	31 3 73		19	.2332	.8210	.3778	.4563	5.6870	14.914	SOLVENT
285	WARD (THOS.W.)	30 9 73		27	.1116	.6401	.2947	.4843	6.0472	10.415	SOLVENT
286	WEDGWOOD	31 3 73		40	.1697	.5213	.2455	.5741	3.3925	11.534	SOLVENT
287	WEIR GROUP	31 12 73		27	.0911	1.1714	.3995	.7371	6.0554	7.295	SOLVENT
288	WESTINGHOUSE BRAKE + SIGNAL CO	29 9 73		19	.1109 **	.7108	.4268	.6608	3.0721	9.925	SOLVENT
289	WESTLAND AIRCRAFT	30 9 73		11	.1226	.7247	.5603	1.0542	3.5077	16.234	SOLVENT
290	WHESSOE	29 9 73		25	.1496	1.0857	.4372	.4680	6.9320	10.350	SOLVENT
291	WILKES(JAMES)	31 12 73		69	.1839	.5919	.4634	.5846	8.5773	20.768	SOLVENT
292	WILMOT-BREEDEN (HOLDINGS)	31 12 73		41	.1324	.8816	.3472	.5889	5.4840	9.803	SOLVENT
293	WINN INDUSTRIES	31 12 73		73	.0929	1.2168	.3863	.5424	5.4555	4.385	SOLVENT
294	WORTH(BOND) HOLDINGS LTD.	30 6 73		37	.1058	1.9413	.3779	.5130	5.5505	-3.392	INSOLVENT
295	YORK TRAILER CO.	31 12 73	**	43	.1849 **	1.7976	.2361	.0602	5.0585	-4.608	INSOLVENT
296	YOUGHAL CARPETS (HOLDINGS)	31 12 73		37	.2851	.8360	.1858	.4284	3.8830	11.873	SOLVENT

KEY

UNDER DESCR.HEADING

* DENOTES OVER 50PC. EQUITY CONTROLLED BY DIRECTORS
** DENOTES COMPANY IS A SUBSIDIARY OF ANOTHER
A DIGIT DENOTES THE NUMBER OF COMPLETED FINANCIAL YEARS PUBLICALLY QUOTED IF LESS THAN 5

FOLLOWING A RATIO

* DENOTES ORIGINAL RATIO OUTSIDE 3*SD OF MEAN AND IS REPLACED BY LIMIT
** DENOTES TOTAL ASSET GROWTH.GT.30PC.AND AVERAGE TOTAL ASSETS USED IN EBIT/TA COMPUTATION

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1974

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)		TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
1	AARONSON BROTHERS	30 9 74		17	.1457		1.1420	.3197	.1897	5.2893	3.556	GRAY AREA
2	ACROW (ENGINEERS)	31 3 74		23	.0947		1.0215	.2445	.5031	2.4424	.702	GRAY AREA
3	ADWEST GROUP	30 6 74		27	.1842		.7516	.3305	.4871	3.8766	10.842	SOLVENT
4	AIRFIX INDUSTRIES	31 3 74		65	.2165		.8878	.2927	.6192	4.3820	11.892	SOLVENT
5	ALBRIGHT + WILSON	31 12 74		68	.2094		.8429	.3877	.7496	4.6945	15.023	SOLVENT
6	ALLEN (EDGAR) + CO.LTD	31 3 74		21	.1025	**	.8863	.2579	.4945	3.5872	4.000	GRAY AREA
7	ALLIED COLLOIDS	31 3 74		60	.3255		1.1665	.3711	.4025	5.9652	15.241	SOLVENT
8	AMALGAMATED POWER ENGINEERING	31 12 74		24	.0818		1.0027	.3747	.9247	3.3259	6.881	SOLVENT
9	ANDERSON STRATHCLYDE	31 3 74		22	.1338		.7098	.2971	.8430	2.2566	9.520	SOLVENT
10	ARMITAGE SHANKS GROUP	30 3 74		14	.2626		.7701	.3314	.5881	5.6018	17.123	SOLVENT
11	ARMSTRONG EQUIPMENT	30 6 74		41	.1585	**	1.2666	.2736	.4623	3.4438	2.239	GRAY AREA
12	ASSOCIATED BISCUIT MANUFACT	31 12 74		50	.1268		.7326	.2862	.4722	10.4017	14.665	SOLVENT
13	ASSOCIATED ENGINEERING	30 9 74		41	.1166		1.1346	.2946	.7550	3.6446	4.702	SOLVENT
14	ASSOCIATED PORTLAND CEMENT	31 12 74		15	.0797	**	.4300	.1282	.1115	5.1457	4.462	SOLVENT
15	ASSOCIATED SPRAYERS	31 8 74		39	.0947	**	2.0082	.3159	.0298	5.0470	-10.230	INSOLVENT
16	AURORA GEAR + ENGINEERING CO.	30 6 74		27	.1510	**	1.4251	.3025	.3411	4.4046	.632	GRAY AREA
17	AVANA GROUP	31 3 74		50	.0368		.9106	.2469	.1907	6.6945	1.327	GRAY AREA
18	AVON RUBBER CO.	28 9 74		41	.0865		1.5141	.3064	.3309	4.9348	-2.874	INSOLVENT
19	BARKER + DOBSON LTD	30 3 74		49	.0639		1.0808	.1859	.0038	10.5030	2.369	GRAY AREA
20	BASSETT (GEO.) HOLDINGS	31 3 74		49	.1490		1.0676	.2595	.0011	10.9188	8.210	SOLVENT
21	BATH AND PORTLAND GROUP	31 10 74		73	.1069		1.7102	.3301	.3724	5.0445	-3.252	INSOLVENT
22	BEAUFORD GROUP	31 12 74	*	2 27	.1050		1.6972	.2764	.7929	3.3838	-2.425	INSOLVENT
23	BEECHAM GROUP	31 3 74		67	.2284		.7786	.2940	.4077	6.4486	14.230	SOLVENT
24	BEYER, PEACOCK + CO.	31 3 74		27	-.0136		.6963	.2794	.5809	2.7014	.823	GRAY AREA
25	BIBBY(J)+SONS	31 12 74		49	.0774		1.1987	.3627	.4658	8.2513	5.909	SOLVENT
26	BIFURCATED ENGINEERING	31 12 74		27	.1577		.9960	.3145	.3335	4.1400	5.600	SOLVENT
27	BIRMID QUALCAST	3 8 74		27	.1149		.8022	.3819	.6994	5.4578	11.305	SOLVENT
28	BLACKMAN + CONRAD	30 9 74		59	.1770		.9057	.1509	.1199	4.7376	3.747	GRAY AREA
29	BLACKWOOD MORTON + SONS	30 6 74		37	.0731		.8896	.2272	.4581	3.4288	1.585	GRAY AREA
30	BOLTON TEXTILE MILL CO.	30 4 74		59	.1034		1.1844	.3305	.4502	5.7575	3.910	GRAY AREA

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1974

COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
31 BONSER ENGINEERING	30 11 74	*	23	.0887	.7583	.3025	.6731	2.0751	5.314	SOLVENT
32 BOWATER CORPORATION	31 12 74		73	.1404	1.1149	.3227	.4823	9.2080	10.390	SOLVENT
33 BOWTHORPE HOLDINGS	31 12 74		19	.2660	.6796	.3264	.6051	3.9737	16.564	SOLVENT
34 BPB INDUSTRIES	31 3 74		14	.1420	.8377	.2556	.3984	7.8270	10.267	SOLVENT
35 BRAHAM MILLAR GROUP	31 3 74		23	.1102	.7445	.3342	.4318	4.1139	7.259	SOLVENT
36 BRIGHT (JOHN) GROUP	31 3 74		62	.1168	.4580	.3239	.7415	4.7194	13.844	SOLVENT
37 BRITISH ELECTRIC TRACTION CO	31 3 74		73	.1389	.6555	.2723	.0608	7.3239	6.846	SOLVENT
38 BRITISH INSULATED CALLENDER'S	31 12 74		19	.1158	** .9372	.3254	.4359	5.9187	7.248	SOLVENT
39 BRITISH OXYGEN COMPANY	30 9 74		68	.1076	.9067	.2243	.3486	4.4501	3.211	GRAY AREA
40 BRITISH STEAM SPECIALITIES	30 3 74		24	.0577	.7864	.2301	.3911	4.7481	2.962	GRAY AREA
41 BROCKHOUSE (J) + CO.	30 9 74		21	.1438	1.3915	.3746	.3895	5.4871	3.432	GRAY AREA
42 BROCKS GROUP OF COMPANIES	31 12 74		75	.1502	.9852	.1912	.1098	3.2709	.551	GRAY AREA
43 BROOKE BOND LIEBIG	30 6 74		49	.1183	.9076	.2358	.5161	4.1812	4.985	SOLVENT
44 BROTHERHOOD(PETER)	31 3 74		22	.1309	.7681	.3191	.5369	2.4829	5.378	SOLVENT
45 BROWN + TAWSHE LTD.	31 3 74		33	.1723	** .9814	.4237	.4666	6.3147	11.737	SOLVENT
46 BROWN(JOHN) + CO	31 3 74		28	.0636	1.2402	.2956	.6345	3.1669	-.491	GRAY AREA
47 BSR	31 12 74		35	.2584	.7757	.4550	.7390	4.4226	18.824	SOLVENT
48 BTR LTD	31 12 74		66	.1758	** 1.1736	.3284	.5266	4.8542	7.082	SOLVENT
49 BULGIN(A.F) + CO.LTD	31 1 74		35	.3440	.4805	.6335	* .7074	5.0842	28.878	SOLVENT
50 BULMER + LUMB (HOLDINGS)	31 3 74		61	.1008	.8835	.2446	.3060	6.3172	5.179	SOLVENT
51 BURGESS PRODUCTS COMPANY	31 7 74		27	.0810	** 1.0299	.2860	.6164	3.1977	2.437	GRAY AREA
52 BURY + MASCO (HOLDINGS)	31 12 74		62	.1705	.6081	.2790	.6407	4.8909	13.345	SOLVENT
53 CARAVANS INTERNATIONAL	31 8 74		43	.0709	1.6227	.2320	.2469	3.8205	-7.971	INSOLVENT
54 CARPETS INTERNATIONAL	28 12 74		37	.0949	.8134	.2881	.8008	3.8895	7.811	SOLVENT
55 CELESTON INDUSTRIES	31 3 74		35	.1747	.5362	.3346	.5930	5.2711	15.283	SOLVENT
56 CENTRAL WAGON CO	31 12 74		33	.2227	** 1.2969	.3943	.4571	7.5830	11.449	SOLVENT
57 CHAMBERLAIN PHIPPS	31 3 74		64	.1684	.9801	.3696	.6884	6.9280	13.195	SOLVENT
58 CHAPMAN + CO.(BALHAM)	31 3 74		54	.2063	.5555	.3542	.5051	6.8606	17.918	SOLVENT
59 CHLORIDE GROUP	31 3 74		41	.1808	** .9050	.3349	.6763	4.7217	11.528	SOLVENT
60 CHUBB + SON	31 3 74		27	.1413	.9184	.3662	.7836	4.3248	10.458	SOLVENT

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
61	CLAYTON DEWANDRE HOLDINGS	31 12 74		41	.1646	1.0019	.3511	.7101	3.8256	9.225	SOLVENT
62	COALITE + CHEMICAL PRODUCTS	31 3 74		72	.1043	.4027	.1988	.2210	6.9670	10.003	SOLVENT
63	COATES BROTHERS + CO	31 12 74		53	.2450	.6337	.3493	.5308	5.8823	17.941	SOLVENT
64	COHEN (GEORGE) 600 GROUP	31 3 74		28	.1097	.8462	.3802	.8539	5.0283	11.342	SOLVENT
65	COMPAIR	30 9 74		22	.1568	1.0350	.3726	.8773	2.9477	9.253	SOLVENT
66	COPE ALLMAN INTERNATIONAL	30 6 74		73	.1572	1.2237	.3175	.3122	5.2390	4.112	GRAY AREA
67	COURTAULDS	31 3 74		60	.1796	.8605	.3905	.8206	4.5681	13.898	SOLVENT
68	CRAY ELECTRONICS	30 4 74	** 4	35	.0816	1.7296	.3467	.5587	3.5178	-4.546	INSOLVENT
69	CRITTAL-HOPE ENGINEERING	31 3 74	**	14	.0537	1.2196	.3636	.5540	5.8522	2.649	GRAY AREA
70	CRODA INTERNATIONAL	31 12 74		68	.2644	1.0294	.3496	.6310	7.3752	16.908	SOLVENT
71	CROWN HOUSE	31 3 74		73	.1097	1.6940	.4746	.6864	7.6465	4.881	SOLVENT
72	CULTER GUARD BRIDGE HOLDINGS	31 3 74		54	.0951	.6024	.3401	.4473	7.6570	12.257	SOLVENT
73	CUSSONS GROUP	31 3 74		67	.1888 **	1.0942	.3899	.6449	6.5026	12.390	SOLVENT
74	DALE ELECTRIC INTERNATIONAL	28 12 74	* 2	19	.2874 **	1.6037	.3752	.7744	3.5254	8.935	SOLVENT
75	DANKS GOWETTON	31 30 74		33	.1649 **	.9406	.4755	.5810	8.7053	16.265	SOLVENT
76	DARTMOUTH INVESTMENTS	31 3 74		20	.1500	1.4167	.3857	.1326	6.2413	2.336	GRAY AREA
77	DECCA	31 3 74		35	.1909	1.2102	.4424	.9326	4.4441	12.154	SOLVENT
78	DE LA RUE	31 3 74		73	.1620 **	.8330	.3618	.2808	5.2280	9.167	SOLVENT
79	DENBYWARE	31 3 74		40	.2569	.4821	.2313	.3610	4.4293	15.277	SOLVENT
80	DICKINSON ROBINSON GROUP	31 12 74		54	.2344	.8425	.3201	.7273	5.3670	15.675	SOLVENT
81	DIMPLEX INDUSTRIES	31 3 74		39	.1561 **	1.5135	.1901	.3383	3.0416	-3.470	INSOLVENT
82	DORSON PARK INDUSTRIES	28 9 74		27	.1926	.9819	.3767	.6239	4.8778	11.648	SOLVENT
83	DOM HOLDINGS	31 3 74		27	.2297 **	1.0644	.4659	.7663	3.1736	13.252	SOLVENT
84	DONCASTER (DANIEL) + SONS	31 3 74		21	.0875	.7749	.2954	.7603	4.1183	7.939	SOLVENT
85	DORMAN SMITH HOLDINGS	31 3 74	*	19	.3243 **	.9034	.4065	.6168	5.6397	20.078	SOLVENT
86	DOWTY GROUP	31 3 74		11	.1593	.5840	.3885	.8175	3.3487	14.627	SOLVENT
87	DUCTILE STEELS	3 6 74		33	.2912	.8131	.4703	.6363	7.2548	22.489	SOLVENT
88	DUPORT	31 7 74		27	.1389 **	.8059	.3234	.4929	6.9919	11.439	SOLVENT
89	EASTWOOD (J.H.)	31 3 74		49	.1714 **	.9521	.1515	.2244	7.3534	6.729	SOLVENT
90	ECONA	31 3 74		14	.1567	.6689	.4494	.5523	5.6768	14.919	SOLVENT

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1974

	COMPANY	A/CS ENDING		DESCR.	IND.	EBIT/TA(T-1)		TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
91	ECONOMIC GROUP	31	3 74		27	.1462		1.2409	.3234	.3450	6.2961	4.926	SOLVENT
92	EDBRO (HOLDINGS)	31	3 74		41	.2271		.7164	.4064	.5240	5.5385	16.654	SOLVENT
93	ELLIOTT (B.)+CO.	31	3 74		28	.1492		1.3514	.4226	.8373	4.6555	7.710	SOLVENT
94	E.R.F. (HOLDINGS)	31	3 74		43	.1313		1.3368	.1603	.5787	3.5465	-.613	GRAY AREA
95	EVER READY	3	3 74		35	.2028		.9786	.2398	.2388	4.2188	6.032	SOLVENT
96	EVODE HOLDINGS	28	9 74		14	.2120		.9819	.3681	.3540	6.8545	12.383	SOLVENT
97	FAIREY CO.	31	3 74		27	.0678		1.0873	.2632	.4135	2.5431	-1.833	INSOLVENT
98	FAIRFAX JERSEY GROUP	30	6 74		3 60	.0633	**	1.3631	.2695	.2741	2.6925	-5.829	INSOLVENT
99	FERGUSON INDUSTRIAL HOLDINGS	28	2 74		73	.1656	**	1.4117	.4782	.5289	8.9867	10.942	SOLVENT
100	FINE ARTS DEVELOPMENTS	31	3 74		53	.2670		.7177	.2867	.6507	3.9302	15.870	SOLVENT
101	FISONS	31	12 74		68	.1301		.9893	.2500	.3821	4.7568	4.391	SOLVENT
102	FOX'S BISCUITS	25	5 74		50	.0459	**	1.4207	.2980	.0326	9.4530	-1.392	GRAY AREA
103	FRANCIS (G.R.) GROUP	31	3 74	*	2 14	.2175		1.6063	.4460	.5387	5.8343	7.320	SOLVENT
104	FRENCH(THOMAS) +SONS LTD	30	6 74	*	62	.2661		1.7501	.3719	.3670	5.2598	4.768	SOLVENT
105	GALLENKAMP (A.) + CO.	30	6 74		31	.1631		1.1565	.3162	.7874	3.4391	7.068	SOLVENT
106	GENERAL ENGINEERING CO.(RATCL)	31	3 74		27	.0947		2.1365	.2892	.1270	2.1092	-14.536	INSOLVENT
107	GENERAL ELECTRIC CO	31	3 74		19	.1442		.7738	.3903	.6100	3.8658	10.664	SOLVENT
108	GLAXO HOLDINGS	30	6 74		67	.2352		1.0521	.4489	.9367	4.5976	16.350	SOLVENT
109	GLYNHED	28	12 74		14	.1680		1.2426	.3383	.6746	5.1678	7.670	SOLVENT
110	GOLDREI (CH.) FOUCARD + SON	29	3 74		49	.1125		1.1690	.3599	.4176	9.4698	8.813	SOLVENT
111	GORDON JOHNSON-STEPHENS	28	2 74		22	.1624	**	1.3512	.5073	.7087	7.2605	11.527	SOLVENT
112	GREENING (N.) + SONS	31	3 74		26	.0871		.3927	.2279	.3845	3.0871	6.845	SOLVENT
113	GRIPPERRODS HOOLINGS	30	4 74	*	37	.3287	**	.9096	.4572	.4454	9.2368	23.588	SOLVENT
114	GUEST,KEEN AND NETTLEFOLDS LTD	31	12 74		27	.1558		.9957	.3069	.4697	5.0450	7.513	SOLVENT
115	HALL (MATTHEW)+CO.	31	12 74		25	.0940		1.9061	.3209	.5961	5.7403	-3.593	INSOLVENT
116	HANKER SIDDELEY GROUP	31	12 74		27	.1104		1.0628	.3338	.6482	2.9694	4.224	GRAY AREA
117	HEAD, WRIGHTSON + CO	31	1 74		25	.0692	**	1.2685	.4388	.3815	7.6046	4.570	SOLVENT
118	HENDERSON (P.C.)	28	2 74		14	.1871		.9940	.3571	.4426	4.5925	9.118	SOLVENT
119	HEPWORTH CERAMIC HOLDINGS	31	12 74		14	.1037		.6968	.2691	.5304	5.6239	8.900	SOLVENT
120	HESTAIR	31	1 74		73	.0667	**	1.2308	.3095	.4776	3.5418	-.916	GRAY AREA

COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)		TL/NCE	CA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
121 HICKSON + WELCH (HOLDINGS)	30 9 74		68	.1743		.8881	.2683	.3019	4.6801	7.183	SOLVENT
122 HIELD BROTHERS	31 3 74		61	.1805	**	.8488	.1845	.6813	2.7372	7.549	SOLVENT
123 HIGHAMS	31 3 74		60	.1402		1.1859	.2696	.6272	4.3907	4.614	SOLVENT
124 HOLLIS BROS. + E.S.A.	31 3 74		17	.2250	**	1.4630	.4098	.5866	5.3528	8.571	SOLVENT
125 HOMFRAY AND CO	30 6 74		37	.1631		.4631	.2301	.6089	3.1678	11.658	SOLVENT
126 HOPKINSONS HOLDINGS	31 1 74		24	.1153		.3060	.3395	.7420	2.0270	12.767	SOLVENT
127 HOUCHIN	30 4 74	*	11	.1701		.6285	.2698	.4059	3.1522	9.092	SOLVENT
128 HOWARD MACHINERY	31 10 74		27	.1705	**	1.5048	.2656	.3922	3.9046	-.059	GRAY AREA
129 HOWDEN GROUP	30 4 74		22	.1151		1.5803	.5856	.7992	5.3042	6.575	SOLVENT
130 ILLINGWORTH,MORRIS + CO.	31 3 74		61	.1520		1.5642	.2623	.3284	3.1458	-3.026	INSOLVENT
131 INGRAM (HAROLD)	30 4 74		59	.3539	**	.7911	.1814	.3357	4.8608	15.894	SOLVENT
132 JEVONS COOPER	30 4 74	*	28	.0706		1.9633	.3120	-.1471	3.9063	-13.628	INSOLVENT
133 JOHNSON + FIRTH BROWN LTD	30 6 74		26	.1176		1.1978	.2612	.6267	4.9766	3.908	GRAY AREA
134 JOHNSON-RICHARDS (H.+R.)	31 3 74		14	.1827		1.4841	.2414	.2547	6.2923	13.057	SOLVENT
135 JUDGE INTERNATIONAL	30 6 74		40	.1207	**	1.0416	.1839	.2264	2.7820	-1.185	GRAY AREA
136 KWIKFORM	30 4 74		27	.1904	**	1.2387	.2820	.9483	3.8836	8.713	SOLVENT
137 LAKE + ELLIOT	31 7 74		21	.0951		1.1447	.3021	.3304	3.4669	-.018	GRAY AREA
138 LAMSON INDUSTRIES	31 12 74		69	.1821		.9165	.3130	.4773	4.9502	9.713	SOLVENT
139 LAURENCE SCOTT	31 12 74		19	.0132		.6562	.3688	.8507	3.1164	6.550	SOLVENT
140 LEE (ARTHUR) + SONS	31 3 74		33	.1557	**	.7809	.3397	.6103	4.7552	11.293	SOLVENT
141 LESNEY PRODUCTS + CO	27 1 74		65	.1870		.6045	.4431	.5641	6.8564	18.380	SOLVENT
142 LETRASET INTRNATIONAL	30 4 74		53	.3510	**	1.4450	.4292	.7960	4.9437	16.363	SOLVENT
143 LLOYD (F.H.) HOLDINGS	31 3 74		27	.0997		.6622	.3504	.5065	4.9240	9.457	SOLVENT
144 LLOYDS INDUSTRIES INT	28 2 74		73	.1771		.9138	.2409	.2093	5.8790	7.138	SOLVENT
145 LONDON MERCHANT SECURITIES	31 3 74		73	.0755		.7279	.1821	.2435	2.0532	-.514	GRAY AREA
146 LUCAS (JOSEPH) (INDUSTRIES)	31 7 74		41	.0791		.8068	.3522	.5642	4.5964	6.996	SOLVENT
147 MCCORQUODALE + CO.	30 9 74		19	.0909	**	.7190	.2696	.4989	5.0409	7.147	SOLVENT
148 MCKECHNIE BROTHERS	31 7 74		32	.2462	**	.8041	.3240	.5384	5.3541	15.159	SOLVENT
149 MACPHERSON (DONALD) GROUP	27 10 74		16	.1434		.9304	.3728	.7877	5.0680	11.279	SOLVENT
150 MAGNET JOINERY	28 2 74		17	.3449	**	.5613	.1994	.3876	3.9203	17.726	SOLVENT

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1974

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
151	MARSHALL(THOMAS)INVERSTMENTS	31 3 74		59	.1847 **	1.4366	.2265	.2334	5.3591	1.032	GRAY AREA
152	MARTONAIR INTERNATIONAL	31 1 74		24	.2577 **	.9074	.3344	.7041	3.4211	13.957	SOLVENT
153	METAL BOX CO.	31 3 74		54	.1492	.9859	.2294	.3334	4.6110	4.441	SOLVENT
154	METAL PRODUCTS CO.(WILLENHALL)	31 3 74		32	.1123 **	1.5059	.3298	.4184	6.5509	1.331	GRAY AREA
155	METROPOLE INDUSTRIES	31 3 74		27	.0997	1.5184	.3476	.6274	3.4676	-.788	GRAY AREA
156	MIDLAND ALUMINIUM	31 3 74		32	.1620	1.0041	.3347	.3726	6.0100	8.427	SOLVENT
157	MINTY	31 1 74		38	.1765	.6738	.3831	.3585	14.2289 *	19.069	SOLVENT
158	M.K. ELECTRIC HOLDINGS	31 3 74		29	.1316	.6126	.2658	.4916	4.4525	9.505	SOLVENT
159	M.L. HOLDINGS	31 3 74		27	.1409	1.2651	.3959	1.0249	2.8778	7.439	SOLVENT
160	MORGAN CRUCIBLE CO.	31 12 74		27	.1538	.9065	.3122	.4292	4.7858	7.882	SOLVENT
161	MUIRHEAD	30 9 74		35	.1007	.6794	.2672	.7321	2.3850	7.023	SOLVENT
162	MTE	31 5 74		19	.2023	.9562	.3622	.3800	5.1470	10.444	SOLVENT
163	MYSON GROUP	31 12 74		30	.0911	1.0254	.2521	.1249	3.6462	-1.190	GRAY AREA
164	NATIONAL CARBONISING CO.	31 3 74		72	-.0120	1.0017	.2061	-.0604	7.2550	-4.146	INSOLVENT
165	NEEPSEND	31 3 74		27	.1075	.9373	.2972	.2698	3.0671	1.874	GRAY AREA
166	NEGRETTI + ZAMBRA	31 3 74		31	.1056	.6467	.3333	.5857	2.9630	8.126	SOLVENT
167	NEWALL MACHINE TOOL CO.	31 3 74		28	-.0039	1.6365	.3247	.7359	1.7665	-8.402	INSOLVENT
168	NEWMARK (LOUIS)	31 3 74		31	.1997	.7566	.4456	.8720	3.9487	16.665	SOLVENT
169	NOVA (JERSEY) KNIT	31 3 74	4	61	.0395	.6471	.2481	.8513	4.5728	5.308	SOLVENT
170	OSBORN (SAMUEL) AND CO.	31 7 74		33	.1546	.7313	.2752	.6587	2.8215	9.015	SOLVENT
171	OZALID GROUP HOLDINGS	31 12 74		69	.1899	.9533	.3139	.6292	4.0008	9.898	SOLVENT
172	PARKLAND TEXTILES	28 2 74		61	.1490	1.3984	.2531	.5049	2.9737	-.192	GRAY AREA
173	PAULS + WHITES	31 3 74		49	.1107 **	1.2001	.3378	.5432	7.8781	7.306	SOLVENT
174	PEGLER-HATTERSLEY	31 3 74		24	.2772	.5398	.3210	.5173	4.2161	18.119	SOLVENT
175	PETBOW HOLDINGS	31 3 74	1	19	.1317 **	.8252	.2862	.5218	3.2558	6.395	SOLVENT
176	PILKINGTON BROTHERS	31 3 74	3	14	.1996	.5967	.2621	.3147	5.9744	13.083	SOLVENT
177	PLESSEY TELECOMMUNICATIONS	30 6 74		19	.1286	.6518	.3182	.6198	3.7425	10.061	SOLVENT
178	PORTALS HOLDINGS	31 12 74		73	.1339	.9658	.4217	.4630	6.6252	10.362	SOLVENT
179	RACAL ELECTRONICS	31 3 74		35	.1770	.8176	.3724	.4666	3.3358	9.678	SOLVENT
180	RANK ORGANISATION	31 10 74		69	.1471	.7103	.1403	.2138	5.0145	6.533	SOLVENT

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1974

COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
181 RANK MOVIS MCDOUGALL	31 8 74		50	.0956	.8154	.2965	.5179	10.5660	12.977	SOLVENT
182 RANSOME HOFFMANN POLLARD	27 9 74		27	.1012	.7307	.2716	.7553	3.2517	7.668	SOLVENT
183 RAYBECK	30 4 74		59	.2084	.7832	.2212	.1390	7.9051	11.424	SOLVENT
184 RCF HOLDINGS	31 7 74		28	.1386	1.0050	.3191	.5481	2.9505	5.128	SOLVENT
185 READICUT INTERNATIONAL	31 3 74		37	.2113	.8701	.2921	.8589	3.6115	12.964	SOLVENT
186 REDLAND	31 3 74		12	.1929 **	.8348	.2351	.1579	10.2007	13.015	SOLVENT
187 REED INTERNATIONAL	31 3 74		73	.1124	.7599	.3018	.4946	6.3864	9.688	SOLVENT
188 RELIANT MOTOR GROUP	28 2 74	**	43	-.0449	1.7462	.1182	-.5350 *	5.7952	-20.824	INSOLVENT
189 RENOLD	31 3 74		27	.1336	.6275	.1720	.4960	2.0839	5.342	SOLVENT
190 REXMORE	31 3 74		62	.1471 **	2.3565	.3729	.2484	4.8151	-9.153	INSOLVENT
191 R.F.D. GROUP	31 3 74		62	-.0209	.7550	.2513	.5483	2.5084	-1.264	GRAY AREA
192 RICHARDSONS, WESTGARTH + CO.	31 3 74		22	.1417 **	.8075	.3985	.5982	6.3263	12.915	SOLVENT
193 ROBERTSON FOOD	31 3 74		49	.1460	.9098	.2426	.7699	4.0020	8.291	SOLVENT
194 ROTAPRINT	31 3 74		69	.1564	1.2445	.3913	.8271	3.2908	7.151	SOLVENT
195 ROWNTREE MACKINTOSH	31 12 74		49	.1619	1.1305	.2554	.1609	6.8541	4.893	SOLVENT
196 ROYAL SOVEREIGN PENCIL CO.	31 12 74		69	.1698	.9980	.3001	.6188	3.9457	8.066	SOLVENT
197 SCAPA GROUP	31 3 74		62	.2204	.2401	.2300	.6934	3.3745	17.814	SOLVENT
198 SCOTROS	31 3 74		49	.1075	1.2423	.3476	.6059	9.4539	9.092	SOLVENT
199 SCOTT + ROBERTSON	28 2 74		62	.1672 **	1.0321	.2993	.8497	4.9206	10.536	SOLVENT
200 SCOTT (JAMES) ENGINEERING	31 1 74		19	.0821	3.1420 *	.2301	.3841	4.0058	-20.532	INSOLVENT
201 SCRAGG (ERNEST) + SONS	30 9 74		22	.1747 **	1.7201	.4856	.6293	4.6047	4.042	GRAY AREA
202 SELINCOURT	31 1 74		59	.1309 **	1.4452	.2385	.4932	3.8770	-.915	GRAY AREA
203 SERCK	30 9 74		27	.0991	1.0215	.3115	.6504	3.6809	4.589	SOLVENT
204 SHAW CARPETS	30 4 74	*	37	.1513	1.5683	.2502	.0271	7.1989	-1.326	GRAY AREA
205 SHEEPBRIDGE ENGINEERING	31 3 74		27	.0820	.6758	.3076	.8421	3.5360	9.005	SOLVENT
206 SIEBE GORMAN HOLDINGS	30 3 74		27	.2211	1.1141	.3370	.7104	3.7035	10.300	SOLVENT
207 SMITH HOLDINGS (WHITWORTH)	31 3 74		22	.0461 **	1.4135	.3262	.4442	3.3831	-4.124	INSOLVENT
208 SMITHS INDUSTRIES	31 7 74		31	.1552	.9614	.2848	.7969	3.5017	8.514	SOLVENT
209 SPILLERS	31 1 74		50	.0857	1.0623	.1951	-.0120	10.0567	3.158	GRAY AREA
210 STAFLEX INTERNATIONAL	31 12 74		59	.1646	1.5133	.2967	1.2028	2.6491	5.387	SOLVENT

COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
211 STAVELEY INDUSTRIES	30 9 74		28	.1059	1.1495	.3438	.5155	5.4824	4.875	SOLVENT
212 STEETLEY COMPANY	31 12 74		25	.1838	.8138	.2954	.5483	7.3404	13.875	SOLVENT
213 STEWART NAIRN	31 3 74		59	-.1517 **	1.5750	.3352	-.0256	5.5078	-16.762	INSOLVENT
214 STODDARD (HOLDINGS)	31 5 74		37	.1849	.8597	.2206	.5760	3.1681	7.830	SOLVENT
215 STOTHERT + PITT	30 6 74		23	.1043	.9347	.2323	.5677	2.9505	3.028	GRAY AREA
216 TECALEMIT	31 3 74		41	.1066	1.0782	.3050	.6012	4.0491	4.200	GRAY AREA
217 THORN ELECTRICAL INDUSTRIES	31 3 74		35	.1993	1.1815	.2675	.2317	5.3265	5.205	SOLVENT
218 TOMKINS (F.H.)	28 4 74		27	.2083	.9126	.3937	.5284	5.0533	12.856	SOLVENT
219 TOOTAL	31 1 74		22	.1658	.8120	.2421	.6535	3.8655	9.211	SOLVENT
220 TUNNEL CEMENT	31 3 74		15	.1019	.3931	.2732	.2927	6.1570	10.906	SOLVENT
221 TURNER + NEWALL	31 12 74		14	.1315	.6557	.2647	.5090	4.0054	8.657	SOLVENT
222 U.K. OPTICAL + INDUSTIAL HOLD.	31 3 74		31	.1604 **	.7484	.3006	.7294	3.4087	10.768	SOLVENT
223 ULTRA ELECTORNIC HOLDINGS	31 3 74		35	.1136	.7728	.3646	.9918	3.0246	11.030	SOLVENT
224 UNERMAN HOLDINGS	31 3 74	** 1	38	.2026 **	1.7722	.4735	.4982	4.8544	3.786	GRAY AREA
225 UNICORN IND.	31 12 74		27	.1318 **	.9943	.2716	.7146	2.4223	4.946	SOLVENT
226 UNILEVER N.V.	31 12 74		49	.1582	.9127	.3115	.7144	6.3104	12.049	SOLVENT
227 UNITECH	31 4 74		35	.1733 **	1.1291	.4278	.4604	6.1456	9.960	SOLVENT
228 UNITED BISUITS (HOLDINGS)	31 12 74		50	.1364	1.0668	.2082	.2880	12.1262 *	9.321	SOLVENT
229 UNITED GAS INDUSTRIES	31 3 74		39	.0416	1.2715	.2956	.7247	3.4560	-.832	GRAY AREA
230 UNITED SPRING + STEEL GROUP	30 9 74		27	.1900	1.2595	.4662	.8250	6.6822	13.525	SOLVENT
231 UNOCHROME INTERNATIONAL	30 6 74		27	.0712	.9135	.4106	.2356	4.0591	3.070	GRAY AREA
232 UTTLEY (WILLIAM)	2 2 74		60	.1401	.6808	.3539	.6383	5.5981	14.721	SOLVENT
233 U.U. TEXTILES	1 5 74	3	59	.1283 **	1.6600	.2438	.0361	4.8784	-6.035	INSOLVENT
234 VANTONA	31 3 74		62	.1736 **	1.3462	.2337	.5149	4.1975	2.684	GRAY AREA
235 VINTEN (V.)	31 3 74	2	31	.1381	.9769	.4054	.7530	2.9048	8.467	SOLVENT
236 VOSPER LTD	31 10 74	**	29	.3197 **	2.0699	.1563	.1884	3.3290	-3.600	INSOLVENT
237 WADDINGTON (JOHN)	31 3 74		65	.1432 **	.9499	.2550	.3727	4.7063	5.407	SOLVENT
238 WAGON REPAIRS	31 3 74		27	.1540	1.1837	.5591	.6886	4.7344	10.899	SOLVENT
239 WALKER (C.+ W.) HOLDINGS	31 1 74		25	.0518	1.7372	.2751	-.0815	4.8699	-11.069	INSOLVENT
240 WARD AND GOLDSTONE	31 3 74		19	.1556 **	1.2313	.3262	.4302	4.4142	4.155	GRAY AREA

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1974

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
241	WARD (THOS. W.)	30 9 74		27	.0893 **	.8315	.2482	.4462	5.4507	5.431	SOLVENT
242	WEDWOOD LTD.	31 3 74	**	40	.2319	.6556	.2723	.5714	3.8419	13.903	SOLVENT
243	WEIR GROUP	27 12 74		27	.0959	1.3210	.4356	.7467	5.9410	6.386	SOLVENT
244	WELLMAN ENGINEERING CORP	31 3 74		25	.0893	.7872	.5463	.6560	5.4491	12.565	SOLVENT
245	WESTINGHOUSE BRAKE + SIGNAL CO	28 9 74		19	.0656	.8526	.3123	.6407	2.4870	3.498	GRAY AREA
246	WESTLAND AIRCRAFT	30 9 74		11	.1307	.7597	.3685	.6412	4.1493	10.393	SOLVENT
247	WHESSOE	28 9 74		25	.0787 **	1.0333	.2603	.2772	4.2644	.205	GRAY AREA
248	WILKINSON MATCH CO.	31 3 74		73	.1231 **	.7558	.2505	.3447	6.2569	8.027	SOLVENT
249	WOLSELEY-HUGHES	31 7 74		30	.1882 **	.9747	.3535	.8504	4.7394	12.861	SOLVENT
250	WOODHEAD (JONAS) + SONS	31 3 74		41	.1651	.8757	.3298	.6130	4.1547	9.879	SOLVENT
251	YATTON FURNITURE	31 3 74		38	.1289	.7785	.2101	.2967	4.7204	5.300	SOLVENT
252	YORKSHIRE CHEMICALS	31 3 74		68	.2818	.5218	.3361	.7852	3.3106	20.004	SOLVENT

KEY

UNDER DESCR.HEADING

* DENOTES OVER 50PC. EQUITY CONTROLLED BY DIRECTORS
** DENOTES COMPANY IS A SUBSIDIARY OF ANOTHER
A DIGIT DENOTES THE NUMBER OF COMPLETED FINANCIAL YEARS PUBLICALLY QUOTED IF LESS THAN 5

FOLLOWING A RATIO

* DENOTES ORIGINAL RATIO OUTSIDE 3*SD OF MEAN AND IS REPLACED BY LIMIT
** DENOTES TOTAL ASSET GROWTH.GT.30PC.AND AVERAGE TOTAL ASSETS USED IN EBIT/TA COMPUTATION

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1975

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
1	ACROW (ENGINEERS)	31 3 75		23	.1160	1.1076	.1980	.5524	2.5358	.509	GRAY AREA
2	ARMSTRONG EQUIPMENT	30 6 75		41	.1716	1.1703	.2760	.5774	3.1849	4.648	SOLVENT
3	BASSETT (GEO.) HOLDINGS	31 3 75		49	.1048	1.1184	.2801	.1056	11.7013 *	6.900	SOLVENT
4	BROWN (JOHN) + CO	31 3 75		28	.0245	1.6945	.3094	.5421	3.3151	-7.840	INSOLVENT
5	CHLORIDE GROUP	31 3 75		41	.1880	.8818	.3282	.6758	4.8479	12.156	SOLVENT
6	CHUBB + SON LTD	31 3 75		27	.1611	1.0289	.3504	.7414	4.0293	9.230	SOLVENT
7	DAWSON INTERNATIONAL	31 3 75	1	61	.0681	1.1421	.2669	.8871	2.8439	2.067	GRAY AREA
8	DE LA RUE CO	31 3 75		73	.1260 **	1.1161	.3126	.1505	4.9573	2.102	GRAY AREA
9	DOWTY GROUP	31 3 75		11	.1515	.6611	.3350	.7966	3.5236	12.541	SOLVENT
10	DUPORT	31 7 75		27	.1665	.8860	.3498	.5778	7.0484	13.370	SOLVENT
11	FAIREY CO.	31 3 75		27	.0658 **	1.4491	.2550	.2799	2.5263	-7.049	INSOLVENT
12	FINE ARTS DEVELOPMENTS	31 3 75		53	.2081 **	.8614	.2050	.6492	3.5318	9.666	SOLVENT
13	GOLDREI (CH.) FOUCARD + SON	29 3 75		49	.1093	1.0546	.3759	.5371	8.6122	10.250	SOLVENT
14	HEAD, WRIGHTSON + CO.	31 1 75		25	.0455	1.4338	.4165	.3153	7.8956	.994	GRAY AREA
15	HESTAIR	31 1 75		73	.1290	1.2353	.2973	.3702	4.6841	2.173	GRAY AREA
16	HOUCHIN	30 4 75	*	11	.1820	.7652	.2458	.4530	3.1554	8.131	SOLVENT
17	HOWDEN GROUP	30 4 75		22	.1126	1.9406	.5517	.8377	4.8782	1.716	GRAY AREA
18	JOHNSON-RICHARDS (H.+R.)TILES	31 3 75		14	.1192	.6527	.2086	.2106	5.0022	5.820	SOLVENT
19	LPC INTERNATIONAL	31 3 75		67	.0881	.7772	.2679	1.1540	3.6764	10.248	SOLVENT
20	METAL BOX CO.	31 3 75		54	.1711	1.0008	.1964	.5118	4.0726	5.662	SOLVENT
21	NORCROS LTD.	31 3 75		73	.1761 **	1.2616	.3506	.7953	6.9527	11.008	SOLVENT
22	PILKINGTON BROTHERS	31 3 75		14	.1087	.6510	.2271	.3791	4.5191	6.501	SOLVENT
23	REDLAND	31 3 75		12	.1434	.8425	.2321	.2842	8.4959	9.688	SOLVENT
24	REED INTERNATIONAL	31 3 75		73	.1411	.7946	.2532	.4703	5.8174	9.048	SOLVENT
25	RENOLD LTD.	31 3 75		27	.1396	.7283	.1898	.5875	2.1279	5.588	SOLVENT
26	ROBERTSON FOODS	31 3 75		49	.1491	1.0623	.2721	.6770	4.4060	6.889	SOLVENT
27	SCAPA GROUP	31 3 75		62	.2037	.4263	.2086	.5931	3.2204	13.583	SOLVENT
28	SPILLERS	31 1 75		50	.0708	1.0876	.2477	.0549	10.0086	3.504	GRAY AREA
29	STRONG + FISHER (HOLDINGS)	31 5 75		59	.1356	1.6824	.2870	.3973	3.8800	-3.349	INSOLVENT
30	TOOTAL	31 1 75		-0	.1191	.8740	.2368	.7037	3.4760	6.190	SOLVENT
31	UNITED GAS INDUSTRIES	31 3 75		39	.0765	1.3059	.3222	.9490	3.0776	2.303	GRAY AREA

Appendix 7.2.1: Firms with Negative Z-Scores on the Basis of Their 1973 Accounts

Appendix 7.2: Firms With Negative Z-Scores

FIRMS WITH NEGATIVE Z-SCORES YEAR: 1973

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
1	BARROW HEPBURN	31 12 73		64	.1209	1.5897	.3319	.2428	6.8315	-.306	
2	BEAR BRAND	31 12 73		59	-.0525	2.4958	.2139	-.3845	6.6863	-25.994	
3	BEMROSE	31 12 73		54	.0653	1.2510	.3198	.3333	4.4921	-1.189	
4	BR. STEEL CONSTRUCTIONS	31 10 73		27	-.0365	2.1569	.3159	.0072	4.4143	-19.034	
5	BROOKE TOOL ENG.(HOLDINGS)LTD.	30 9 73		25	.0178	1.0530	.2304	.3057	2.0158	-5.649	
6	CRANE FRUEHAUF	31 12 73		43	.1042 **	1.3914	.2940	.1834	5.2331	-1.558	
7	DALE ELECTRIC INTERNATIONAL	29 12 73	* 1	19	.2883 **	2.3436	.3957	.4427	3.8750	-1.336	
8	DEXION-COMINO INTERNATIONAL	31 10 73	*	27	.1388	1.7732	.3746	.1423	7.6933	-.695	
9	FAIREY CO.LTD.	31 3 73		27	.0830 **	1.1762	.2580	.3665	2.5059	-2.428	
10	FEB INTERNATIONAL	31 12 73	*	68	.1261	1.9549	.4092	.0744	10.0949	-.686	
11	FOLKES (JOHN) HEFO	31 12 73		27	.1365 **	1.9228	.3107	.0924	4.7283	-7.202	
12	HADEN CARRIER	31 12 73		30	.0650	1.9323	.3510	.0892	6.9796	-7.604	
13	HALL (MATTHEW)+CO.	31 12 73		25	.1150 **	1.8246	.3248	.5258	6.3764	-1.496	
14	ILLINGWORTH,MORRIS + CO.	31 3 73		61	.1522	2.0113	.2812	.3459	3.3156	-7.386	
15	JEVONS COOPER	30 4 73		28	.0781 **	1.9772	.3192	-.2440	4.6875	-13.282	
16	LAKE + ELLIOT	31 1 73		21	-.0373	.7328	.3023	.3235	2.8126	-2.490	
17	NEWALL MACHINE TOOL CO.	31 3 73		28	-.0768	1.2886	.2982	.8222	1.6912	-7.779	
18	NEWMAN INDUSTRIES	31 12 73		19	.0893	1.6094	.4133	.2461	3.8124	-4.005	
19	ROTORK	31 12 73		24	.0922	1.5405	.4103	.2996	4.9637	-1.435	
20	SHAW (FRANCIS) AND CO. LTD.	31 12 73		22	.0702	1.7853	.3889	.9314	2.2283	-3.363	
21	STEEL BROTHERS HOLDINGS	31 12 73	** 3	73	.1096 **	1.4373	.3111	.2060	6.0555	-.634	
22	TRIANCO GROUP	31 12 73		27	-.0869	1.7920	.3453	.4417	3.7595	-14.001	
23	UNOCHROME INTERNATIONAL	30 6 73		27	.0392	1.1902	.3272	.0128	3.8661	-4.972	
24	VOSPER	31 10 73	**	29	.0688	2.4348	.2694	-.0162	3.5285	-19.058	
25	WORTH(BOND) HOLDINGS LTD.	30 6.73		37	.1058	1.9413	.3779	.5130	5.5505	-3.392	
26	YORK TRAILER CO.	31 12 73	**	43	.1849 **	1.7976	.2361	.0602	5.0585	-4.608	

Appendix 7.2.2: Firms With Negative Z-Scores on the Basis of Their 1974 Accounts

FIRMS WITH NEGATIVE Z-SCORES YEAR: 1974

	COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	CA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
1	ASSOCIATED SPRAYERS	31 8 74		3 39	.0947 **	2.0082	.3159	.0298	5.0470	-10.230	
2	AVON RUBBER CO.	28 9 74		41	.0865	1.5141	.3064	.3309	4.9348	-2.874	
3	BATH AND PORTLAND GROUP	31 10 74		73	.1069	1.7102	.3301	.3724	5.0445	-3.252	
4	BEAUFORD GROUP	31 12 74	*	2 27	.1050	1.6972	.2764	.7929	3.3838	-2.425	
5	BROWN(JOHN) + CO	31 3 74		28	.0636	1.2402	.2956	.6345	3.1869	-.491	
6	CARAVANS INTERNATIONAL	31 8 74		43	.0709	1.6227	.2320	.2469	3.8205	-7.971	
7	CRAY ELECTRONICS	30 4 74	**	4 35	.0816	1.7296	.3467	.5587	3.5178	-4.546	
8	DIMPLEX INDUSTRIES	31 3 74		39	.1561 **	1.5135	.1901	.3383	3.0416	-3.470	
9	E.R.F. (HOLDINGS)	31 3 74		43	.1313	1.3368	.1603	.5787	3.5465	-.613	
10	FAIREY CO.	31 3 74		27	.0638	1.0873	.2632	.4135	2.5431	-1.833	
11	FAIRFAX JERSEY GROUP	30 6 74		3 60	.0633 **	1.3631	.2695	.2741	2.6925	-5.829	
12	FOX'S BISCUITS	25 5 74		50	.0459 **	1.4207	.2980	.0326	9.4530	-1.392	
13	GENERAL ENGINEERING CO.(RATCL)	31 3 74		27	.0947	2.1365	.2892	.1270	2.1092	-14.536	
14	HALL (MATTHEW)+CO.	31 12 74		25	.0940	1.9061	.3209	.5961	5.7403	-3.593	
15	HESTAIR	31 1 74		73	.0667 **	1.2308	.3095	.4776	3.5418	-.916	
16	HOWARD MACHINERY	31 10 74		27	.1705 **	1.5048	.2656	.3922	3.9046	-.059	
17	ILLINGWORTH,MORRIS + CO.	31 3 74		61	.1520	1.5642	.2623	.3284	3.1458	-3.026	
18	JEVONS COOPER	30 4 74	*	28	.0706	1.9633	.3120	-.1431	3.9063	-13.628	
19	JUDGE INTERNATIONAL	30 6 74		40	.1207 **	1.0416	.1839	.2264	2.7820	-1.185	
20	LAKE + ELLIOT	31 7 74		21	.0951	1.1447	.3021	.3304	3.4669	-.018	
21	LONDON MERCHANT SECURITIES	31 3 74		73	.0755	.7279	.1821	.2435	2.0532	-.514	
22	METROPOLE INDUSTRIES	31 3 74		27	.0997	1.5184	.3476	.6274	3.4676	-.788	
23	MYSON GROUP	31 12 74		30	.0911	1.0254	.2521	.1249	3.6462	-1.190	
24	NATIONAL CARBONISING CO.	31 3 74		72	-.0120	1.0017	.2061	-.0604	7.2550	-4.146	
25	NEWALL MACHINE TOOL CO.	31 3 74		28	-.0039	1.6365	.3247	.7359	1.7665	-8.402	
26	PARKLAND TEXTILES	28 2 74		61	.1490	1.3984	.2531	.5049	2.9737	-.192	
27	RELIANT MOTOR GROUP	28 2 74	**	43	-.0449	1.7462	.1182	-.5350 *	5.7952	-20.824	
28	REXMORE	31 3 74		62	.1471 **	2.3565	.3729	.2484	4.8151	-9.153	
29	R.F.D. GROUP	31 3 74		62	-.0209	.7550	.2513	.5483	2.5084	-1.264	
30	SCOTT (JAMES) ENGINEERING	31 1 74		19	.0821	3.1420 *	.2301	.3841	4.0058	-20.532	
31	SELINCOURT	31 1 74		59	.1309 **	1.4452	.2396	.4932	3.8770	-.915	
32	SHAW CARPETS	30 4 74	*	37	.1513	1.5683	.2502	.0271	7.1989	-1.326	
33	SMITH HOLDINGS (WHITWORTH)	31 3 74		22	.0461 **	1.4135	.3262	.4442	3.3831	-4.124	
34	STEWART NAIRN	31 3 74		59	-.1517 **	1.5750	.3352	-.0256	5.5078	-16.762	
35	UNITED GAS INDUSTRIES	31 3 74		39	.0416	1.2715	.2956	.7247	3.4560	-.832	
36	U.U.TEXTILES	1 5 74		3 59	.1283 **	1.6600	.2438	.0361	4.8784	-6.035	
37	VOSPER LTD	31 10 74	**	29	.3197 **	2.0899	.1563	.1884	3.3290	-3.600	
38	WALKER (C.+ W.) HOLDINGS	31 1 74		25	.0508	1.7372	.2751	-.0815	4.8699	-11.069	

COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
121 HICKSON + WELCH (HOLDINGS)	30 9 74		68	.1743	.8881	.2683	.3019	4.6801	7.183	SOLVENT
122 HIELD BROTHERS	31 3 74		61	.1805 **	.8488	.1845	.6813	2.7372	7.549	SOLVENT
123 HIGHAMS	31 3 74		60	.1402	1.1859	.2696	.6272	4.3907	4.614	SOLVENT
124 HOLLIS BROS. + E.S.A.	31 3 74		17	.2250 **	1.4630	.4098	.5866	5.3528	8.571	SOLVENT
125 HOMFRAY AND CO	30 6 74		37	.1631	.4631	.2301	.6689	3.1678	11.658	SOLVENT
126 HOPKINSONS HOLDINGS	31 1 74		24	.1153	.3060	.3395	.7420	2.0270	12.767	SOLVENT
127 HOUCHIN	30 4 74	*	11	.1701	.6285	.2698	.4059	3.1522	9.092	SOLVENT
128 HOWARD MACHINERY	31 10 74		27	.1705 **	1.5048	.2656	.3922	3.9046	-.059	GRAY AREA
129 HOWDEN GROUP	30 4 74		22	.1151	1.5803	.5856	.7992	5.3042	6.575	SOLVENT
130 ILLINGWORTH,MORRIS + CO.	31 3 74		61	.1520	1.5642	.2623	.3284	3.1458	-3.026	INSOLVENT
131 INGRAM (HAROLD)	30 4 74		59	.3539 **	.7911	.1814	.3357	4.8608	15.894	SOLVENT
132 JEVONS COOPER	30 4 74	*	28	.0706	1.9633	.3120	-.1471	3.9063	-13.628	INSOLVENT
133 JOHNSON + FIRTH BROWN LTD	30 6 74		26	.1176	1.1978	.2612	.6267	4.9766	3.908	GRAY AREA
134 JOHNSON-RICHARDS (H.+R.)	31 3 74		14	.1827	.4841	.2414	.2547	6.2923	13.057	SOLVENT
135 JUDGE INTERNATIONAL	30 6 74		40	.1207 **	1.0416	.1839	.2264	2.7820	-1.185	GRAY AREA
136 KWIKFORM	30 4 74		27	.1904 **	1.2387	.2820	.9483	3.8836	8.713	SOLVENT
137 LAKE + ELLIOT	31 7 74		21	.0951	1.1447	.3021	.3304	3.4669	-.018	GRAY AREA
138 LAMSON INDUSTRIES	31 12 74		69	.1821	.9165	.3130	.4773	4.9502	9.713	SOLVENT
139 LAURENCE SCOTT	31 12 74		19	.0132	.6562	.3688	.8507	3.1164	6.550	SOLVENT
140 LEE (ARTHUR) + SONS	31 3 74		33	.1557 **	.7809	.3397	.6103	4.7552	11.293	SOLVENT
141 LESNEY PRODUCTS + CO	27 1 74		65	.1870	.6045	.4431	.5641	6.8564	18.380	SOLVENT
142 LETRASET INTRNATIONAL	30 4 74		53	.3510 **	1.4450	.4292	.7960	4.9437	16.363	SOLVENT
143 LLOYD (F.H.) HOLDINGS	31 3 74		27	.0997	.6622	.3504	.5065	4.9240	9.457	SOLVENT
144 LLOYDS INDUSTRIES INT	28 2 74		73	.1771	.9138	.2409	.2093	5.8790	7.138	SOLVENT
145 LONDON MERCHANT SECURITIES	31 3 74		73	.0755	.7279	.1821	.2435	2.0532	-.514	GRAY AREA
146 LUCAS (JOSEPH) (INDUSTRIES)	31 7 74		41	.0791	.8068	.3522	.5642	4.5964	6.996	SOLVENT
147 MCCORQUODALE + CO.	30 9 74		19	.0909 **	.7190	.2696	.4989	5.0409	7.147	SOLVENT
148 MCKECHNIE BROTHERS	31 7 74		32	.2462 **	.8041	.3240	.5384	5.3541	15.159	SOLVENT
149 MACPHERSON (DONALD) GROUP	27 10 74		16	.1434	.9394	.3728	.7877	5.0680	11.279	SOLVENT
150 MAGNET JOINERY	28 2 74		17	.3443 **	.5613	.1994	.3876	3.9203	17.726	SOLVENT

Appendix 7.4: Constituent Company Ratio and Z-Score Histogram and Ogive Distributions

Appendix 7.4.1 : 296 Company 1973 data

Appendix 7.4.2 : 252 Company 1974 data

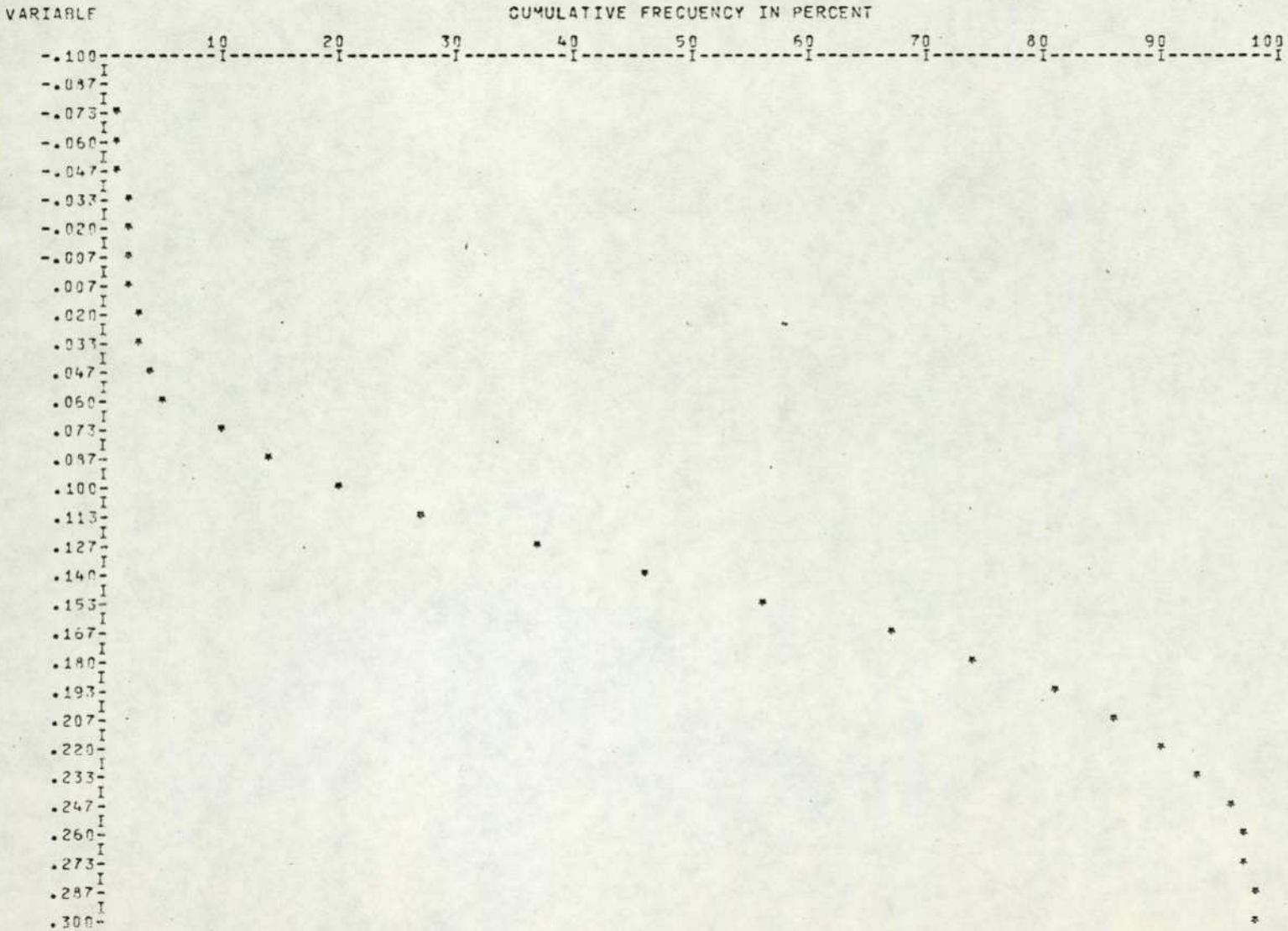
COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1974

COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	QA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
181 RANK HOVIS MCDOUGALL	31 8 74		50	.0956	.8154	.2965	.5179	10.5660	12.977	SOLVENT
182 RANSOME HOFFMANN POLLARD	27 9 74		27	.1012	.7307	.2716	.7553	3.2517	7.688	SOLVENT
183 RAYBECK	30 4 74		59	.2084	.7832	.2212	.1390	7.9051	11.424	SOLVENT
184 RCF HOLDINGS	31 7 74		28	.1386	1.0050	.3191	.5481	2.9505	5.128	SOLVENT
185 READICUT INTERNATIONAL	31 3 74		37	.2113	.8701	.2921	.8589	3.6115	12.964	SOLVENT
186 REDLAND	31 3 74		12	.1929	** .8348	.2351	.1579	10.2007	13.015	SOLVENT
187 REED INTERNATIONAL	31 3 74		73	.1124	.7599	.3018	.4946	6.3864	9.688	SOLVENT
188 RELIANT MOTOR GROUP	28 2 74	**	43	-.0449	1.7462	.1182	-.5350 *	5.7952	-20.824	INSOLVENT
189 RENOLD	31 3 74		27	.1336	.6275	.1720	.4960	2.0889	5.342	SOLVENT
190 REXMORE	31 3 74		62	.1471	** 2.3565	.3729	.2484	4.8151	-9.153	INSOLVENT
191 R.F.D. GROUP	31 3 74		62	-.0209	.7550	.2513	.5483	2.5084	-1.264	GRAY AREA
192 RICHARDSONS, WESTGARTH + CO.	31 3 74		22	.1417	** .8075	.3985	.5982	6.3263	12.915	SOLVENT
193 ROBERTSON FOOD	31 3 74		49	.1460	.9098	.2426	.7699	4.0020	8.291	SOLVENT
194 ROTAPRINT	31 3 74		69	.1564	1.2445	.3913	.8271	3.2908	7.151	SOLVENT
195 ROWNTREE MACKINTOSH	31 12 74		49	.1619	1.1305	.2554	.1609	6.8541	4.893	SOLVENT
196 ROYAL SOVEREIGN PENCIL CO.	31 12 74		69	.1698	.9980	.3001	.6188	3.9457	8.066	SOLVENT
197 SCAPA GROUP	31 3 74		62	.2204	.2401	.2300	.5934	3.3745	17.814	SOLVENT
198 SCOTROS	31 3 74		49	.1075	1.2423	.3476	.6059	9.4539	9.092	SOLVENT
199 SCOTT + ROBERTSON	28 2 74		62	.1672	** 1.0321	.2993	.8497	4.9206	10.536	SOLVENT
200 SCOTT (JAMES) ENGINEERING	31 1 74		19	.0821	3.1420 *	.2301	.3841	4.0058	-20.532	INSOLVENT
201 SCRAGG (ERNEST) + SONS	30 9 74		22	.1747	** 1.7201	.4856	.6293	4.6047	4.042	GRAY AREA
202 SELINCOURT	31 1 74		59	.1309	** 1.4452	.2386	.4932	3.8770	-.915	GRAY AREA
203 SERCK	30 9 74		27	.0991	1.0215	.3115	.6504	3.6809	4.589	SOLVENT
204 SHAW CARPETS	30 4 74	*	37	.1513	1.5683	.2502	.0271	7.1989	-1.326	GRAY AREA
205 SHEEPBRIDGE ENGINEERING	31 3 74		27	.0820	.6758	.3076	.8421	3.5360	9.005	SOLVENT
206 SIEBE GORMAN HOLDINGS	30 3 74		27	.2211	1.1141	.3370	.7104	3.7035	10.300	SOLVENT
207 SMITH HOLDINGS (WHITWORTH)	31 3 74		22	.0461	** 1.4135	.3262	.4442	3.3831	-4.124	INSOLVENT
208 SMITHS INDUSTRIES	31 7 74		31	.1552	.9614	.2848	.7969	3.5017	8.514	SOLVENT
209 SPILLERS	31 1 74		50	.0857	1.0623	.1961	-.0120	10.0567	3.158	GRAY AREA
210 STAFLEX INTERNATIONAL	31 12 74		59	.1646	1.5133	.2967	1.2028	2.6491	5.387	SOLVENT

DISTRIBUTION OF RATIO 1:EBIT/TAT-1 FOR 296 FIRMS. YEAR: 1973

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

.36
.31
.34
.33
.37



MEAN OF THE DISTRIBUTION= .1457
ST.DEV.OF THE DISTRIBUTION= .0635

COMPANY SOLVENCY ANALYSIS-RATIOS AND Z-SCORES FOR YEAR 1974

COMPANY	A/CS ENDING	DESCR.	IND.	EBIT/TA(T-1)	TL/NCE	CA/TA	WC/NW	STOCKTURN	Z-SCORE	CLASSIF.
241 WARD (THOS. W.)	30 9 74		27	.0893 **	.8315	.2482	.4462	5.4507	5.481	SOLVENT
242 WEDWOOD LTD.	31 3 74	**	40	.2319	.6556	.2723	.5714	3.8419	13.903	SOLVENT
243 WEIR GROUP	27 12 74		27	.0959	1.3210	.4356	.7467	5.9410	6.386	SOLVENT
244 WELLMAN ENGINEERING CORP	31 3 74		25	.0893	.7872	.5463	.6560	5.4491	12.565	SOLVENT
245 WESTINGHOUSE BRAKE + SIGNAL CO	28 9 74		19	.0656	.8526	.3123	.6407	2.4870	3.498	GRAY AREA
246 WESTLAND AIRCRAFT	30 9 74		11	.1307	.7597	.3685	.6412	4.1493	10.393	SOLVENT
247 WHESSOE	28 9 74		25	.0787 **	1.0333	.2603	.2772	4.2644	.205	GRAY AREA
248 WILKINSON MATCH CO.	31 3 74		73	.1231 **	.7558	.2505	.3447	6.2569	8.027	SOLVENT
249 WOLSELEY-HUGHES	31 7 74		30	.1882 **	.9747	.3535	.8504	4.7394	12.861	SOLVENT
250 WOODHEAD (JONAS) + SONS	31 3 74		41	.1651	.8757	.3298	.6130	4.1547	9.879	SOLVENT
251 YATTON FURNITURE	31 3 74		38	.1289	.7785	.2101	.2967	4.7204	5.300	SOLVENT
252 YORKSHIRE CHEMICALS	31 3 74		68	.2818	.5218	.3361	.7852	3.3106	20.004	SOLVENT

KEY

UNDER DESCR.HEADING

* DENOTES OVER 50PC. EQUITY CONTROLLED BY DIRECTORS
** DENOTES COMPANY IS A SUBSIDIARY OF ANOTHER
A DIGIT DENOTES THE NUMBER OF COMPLETED FINANCIAL YEARS PUBLICALLY QUOTED IF LESS THAN 5

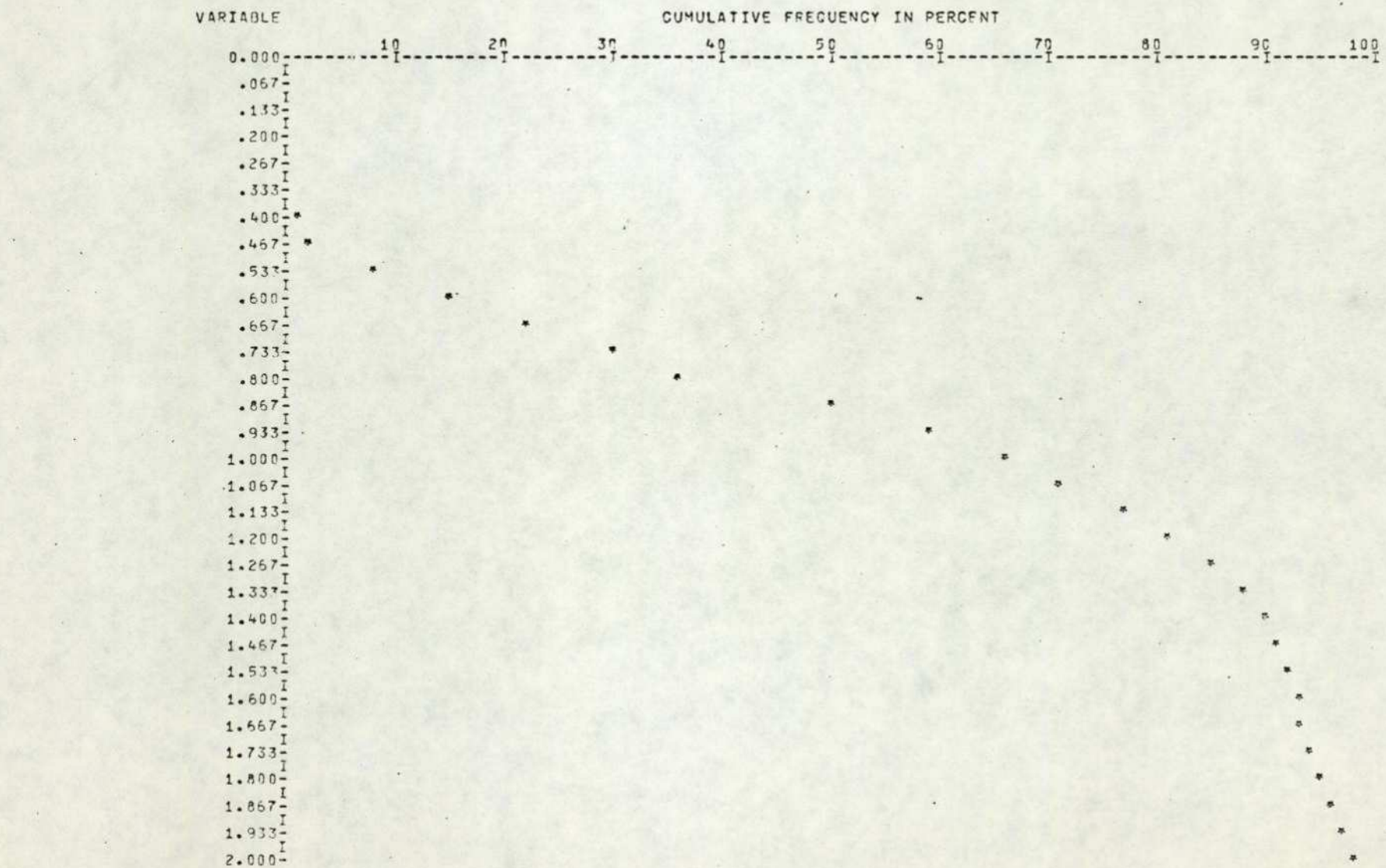
FOLLOWING A RATIO

* DENOTES ORIGINAL RATIO OUTSIDE 3*SD OF MEAN AND IS REPLACED BY LIMIT
** DENOTES TOTAL ASSET GROWTH.GT.30PC.AND AVERAGE TOTAL ASSETS USED IN EBIT/TA COMPUTATION

DISTRIBUTION OF RATIO 2:TL/NCE FOR 296 FIRMS. YEAR: 1973

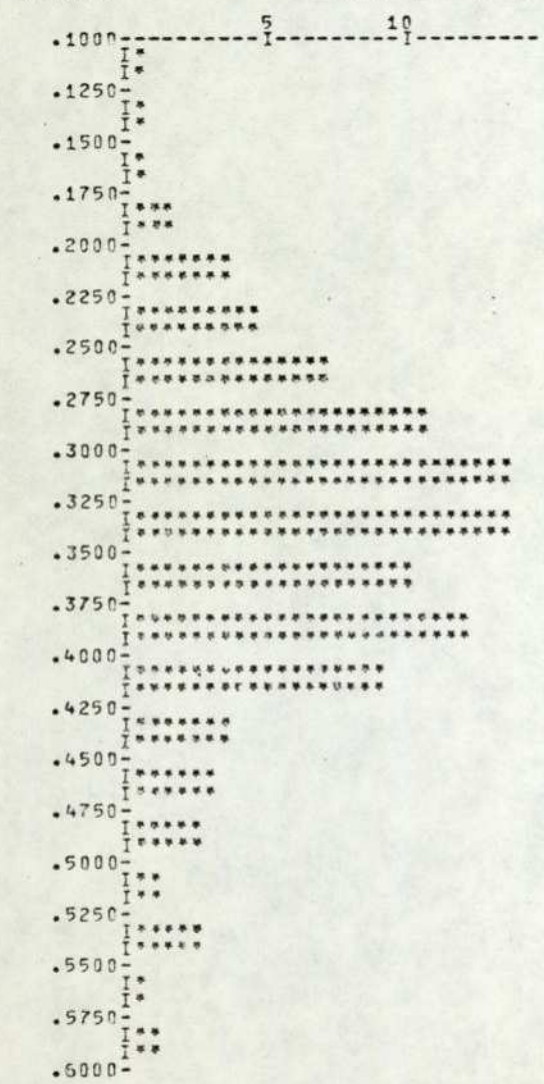
THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

2.50
2.10
2.16
2.34
2.01
2.43



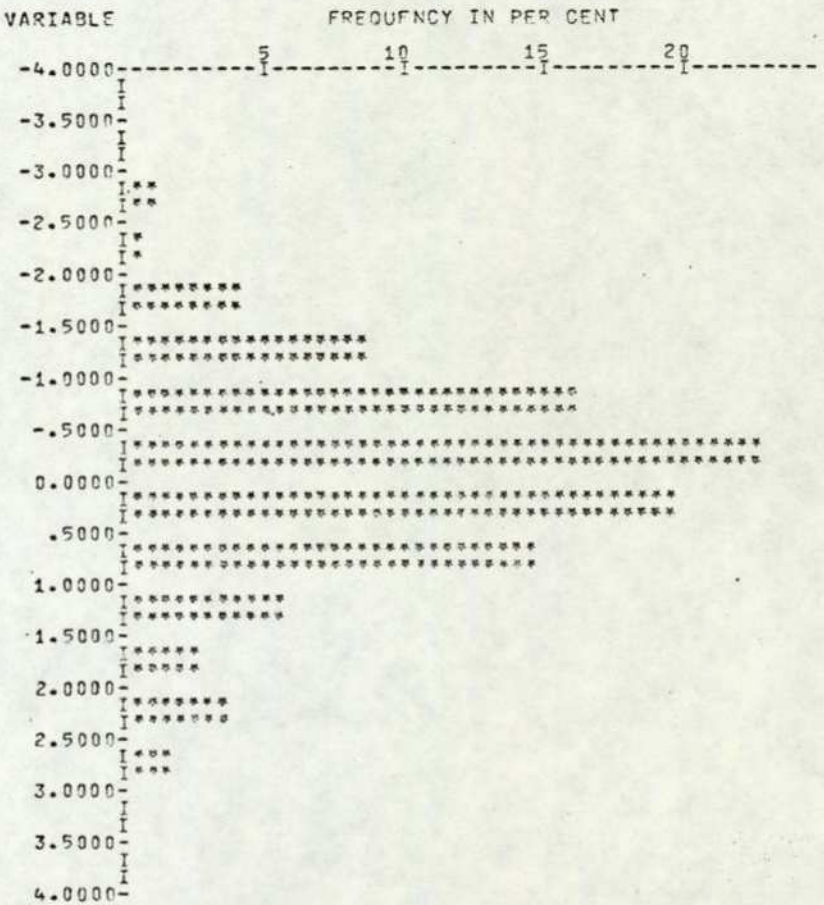
MEAN OF THE DISTRIBUTION= .9523
ST.DEV. OF THE DISTRIBUTION= .3809

DISTRIBUTION OF RATIO 3:QA/TA FOR 296 FIRMS. YEAR: 1973



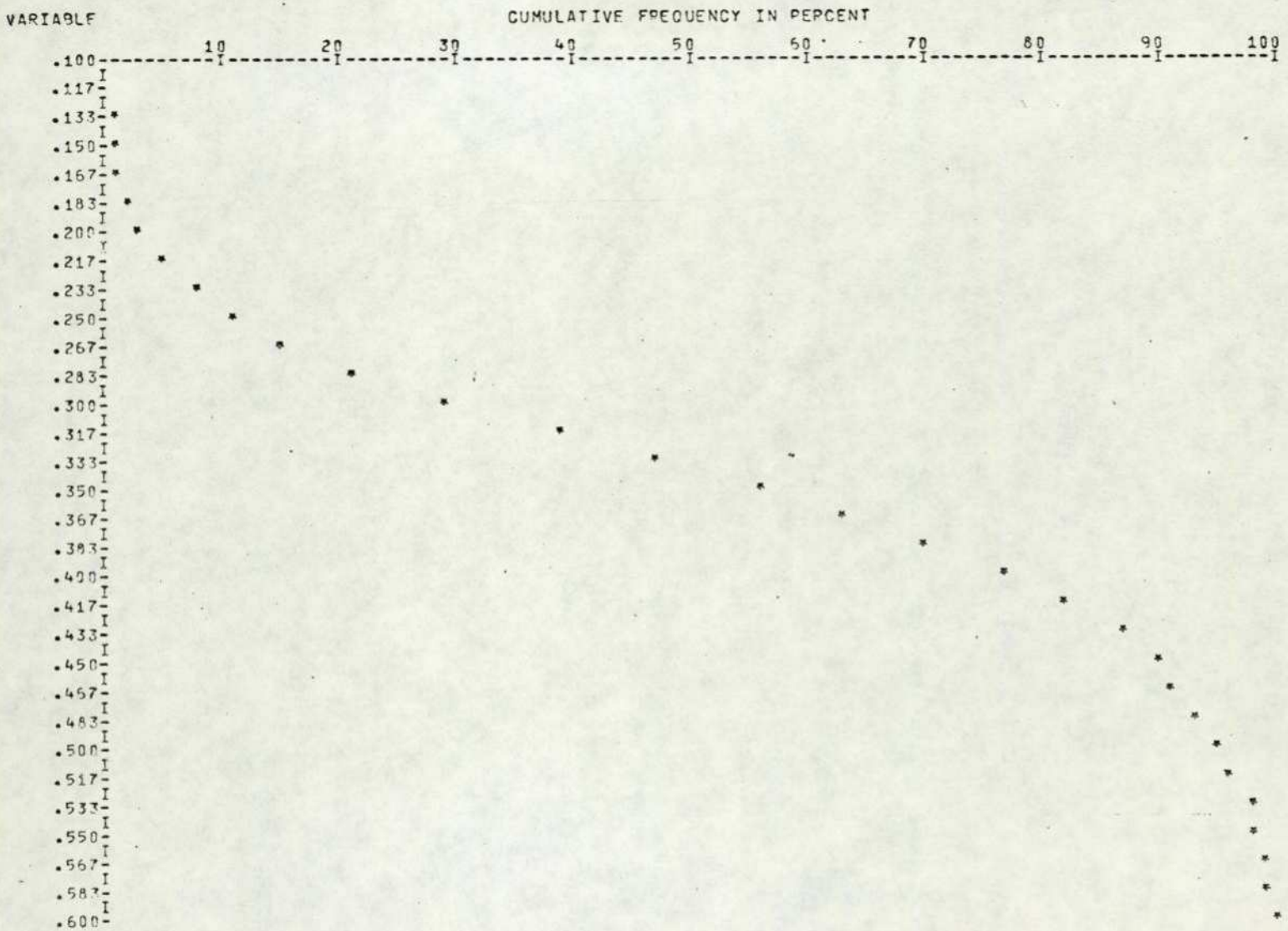
MEAN OF THE DISTRIBUTION= .3455
ST.DEV.OF THE DISTRIBUTION= .0842

STANDARDIZED DISTRIBUTION OF RATIO 3:QA/TA FOR 296 FIRMS. YEAR: 1973



MEAN OF THE DISTRIBUTION= .0000
ST.DEV.OF THE DISTRIBUTION= 1.0000

DISTRIBUTION OF RATIO 3:QA/TA FOR 296 FIRMS. YEAR: 1973



MEAN OF THE DISTRIBUTION= .3455
ST.DEV.OF THE DISTRIBUTION= .0842

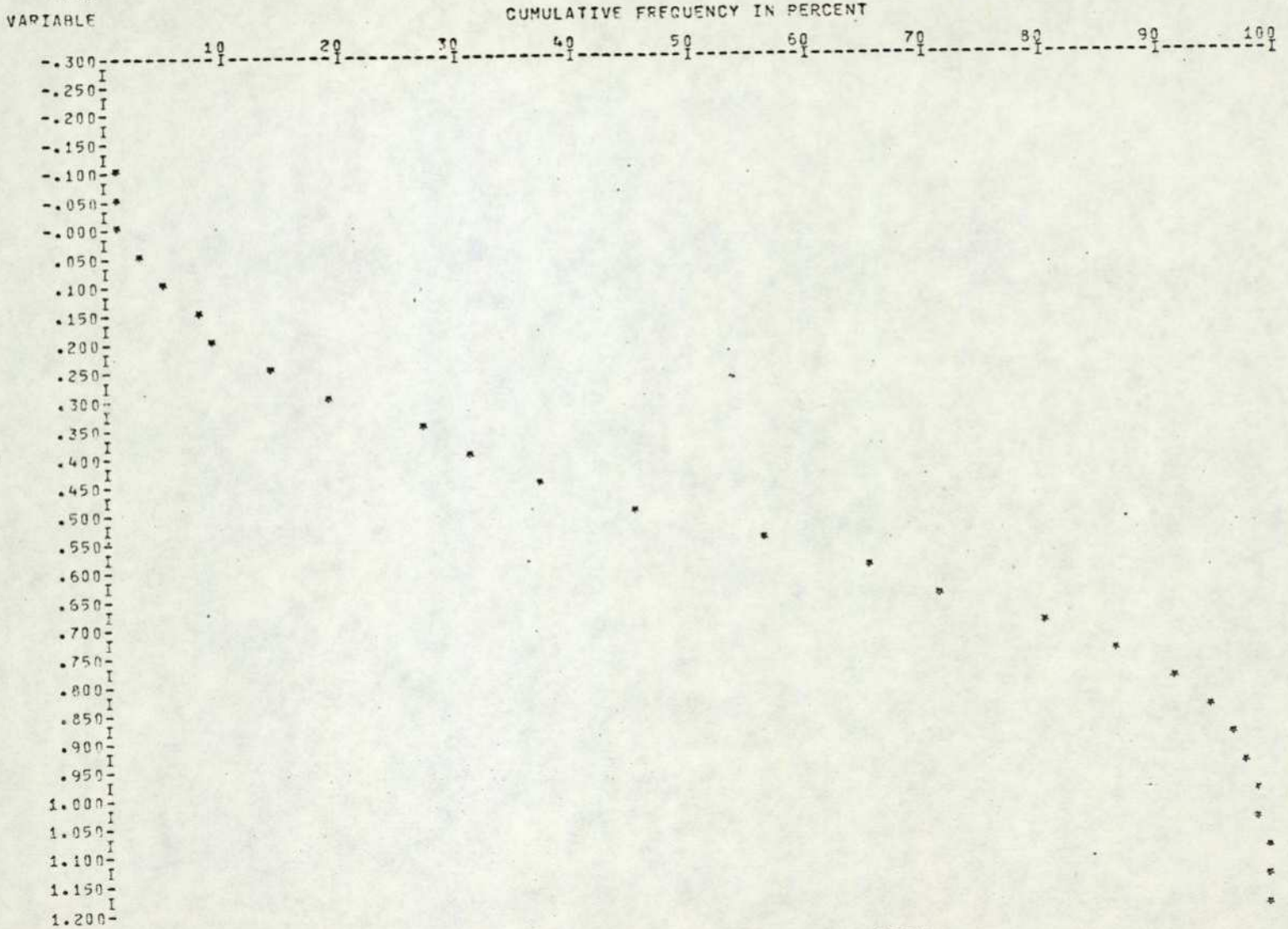
APPENDIX 7.3. SUMMARY INDUSTRY TABULATIONS, 1973 and 1974 and COMMON 1973/4 DATA

Industry Classification	SE Industry Code	Cos. in SE Year Book 1973/4	1973 Cos.	1974 Cos.	1973/4 Common Cos.
CAPITAL GOODS					
Aircraft and components	11	5	2	3	2
Bricks and roofing tiles	12	9	2	1	1
Building materials etc.	14	44	10	12	6
Cement and concrete	15	9	3	2	2
Paint	16	11	2	1	1
Timber	17	24	4	3	2
Electricals (ex. light electronics, radio & TV)	19	41	13	13	7
Boiler makers	20	5	4	1	
Founders and stampers	21	19	3	4	2
Industrial plant, engines and compressors	22	41	11	9	3
Mechanical handling	23	12	2	4	1
Pumps and valves	24	10	4	5	4
Steel and chemical plant	25	15	8	6	3
Wires and ropes	26	10	5	2	1
Miscellaneous engineering	27	133	42	35	21
Machine tools	28	27	11	7	4
Shipbuilding	29	9	1	2	1
Heating and ventilating	30	11	3	2	1
Instruments	31	16	3	6	2
Metallurgy	32	27	5	3	1
Special steels	33	19	5	6	4
CONSUMER DURABLES					
Electronics, radio & TV	35	33	3	11	3
Floor covering	37	20	10	7	3
Furniture and bedding	38	26	2	3	
Household appliances	39	15	5	3	2
Kitchen and tableware	40	13	2	3	2
Motor components	41	30	13	9	5
Motor vehicles	43	17	6	3	1
CONSUMER GOODS (NON DURABLE)					
Leisure	48		1		
General food manufacturing	49	50	9	11	6
Milling and flour confectionary	50	10	6	6	6
Publishing and printing	53	31	8	3	1
Packaging and paper	54	41	9	4	1
Clothing	59	87	12	9	3
Cotton and synthetic	60	16	4	4	1
Wool	61	25	3	5	1
Miscellaneous textiles	62	48	7	8	4
Footwear	64	31	1	1	
Toys and games	65	10	4	3	1
OTHER GROUPS					
Plastic and rubber fabricators	66	18	4	1	1
Drugs and pharmacy	67	14	3	3	2
General chemicals	68	28	10	7	6
Office equipment	69	24	10	5	3
Freight and fuel handling, fuel mft.	72	27		2	
Industrial holding companies	73	101	18	13	4
Miscellaneous (unclassifiable)	75		3	1	1
		1212	296	252	126

DISTRIBUTION OF RATIO 4:WC/NW FOR 296 FIRMS. YEAR: 1973

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

-.38
1.32
1.23

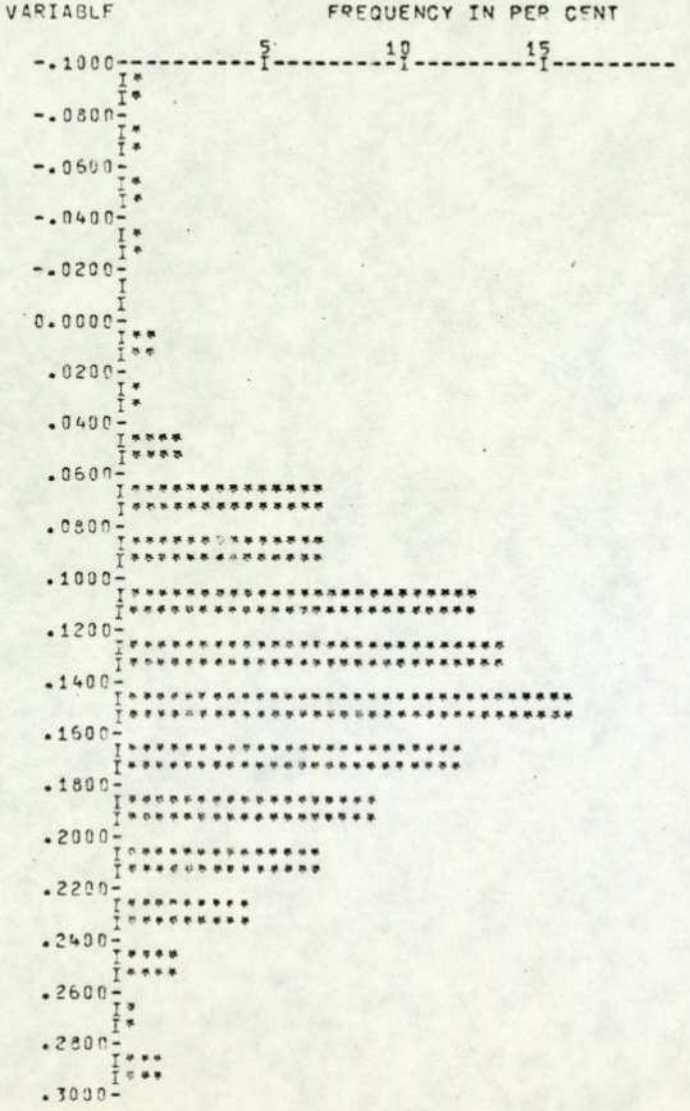


MEAN OF THE DISTRIBUTION= .5053
ST.DEV.OF THE DISTRIBUTION= .2404

DISTRIBUTION OF RATIO 1:EBIT/TAT-1 FOR 296 FIRMS. YEAR: 1973

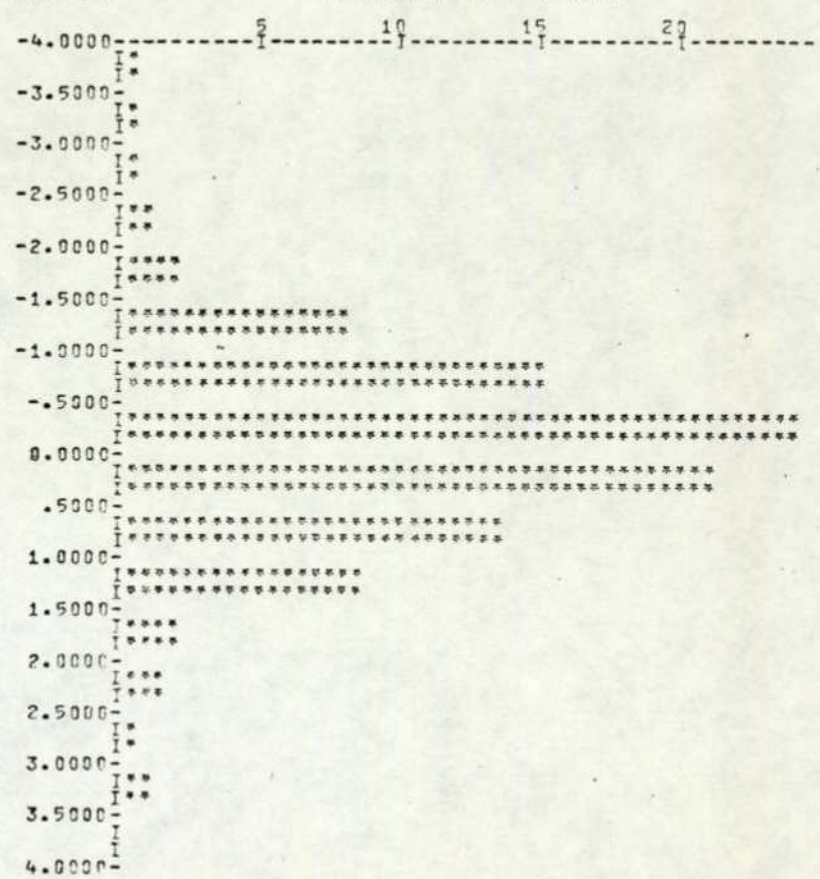
THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

.3605
.3162
.3379
.3337
.3654



MEAN OF THE DISTRIBUTION= .1457
ST.DEV.OF THE DISTRIBUTION= .0635

STANDARDIZED DISTRIBUTION OF RATIO 1:EBIT/TAT-1 FOR 296 FIRMS. YEAR: 1973

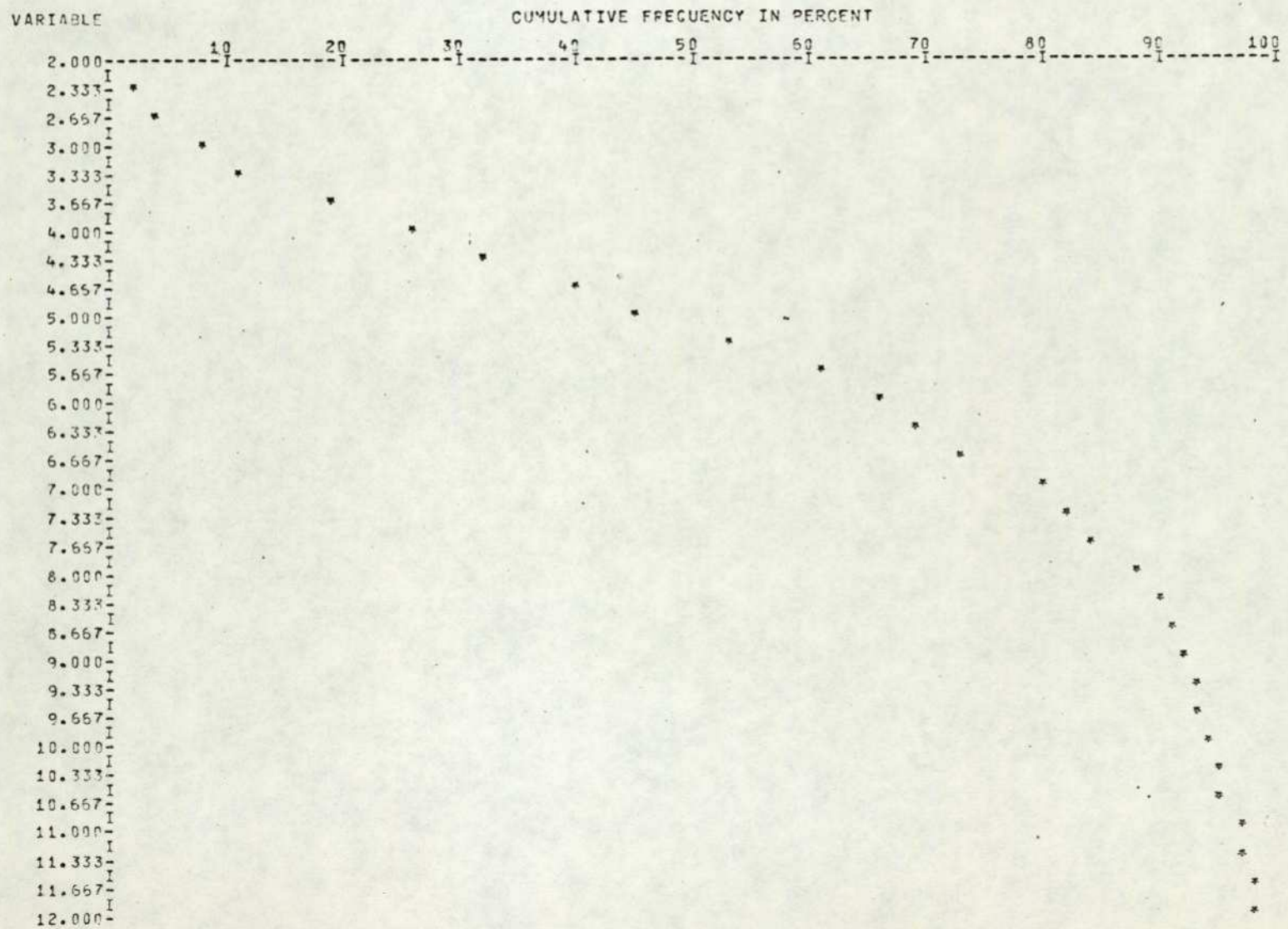


MEAN OF THE DISTRIBUTION= .0000
ST.DEV.OF THE DISTRIBUTION= 1.0000

DISTRIBUTION OF RATIO 5:STOCKTURN FOR 296 FIRMS. YEAR: 1973

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

12.29
12.99
15.35
1.69
12.06
16.12

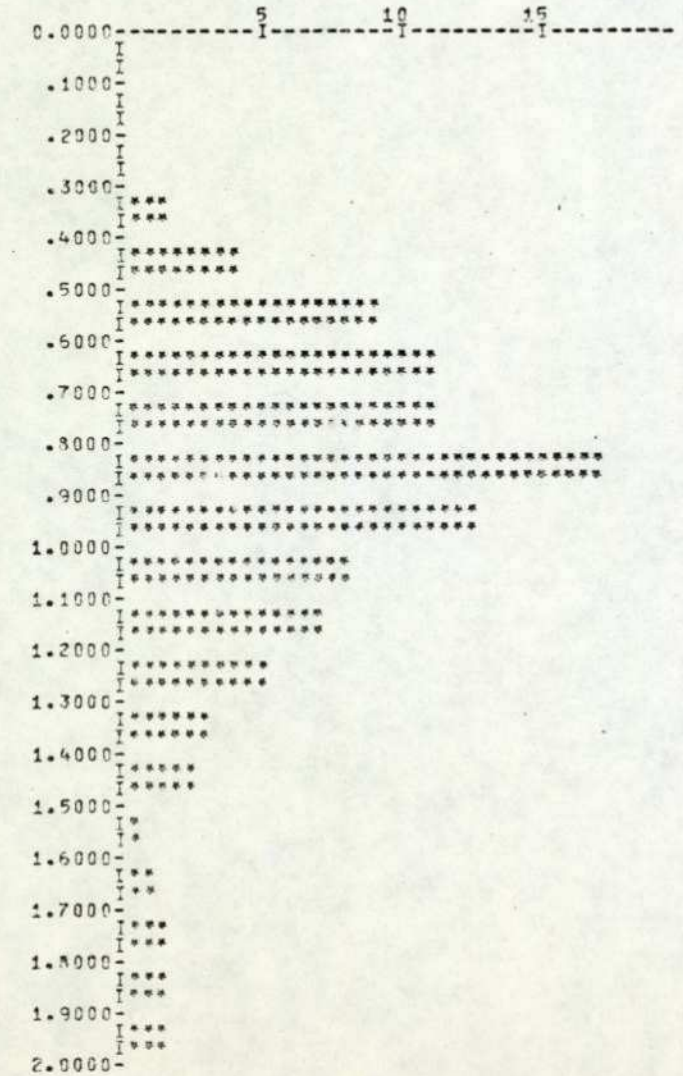


MEAN OF THE DISTRIBUTION= 5.5731
ST.DEV.OF THE DISTRIBUTION= 2.2796

DISTRIBUTION OF RATIO 2:TL/NCE FOR 296 FIRMS. YEAR: 1973

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

2.4958
2.0939
2.1569
2.3436
2.0113
2.4348



MEAN OF THE DISTRIBUTION= .9523
ST.DEV.OF THE DISTRIBUTION= .3809

STANDARDIZED DISTRIBUTION OF RATIO 2:TL/NCE FOR 296 FIRMS. YEAR: 1973

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

4.0526

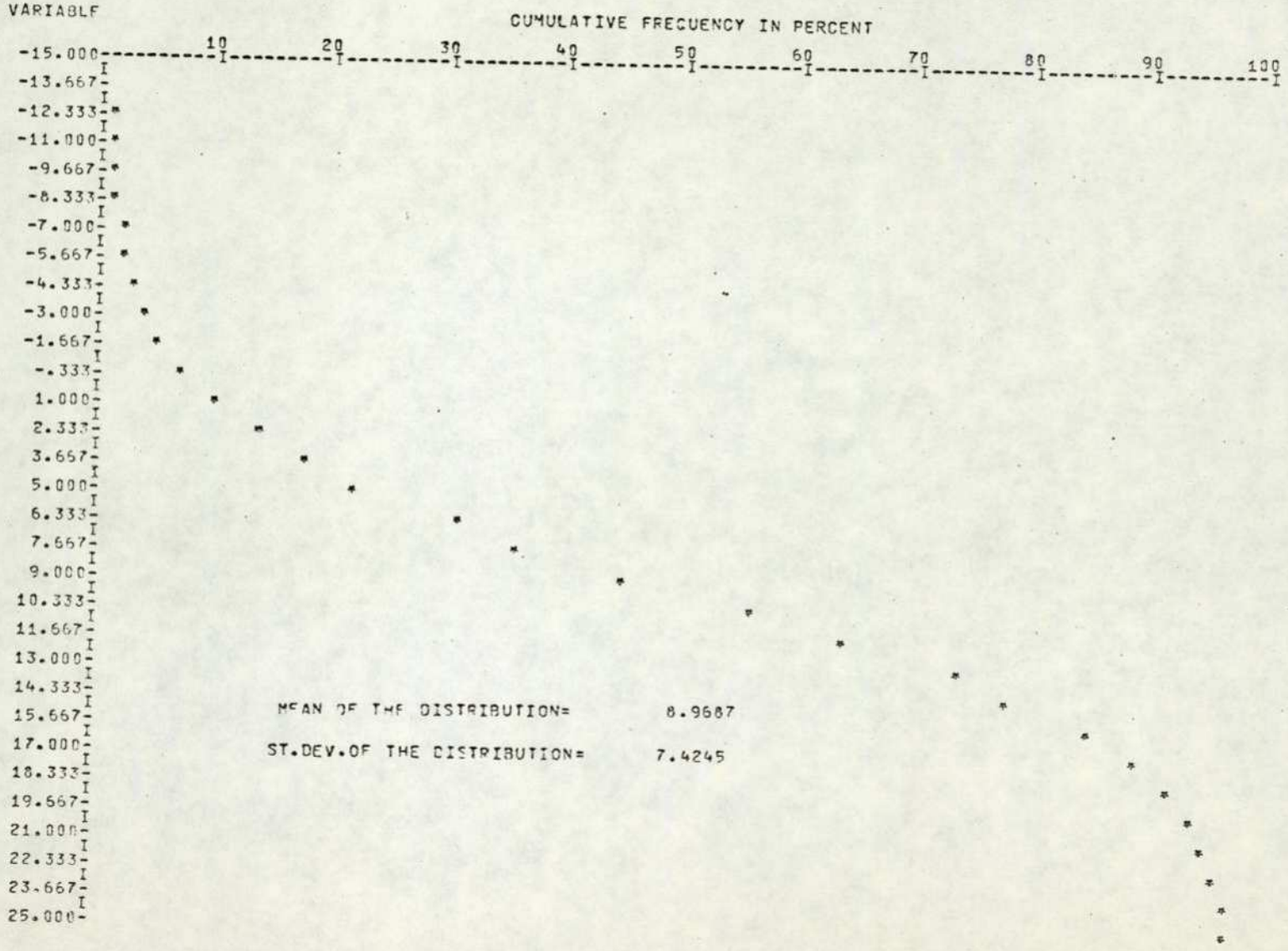


MEAN OF THE DISTRIBUTION= .0000
ST.DEV.OF THE DISTRIBUTION= 1.0000

DISTRIBUTION OF RATIO 6:Z-SCORE FOR 296 FIRMS. YEAR: 1973

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

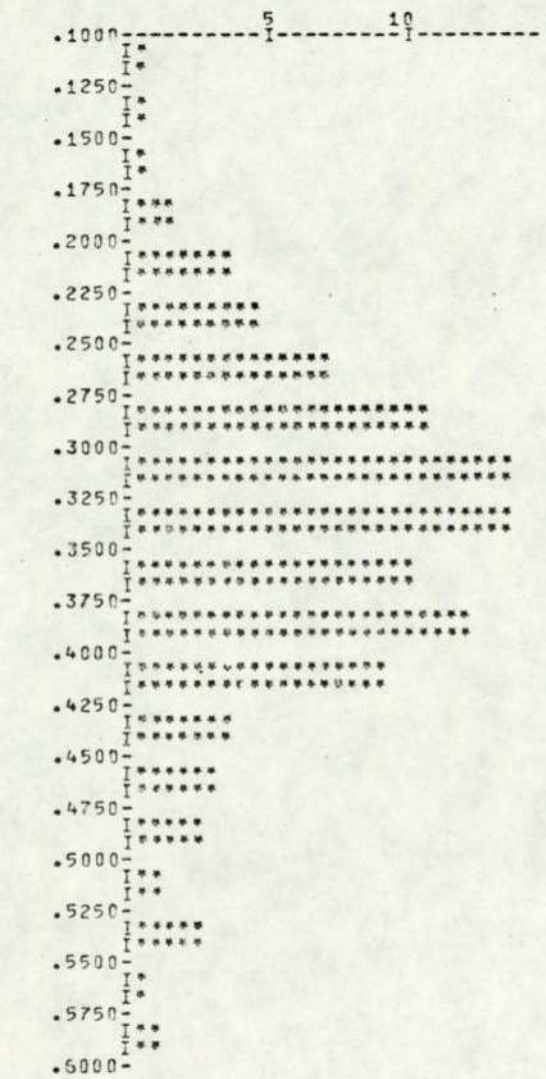
-25.99
-19.03
26.81
27.76
25.60
29.11
25.78
30.79
-19.06



MEAN OF THE DISTRIBUTION= 8.9687

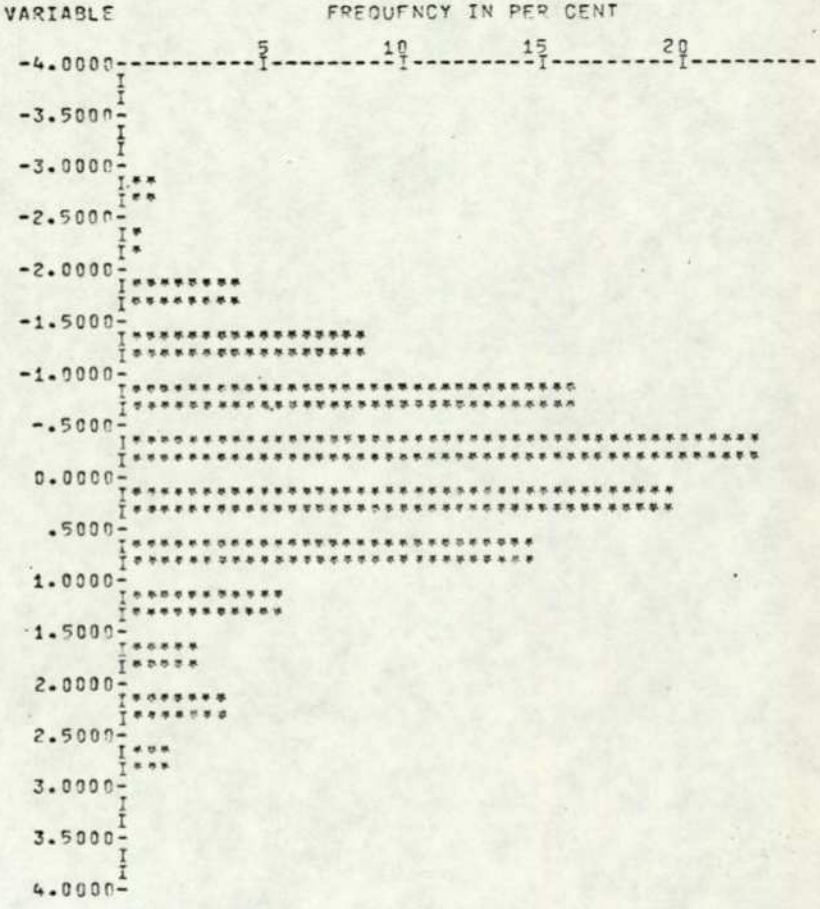
ST.DEV.OF THE DISTRIBUTION= 7.4245

DISTRIBUTION OF RATIO 3:QA/TA FOR 296 FIRMS. YEAR: 1973



MEAN OF THE DISTRIBUTION= .3455
ST.DEV.OF THE DISTRIBUTION= .0842

STANDARDIZED DISTRIBUTION OF RATIO 3:QA/TA FOR 296 FIRMS. YEAR: 1973

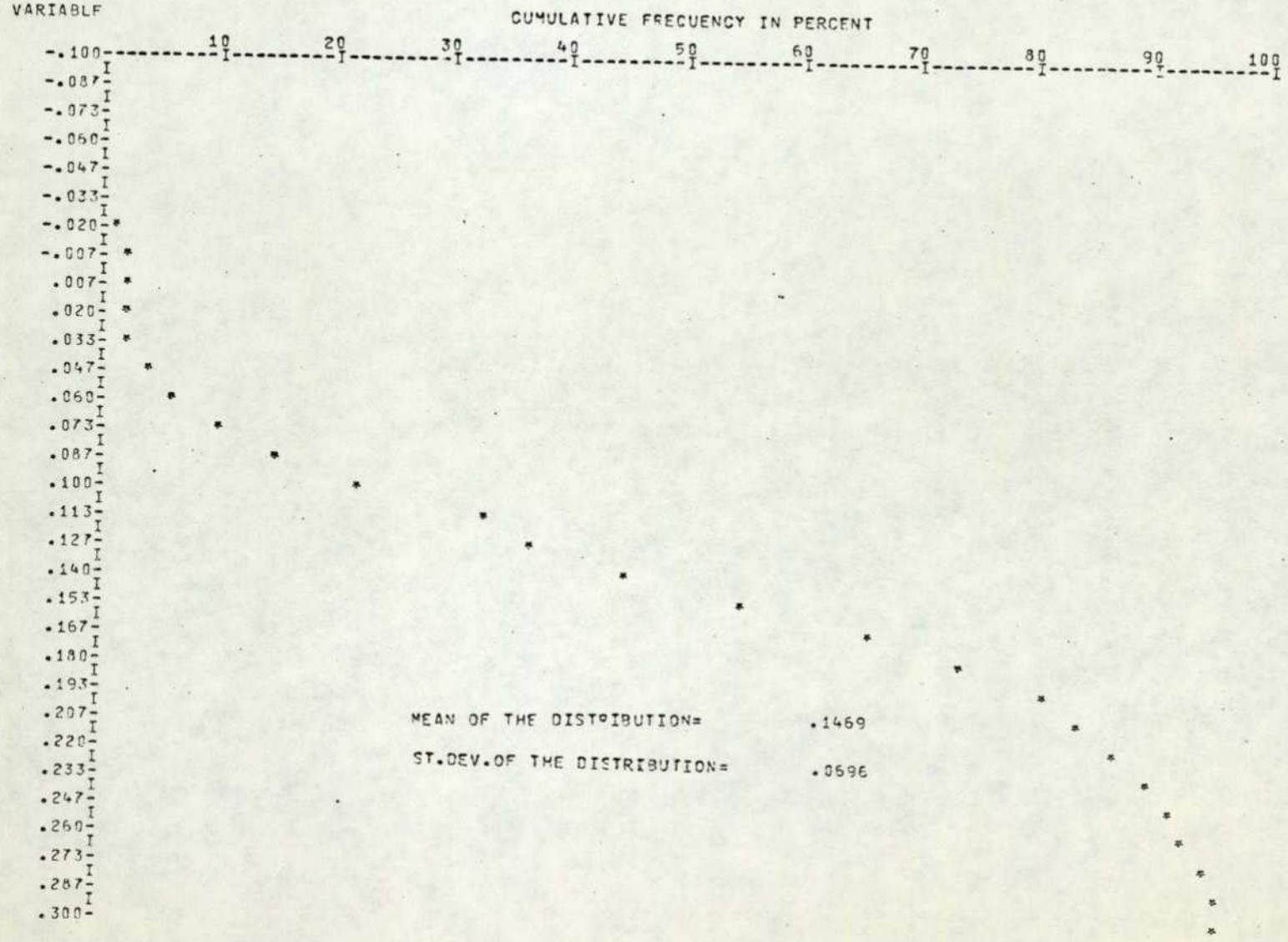


MEAN OF THE DISTRIBUTION= .0000
ST.DEV.OF THE DISTRIBUTION= 1.0000

DISTRIBUTION OF RATIO 1:EBIT/TAT-1 FOR 252 FIRMS. YEAR: 1974

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

.33
.34
.32
.33
.35
.35
.34
-.15
.32



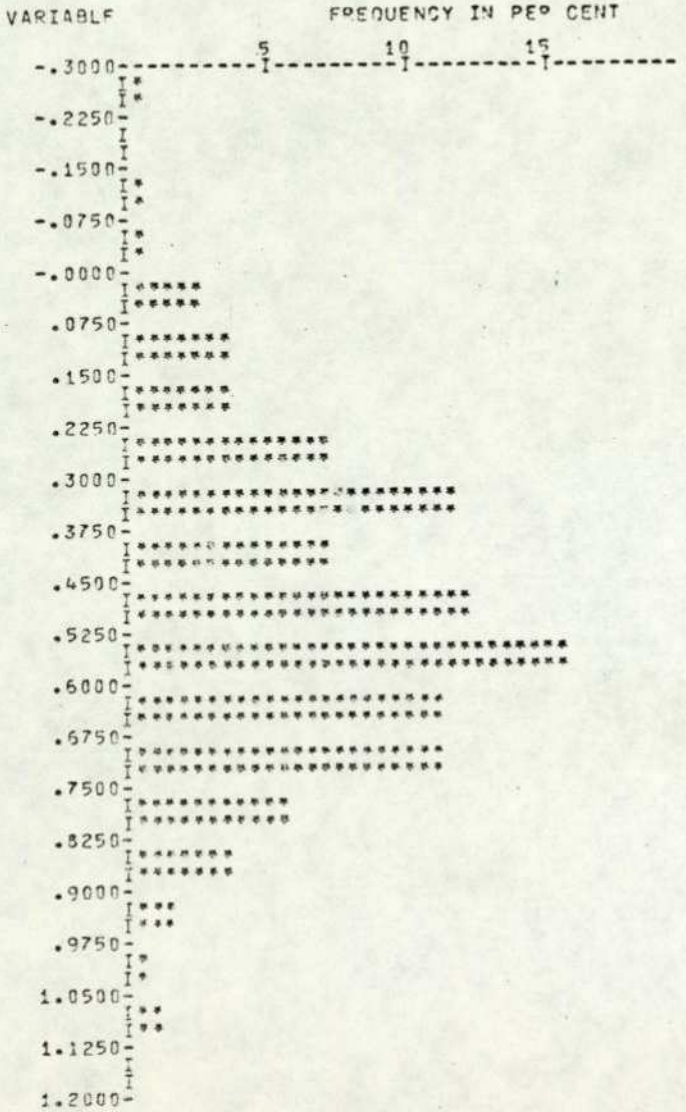
MEAN OF THE DISTRIBUTION= .1469

ST.DEV.OF THE DISTRIBUTION= .0696

DISTRIBUTION OF RATIO 4:WC/NW FOR 296 FIRMS. YEAR: 1973

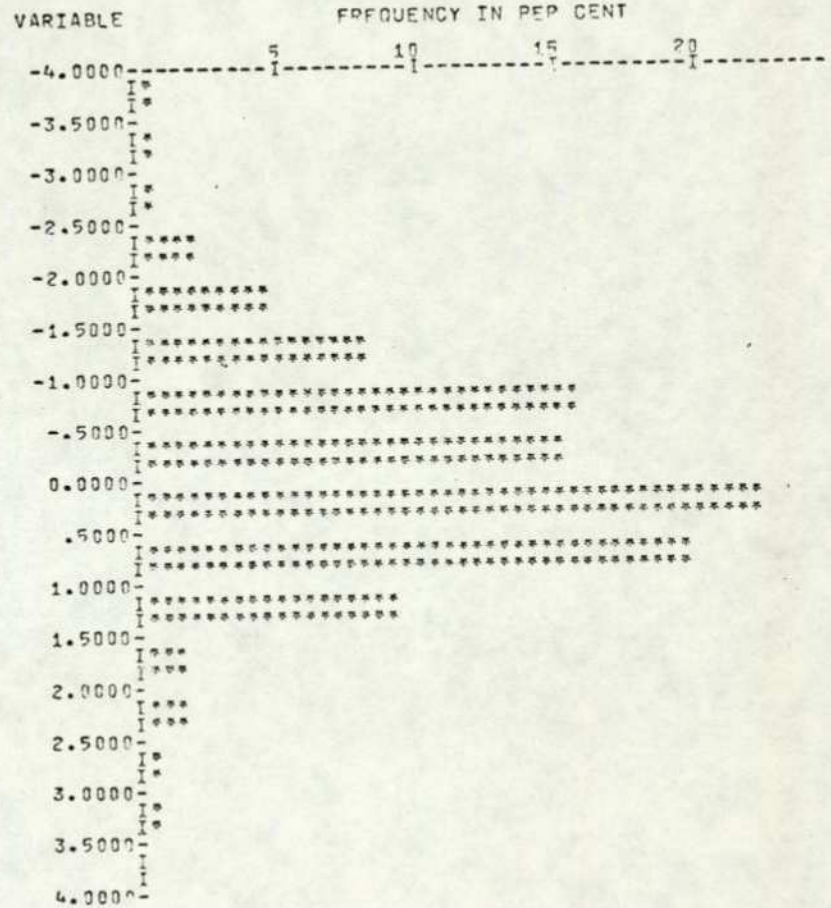
THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

-.3845
1.3248
1.2253



MEAN OF THE DISTRIBUTION= .5053
ST.DEV.OF THE DISTRIBUTION= .2404

STANDARDIZED DISTRIBUTION OF RATIO 4:WC/NW FOR 296 FIRMS. YEAR: 1973

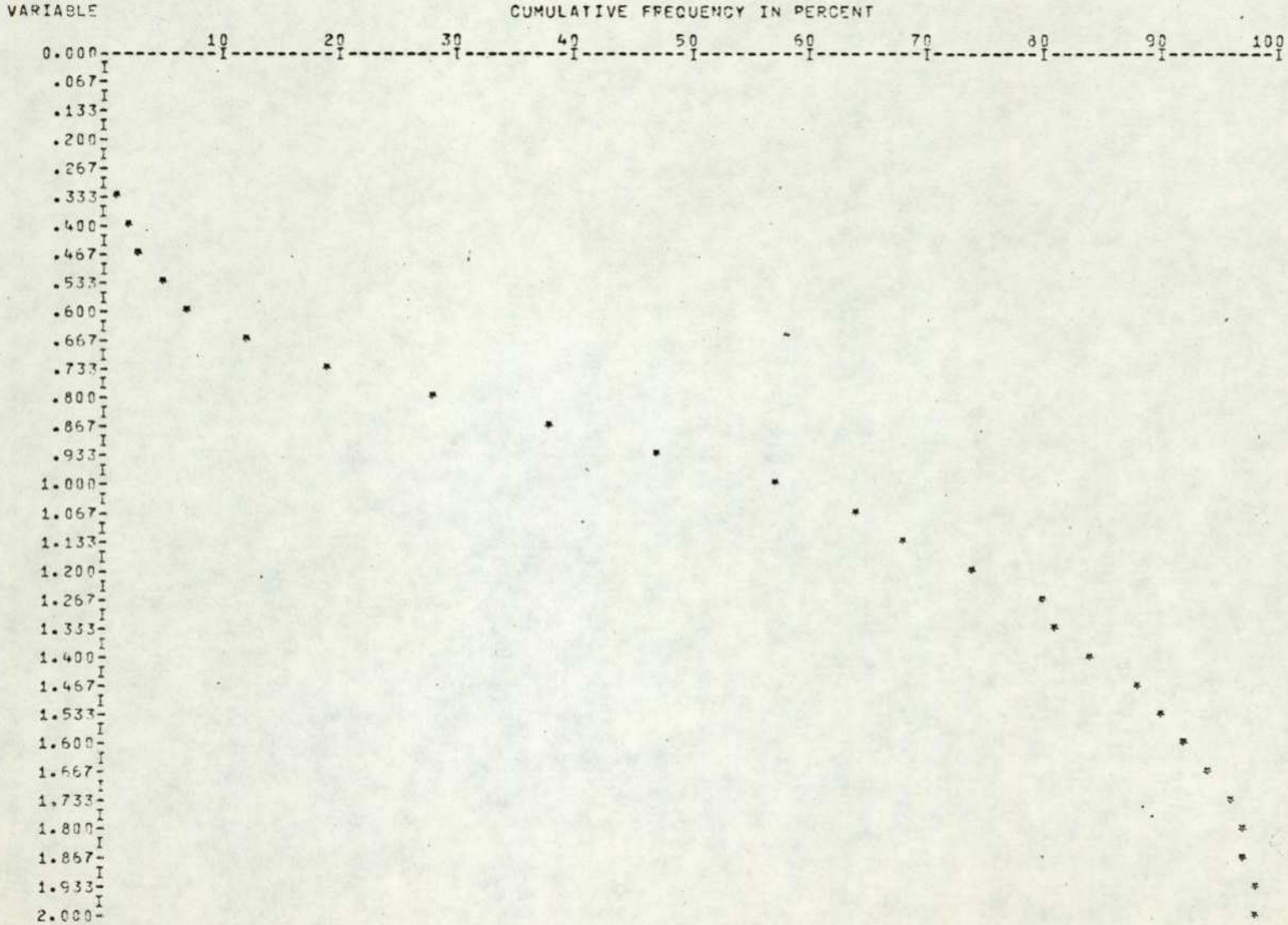


MEAN OF THE DISTRIBUTION= .0000
ST.DEV.OF THE DISTRIBUTION= 1.0000

DISTRIBUTION OF RATIO 2:TL/NCE FOR 252 FIRMS. YEAR: 1974

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

2.01
2.14
2.35
3.14
2.09



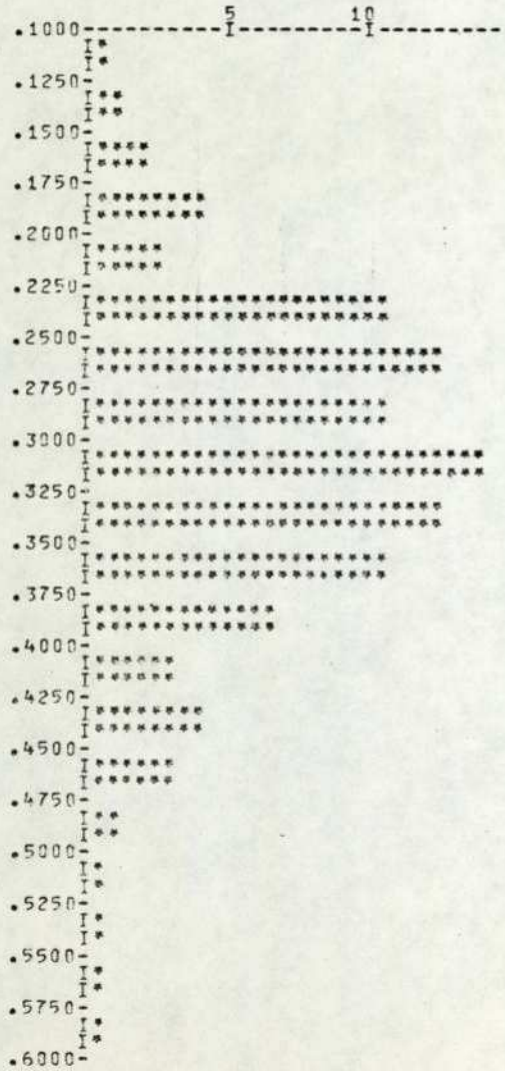
MEAN OF THE DISTRIBUTION= 1.0272
ST.DEV.OF THE DISTRIBUTION= .3792

DISTRIBUTION OF RATIO 3:QA/TA FOR 252 FIRMS. YEAR: 1974

THE FOLLOWING OBSERVATIONS ARE OUTSIDE THE SPECIFIED RANGE:

.6335

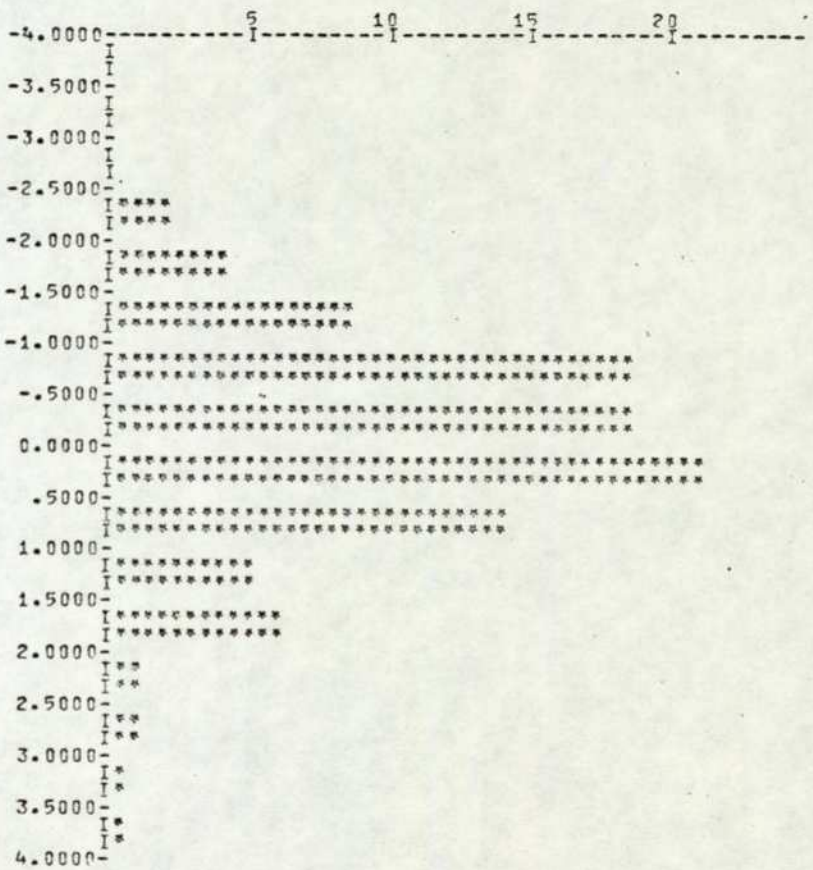
VARIABLE FREQUENCY IN PER CENT



MEAN OF THE DISTRIBUTION= .3161
ST.DEV.OF THE DISTRIBUTION= .0820

STANDARDIZED DISTRIBUTION OF RATIO 3:QA/TA FOR 252 FIRMS. YEAR: 1974

VARIABLE FREQUENCY IN PER CENT

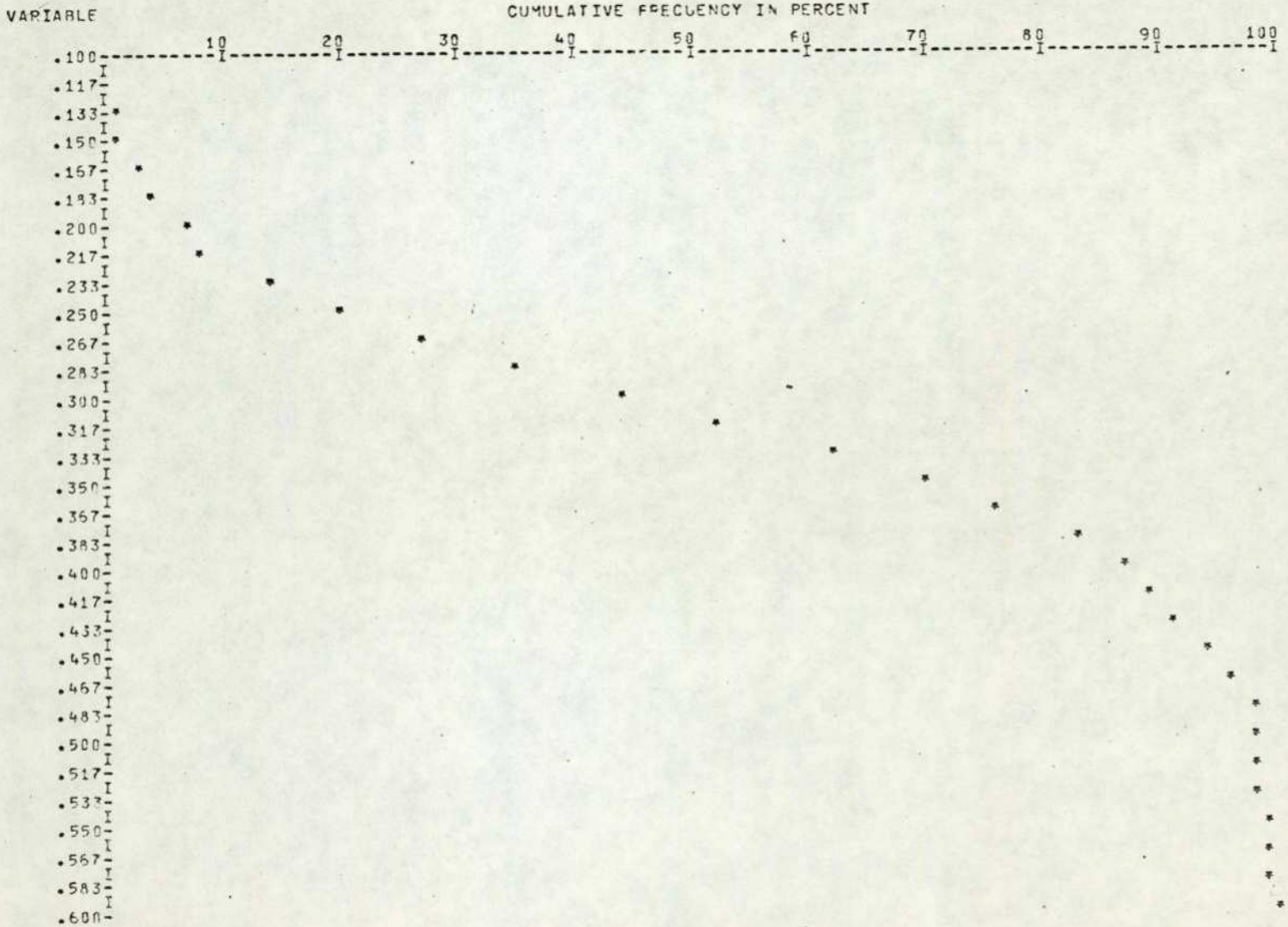


MEAN OF THE DISTRIBUTION= .0000
ST.DEV.OF THE DISTRIBUTION= 1.0000

DISTRIBUTION OF RATIO 3:QA/TA FOR 252 FIRMS. YEAR: 1974

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

.63

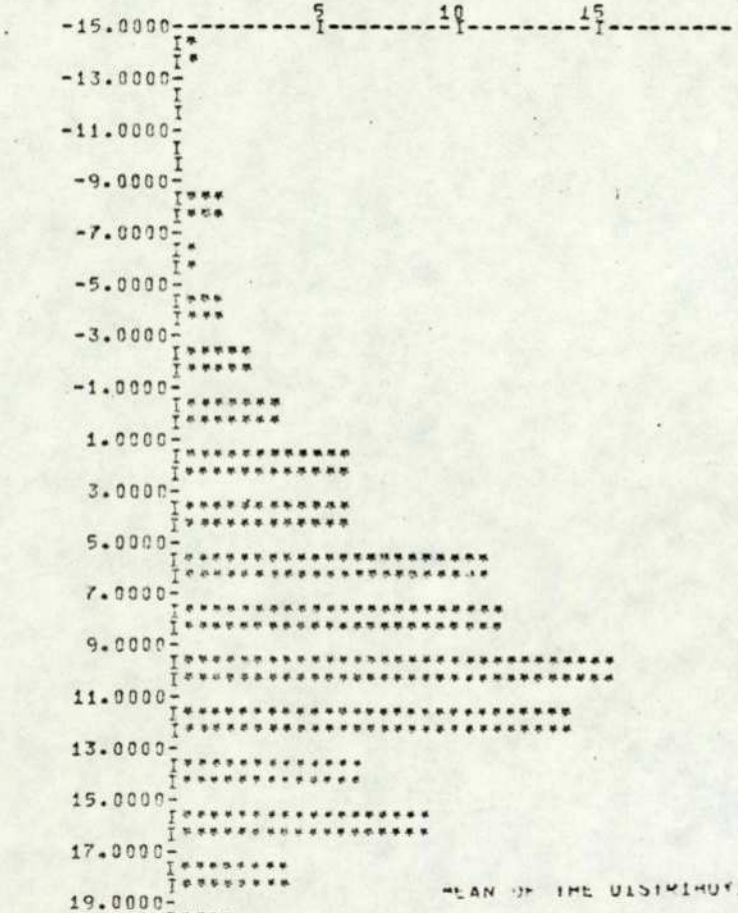


MEAN OF THE DISTRIBUTION= .3161
ST.DEV.OF THE DISTRIBUTION= .0820

DISTRIBUTION OF RATIO 6:Z-SCORE FOR 296 FIRMS. YEAR: 1973

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

-25.9940
-19.0340
26.8060
27.7500
25.6040
29.1070
25.7750
30.7860
-19.0580



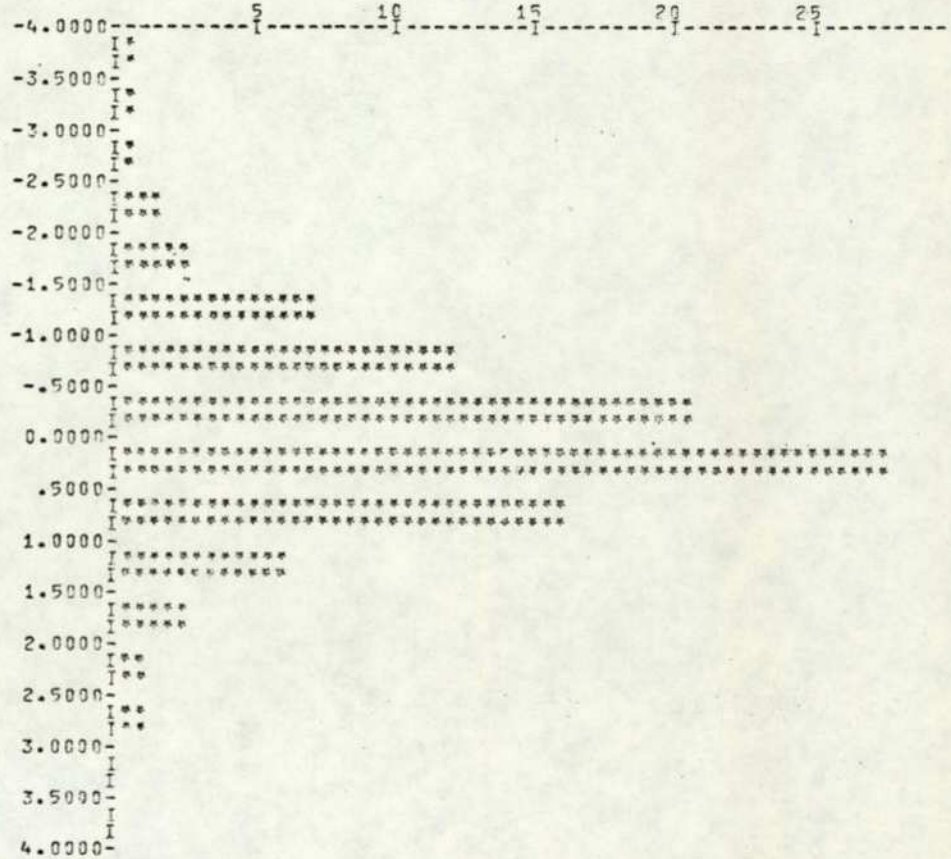
MEAN OF THE DISTRIBUTION= 6.9567

ST.DEV.OF THE DISTRIBUTION= 7.4245

STANDARDIZED DISTRIBUTION OF RATIO 6:Z-SCORE FOR 296 FIRMS. YEAR: 19

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

-4.7091

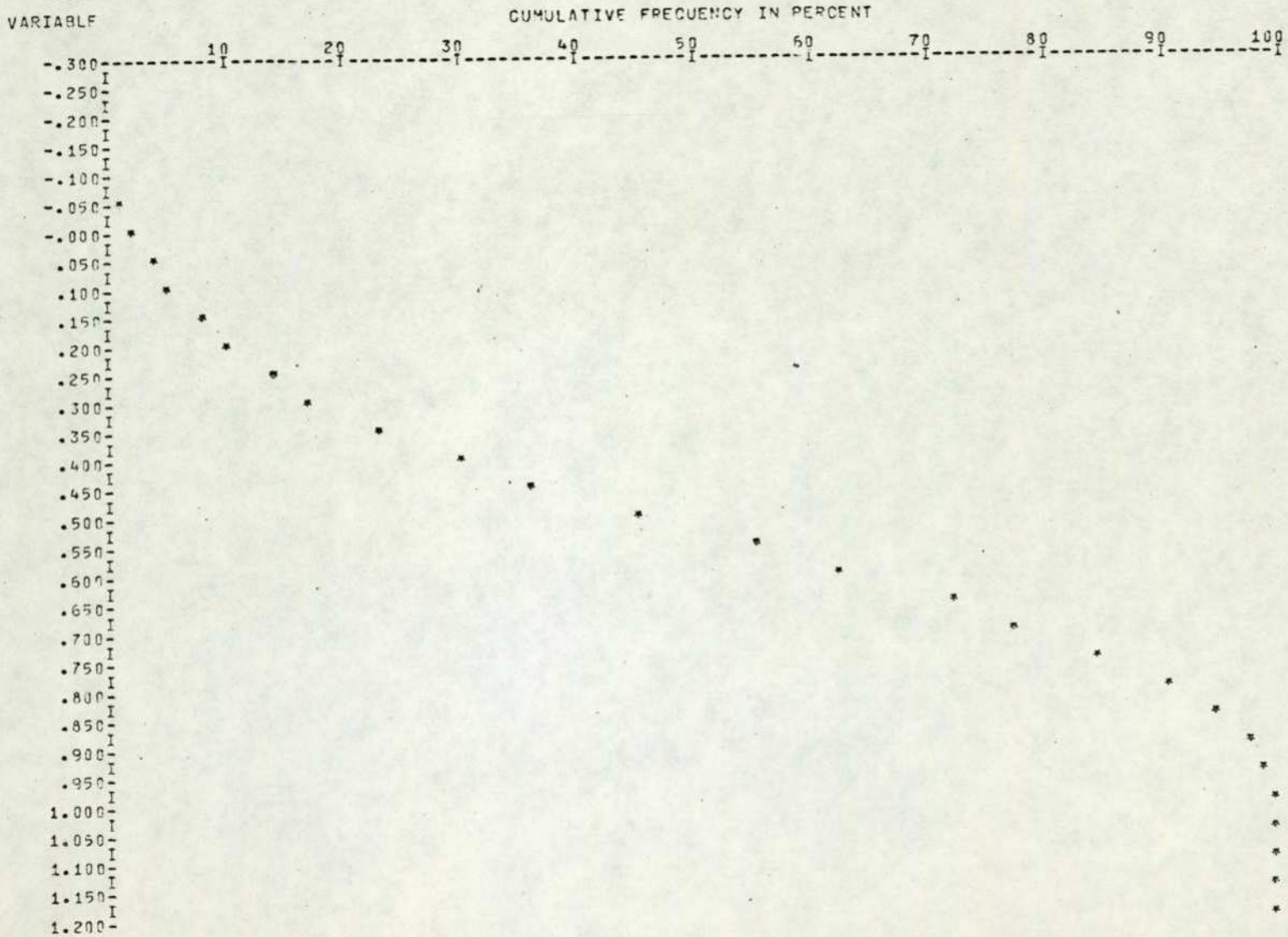


MEAN OF THE DISTRIBUTION= .0000
ST.DEV.OF THE DISTRIBUTION= 1.0000

DISTRIBUTION OF RATIO 41:WC/NW FOR 252 FIRMS. YEAR: 1974

THE FOLLOWING OBSERVATIONS ARE OUTSIDE THE SPECIFIED RANGE:

-.54
1.20

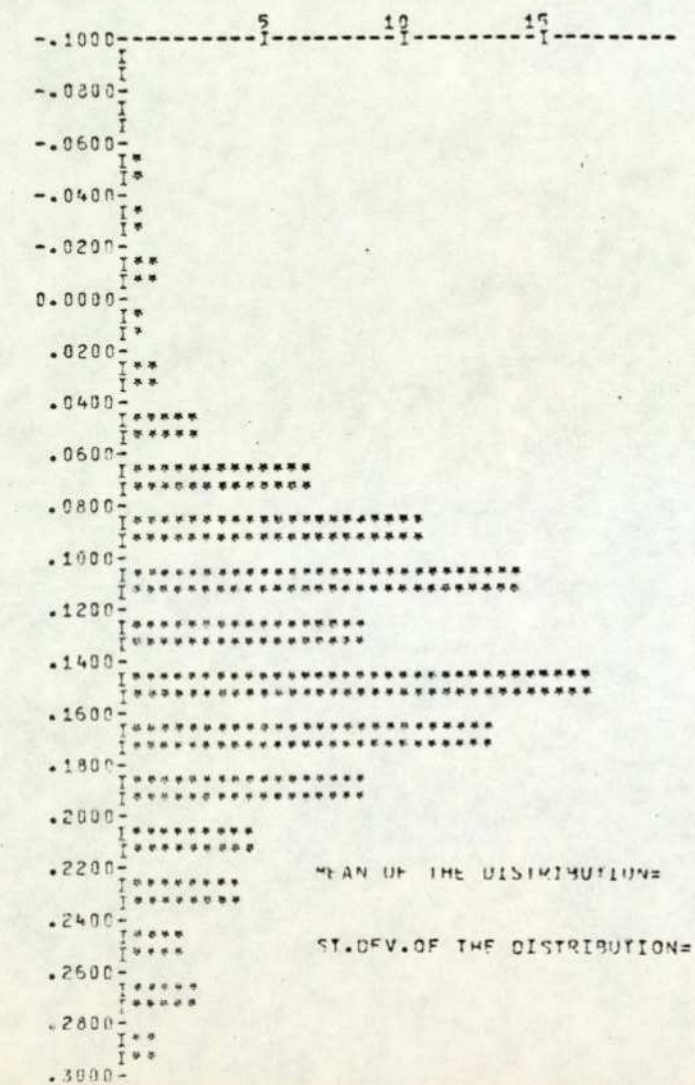


MEAN OF THE DISTRIBUTION= .5087
ST.DEV.OF THE DISTRIBUTION= .2407

DISTRIBUTION OF RATIO 1:EBIT/TAT-1 FOR 252 FIRMS. YEAR: 1974

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

.3265
.3440
.3243
.3287
.3539
.3510
.3449
-.1517
.3197



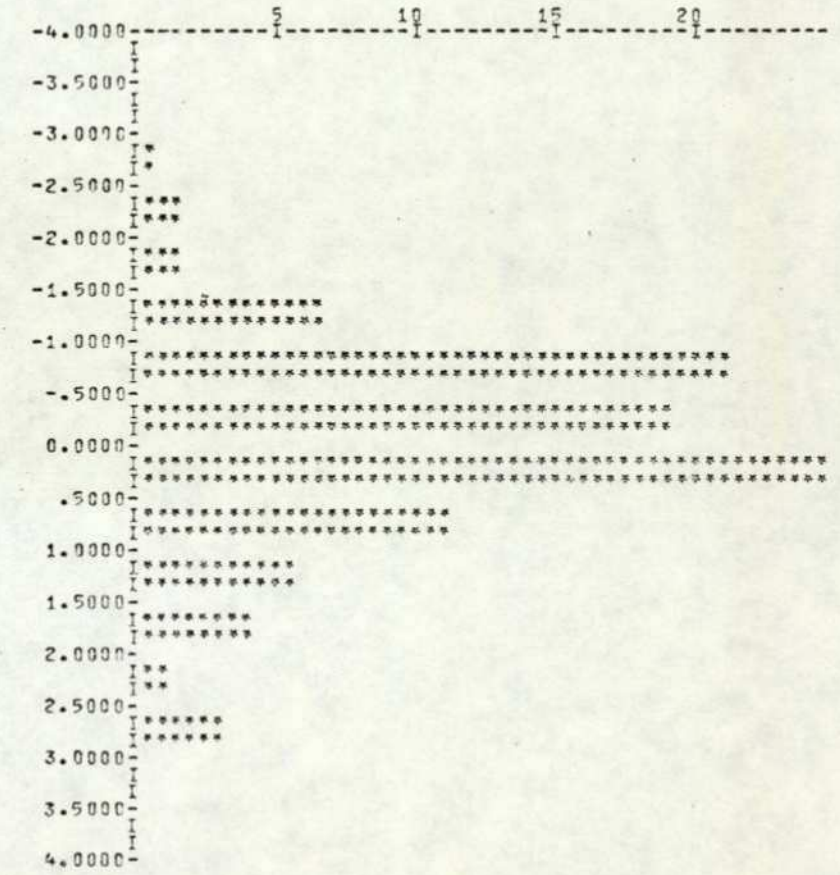
MEAN OF THE DISTRIBUTION= .1454

ST.DEV.OF THE DISTRIBUTION= .0695

STANDARDIZED DISTRIBUTION OF RATIO 1:EBIT/TAT-1 FOR 252 FIRMS. YEAR: 197

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

-4.2924



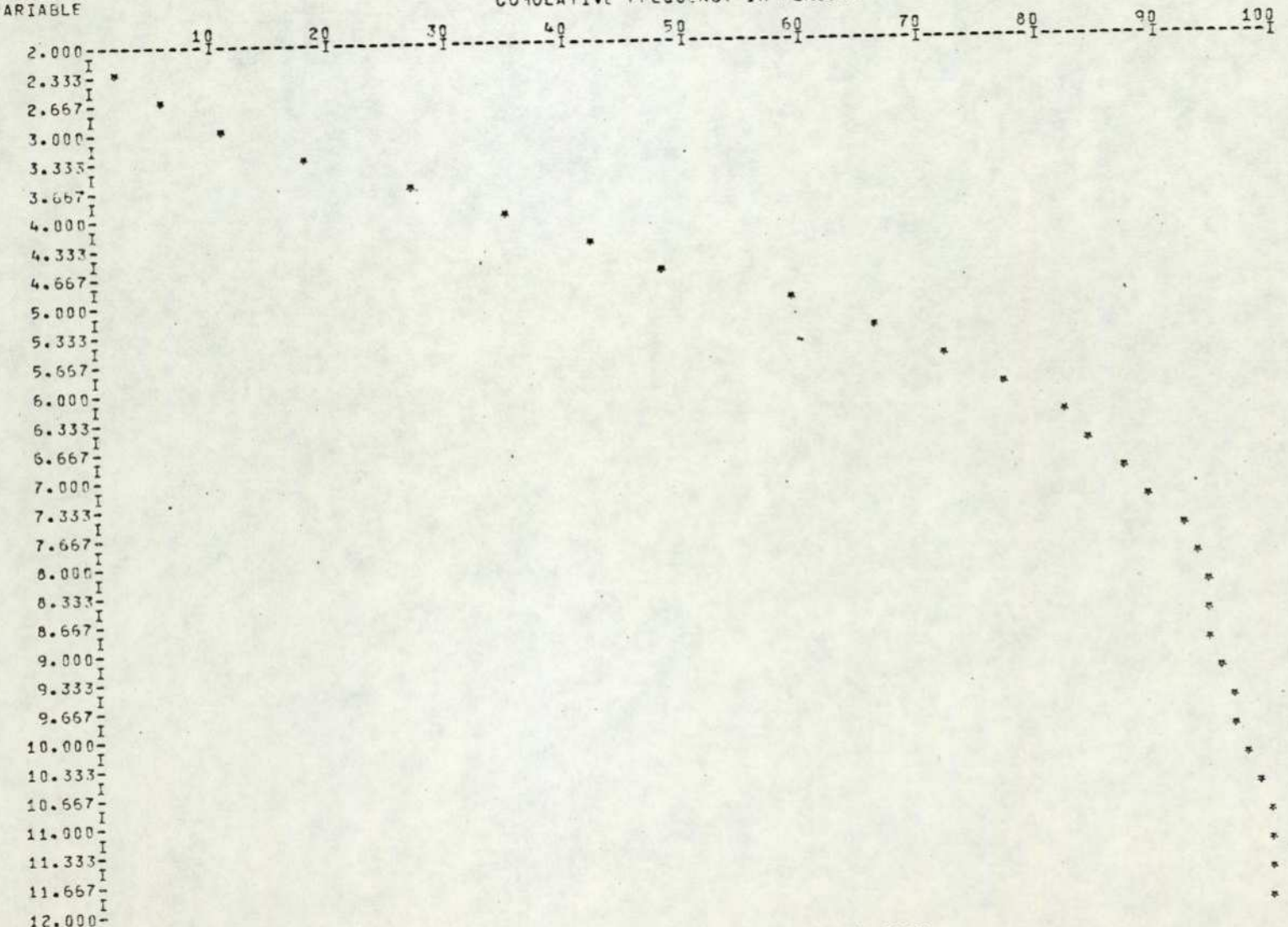
MEAN OF THE DISTRIBUTION= .0000

ST.DEV.OF THE DISTRIBUTION= 1.0000

DISTRIBUTION OF RATIO 5:STOCKTURN FOR 252 FIRMS. YEAR: 1974

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

14.23
1.77
12.13

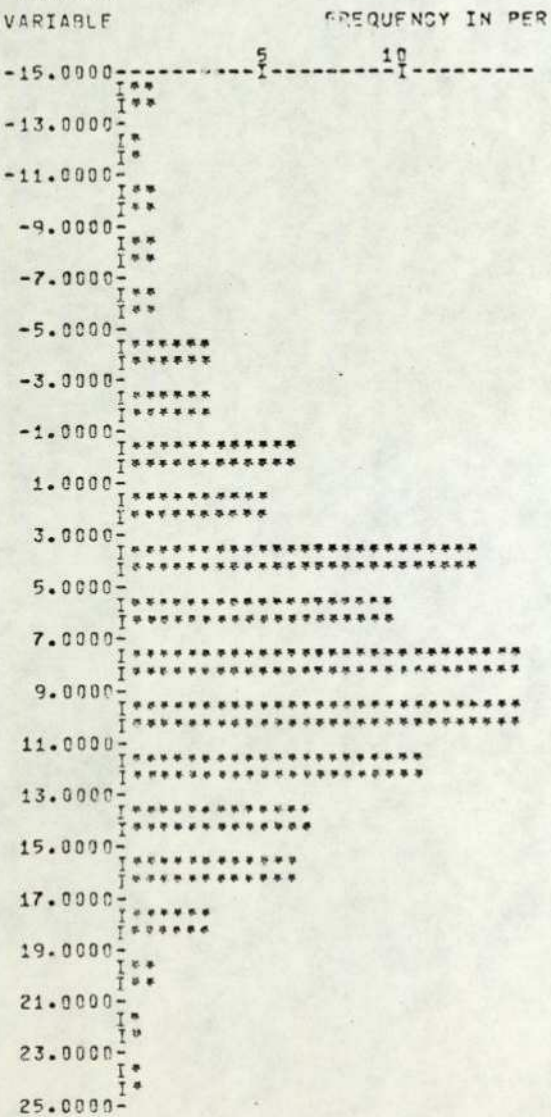


MEAN OF THE DISTRIBUTION= 4.9635
ST.DEV.OF THE DISTRIBUTION= 1.9423

DISTRIBUTION OF RATIO 6:Z-SCORE FOR 252 FIRMS. YEAR: 1974

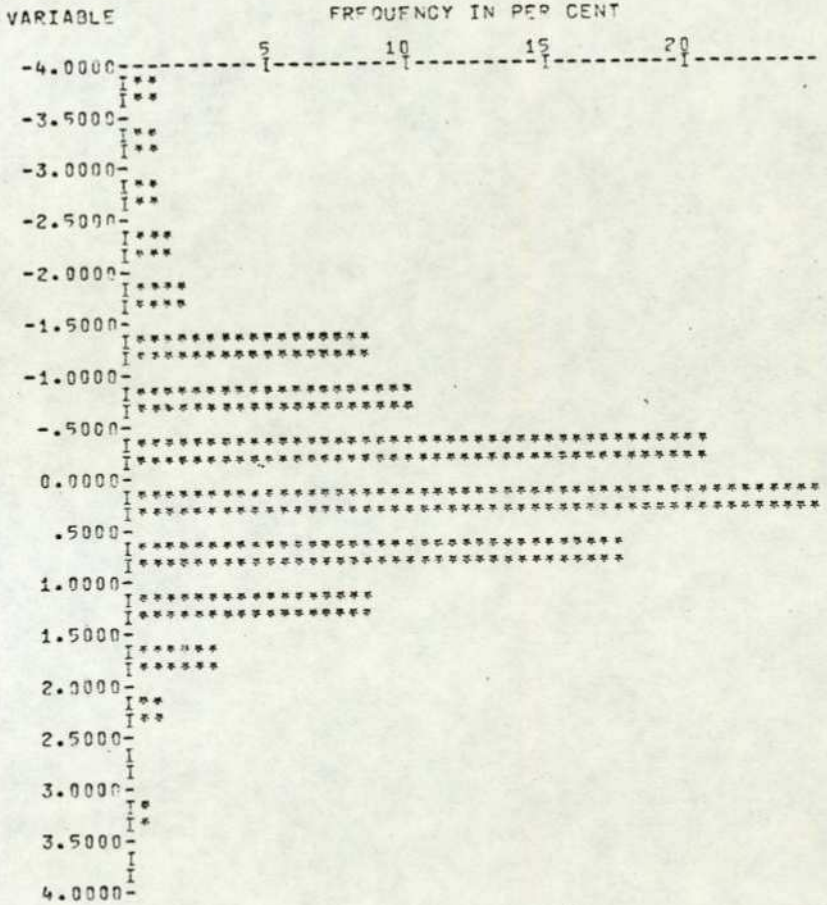
THE FOLLOWING OBSERVATIONS ARE OUTSIDE THE SPECIFIED RANGE:

28.8780
-20.8240
-20.5320
-16.7620



MEAN OF THE DISTRIBUTION= 7.1095
ST.DEV.OF THE DISTRIBUTION= 7.2012

STANDARDIZED DISTRIBUTION OF RATIO 6:Z-SCORE FOR 252 FIRMS. YEAR: 1974

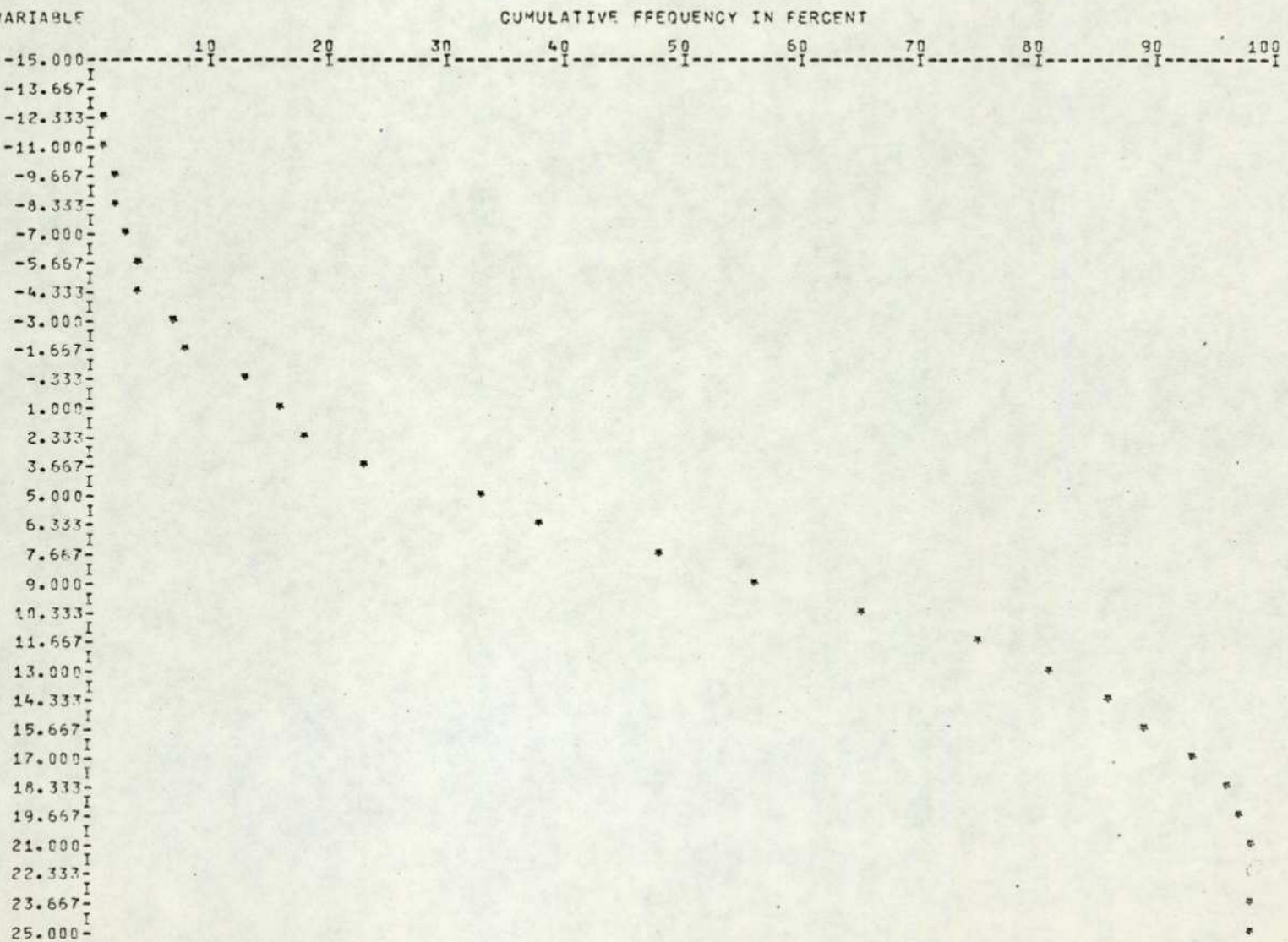


MEAN OF THE DISTRIBUTION= .0000
ST.DEV.OF THE DISTRIBUTION= 1.0000

DISTRIBUTION OF RATIO 6:Z-SCORE FOR 252 FIRMS. YEAR: 1974

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

28.88
-20.82
-20.53
-16.76



MEAN OF THE DISTRIBUTION= 7.1095
ST.DEV.OF THE DISTRIBUTION= 7.2012

Note: numbers in brackets denote Stock Exchange industry code and
* - derived separately.

1.	Associated Sprayers	(39)	31.8.75	- 4.527 *
			31.8.74	-10.230
			31.8.73	1.559
2.	Avon Rubber	(41)	27.9.75	- 9.563 *
			28.9.74	- 2.874
			28.9.73	4.023 } appendix
			28.9.72	2.788 } 6.9.3
			28.9.71	4.692 }
			28.9.70	4.154 }
3.	Bath & Portland Group	(73)	31.10.74	- 3.252
			31.10.73	0.172
	(Large construction interests)		31.10.72	1.678
			31.10.71	- 1.263
			31.10.70	- 4.932
			31.10.69	- 4.388
4.	Bear Brand	(59)	31.12.74	-31.752 *
			31.12.73	-25.994
			31.12.72	-16.967
			31.12.71	-29.412
5.	Beauford Group	(27)	31.12.74	- 2.425
			31.12.73	5.631
6.	British Printing Corporation	(53)	31.12.74	8.306
			31.12.73	11.078
			31.12.72	9.002
			31.12.71	4.491
			31.12.70	- 2.615
			31.12.69	5.273
	British Steel Constructions (Birmingham) Ltd	(27)	31.10.73	-19.034
7.	Brooke Tool Engineering (Hldgs)Ltd	(25)	30.9.75	-17.416 *
			30.9.74	-11.055 *
			30.9.73	- 5.649
8.	Brown (John) & Co.	(28)	31.3.75	- 7.840
			31.3.74	- 0.491
			31.3.73	- 1.189 } appendix
			31.3.72	- 2.734 } 6.9.3
			31.3.71	- 3.352 }
			31.3.70	1.078 }
9.	Caravans International	(43)	31.8.75	- 8.469 *
			31.8.74	- 7.971
			31.8.73	3.525
			31.8.72	2.689
10.	Cope Sportswear	(59)	31.12.74	-16.260 *
			31.12.73	-17.524
			31.12.72	- 1.933

11.	Dexion-Comino International (27)	31.10.73	- 0.695	
		31.10.72	1.728	
		31.10.71	- 3.355	
12.	Dimplex Industries (39)	31.3.75	-11.450	*
		31.3.74	- 3.47[illegible]	
13.	Fairfax Jersey Group (60)	30.6.75	-12.454	*
		30.6.74	- 5.829	
		30.6.73	6.250	
		30.6.72	13.376	
		30.6.71	12.800	
14.	Fairey Co. Ltd. (27)	31.3.75	- 5.105 [1]	
		31.3.74	.112 [1]	
		31.3.73	- .126 [1]	
		31.3.72	7.061	
		31.3.71	5.702	*
		31.3.70	5.467	
15.	Folkes (John) Hefo (27)	31.12.74	1.395	*
		31.12.73	- 7.202	
16.	General Engineering Co. (Ratcliffe) (27)	31.3.75	-18.439	*
		31.3.74	-14.536	
17.	Haden Carrier (30)	31.12.74	-11.382	*
		31.12.73	- 7.604	
18.	Hall (Mathew) & Co. (25)	31.12.74	- 3.593	
		31.12.73	- 1.496	
19.	Illingworth, Morris & Co. (61)	31.3.75	- 2.496	*
		31.3.74	- 3.026	
		31.3.73	- 7.386	
		31.3.72	- 5.290	
		31.3.71	1.202	
		31.3.70	- .396	
		31.3.69	- .528	
20.	Jevons Cooper (28)	30.4.75	-12.798	*
		30.4.74	-13.628	
		30.4.73	-13.282	
21.	National Carbonishing (72)	31.3.75	11.163	*
		31.3.74	- 4.146	
22.	Newall Machine Tool Co. (28)	31.3.75	- 3.919	*
		31.3.74	- 8.402	
		31.3.73	- 7.779	
23.	Newman Industries (19)	31.12.74	.603	*
		31.12.73	- 4.005	
24.	Reliant Motor Group (43)	28.2.75	-10.798	*
		28.2.74	-20.824	

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1. Learning costs are capitalized. If they are charged to the P/L account the z-scores become -7.049, -1.833 and -2.428 respectively.

25.	Rexmore Ltd (62)	31.3.75	- 9.765	*
		31.3.74	- 9.153	
26.	Reyrolle Parsons (19)	31.12.73	5.594	
		31.12.72	- 1.729	
		31.12.71	- 3.068	appendix
		31.12.70	5.004	6.9.3
		31.12.69	10.062	
27.	Scott (James) Engineering (19)	31.1.75	-20.775	*
		31.1.74	-20.532	
28.	Shaw (Francis) & Co. Ltd. (22)	31.12.74	- 8.607	*
		31.12.73	- 3.363	
29.	Smith Holdings (Whitworth) (58)	31.3.75	- .436	*
		31.3.74	- 4.124	
30.	Stewart Nairn (59)	31.3.75	.851	*
		31.3.74	-16.762	
31.	Strong and Fisher (Holdings) (59)	31.5.75	- 3.349	
		31.5.74	- .464	*
		31.5.73	- .536	*
		31.5.72	- .632	
		31.5.71	.468	appendix
		31.5.70	- 2.791	6. 9.3
		31.5.69	3.218	
32.	Trianco Group (27)	31.12.74	-17.825	*
		31.12.73	-14.001	
		31.12.72	2.474	
33.	Unochrome International (27)	30.6.74	3.070	
		30.6.73	- 4.972	
34.	U. U. Textiles (59)	1.5.75	-21.408	*
		1.5.74	- 6.035	
35.	Vosper (29)	31.10.74	-13.600	
		31.10.73	-19.058	
36.	Walker (C&W) Holdings (25)	31.1.75	- .776	*
		31.1.74	-11.069	
37.	Worth (Bond) Holdings (37)	30.6.75	-12.877	*
		30.6.74	- 5.166	*
		30.6.73	- 3.392	
38.	York Trailer Co. (43)	31.12.74	- 3.504	*
		31.12.73	- 4.608	

Appendix 7.6: The 126 Companies for which Data was Available for both 1973 and 1974

(Note: * denotes the 1973 data is taken from appendices 6.9.2 or 6.9.3)

Aaronson Bros
Acrow Engineers
Adwest Group
Albright & Wilson
Amalgamated Power Engineering
Armstrong Equipment
Associated Biscuits
Associated Engineering
Associated Portland Cement
Associated Sprayers
Aurora Gear and Engineering
Avana Group
* Avon Rubber
Bath & Portland Cement
Beauford Group
* Beecham Group
Bibby (J) & Sons
Bifurcated Engineering Ltd
Birmid Qualcast
Blackman & Conrad Ltd
Bowater Group
B.I.C.C.
British Oxygen
Brockhouse (J) & Co Ltd
Brocks Group
* Brooke Bond Liebig
Brotherhood (Peter)
Brown & Tawse Ltd
* Brown (John)
B.S.R.
B.T.R.
Burgess Products Co (Hldgs) Ltd
Bury & Masco (Hldgs) Ltd
Caravan International
Carpets International Ltd
Central Wagon
Clayton Dewandre Holdings Ltd
Coates Bros
Compair
Cope Allman International
Critall-Hope Engineering
Croda International
Dale Electric International
Dickinson Robinson Group
Dobson Park Industries
* Doncaster (Daniel)
* Dowty Group
Duport
* Eastwood (J.B.)
* Ever Ready
Evode Holdings
Fairey Co Ltd
Fairfax Jersey Group
Fisons
Fox's Biscuits
Francis (G.R.) Group Ltd
French (Thomas) & Sons
* G.E.C.
Glaxo
Glynwed Ltd
Gripperrods Holdings
Guest, Keen & Nettlefold
Hall (Matthew) & Co
Hawker Siddeley Group
Head Wrightson & Co
Hepworth Ceramic Holdings
Hickson & Welch (Holdings)
Hollis Brothers & E.S.A.

Appendix 7.6 continued

Homfray & Co
* Hopkinson Holdings
Howard Machinery
Illingworth, Morris & Co
Johnson & Firth Brown
Judge International
Laurence Scott
Lee (Arthur) & Sons Ltd
Lesney Products & Co
Lucas (Joseph) Inds.
McKechnie Brothers
Macpherson (Donald) Group
Martonair International
* M. K. Electric
Morgan Crucible Co
Muirhead
Neepsend
Negretti & Zambra
Newall Machine Tool Co
Osborn (Samuel) & Co
Ozalid Group Holdings
* Pegler-Hattersley
Plessey Telecommunications
Portals Holdings
Rank Organisation
Ranks Hovis McDougall
Ransome Hoffmann Pollard
R.C.F. Holdings
Redland Ltd
Rowntree Mackintosh
Royal Sovereign Pencil Co
* Scapa Group
* Scotcros
Scragg (Ernest) & Sons
Selincourt
Serck
* Smiths Industries
Spillers
Staflex International
Staverley Industries
* Tunnel Cement
Turner & Newall
Unicorn Industries
Unilever
United Biscuits Holdings
United Gas Industries
Unochrome International
Vantona Ltd
Vosper
Wagon Repairs Ltd
Ward & Goldstone
Ward (Thomas W.)
Wedgwood
Weir Group
Westinghouse Brake & Signal
Westland Aircraft
Whessoe
* Yorkshire Chemicals

Appendix 7.7: Z-Score Histograms and Ogives for the 126 Common 1973/4 Companies

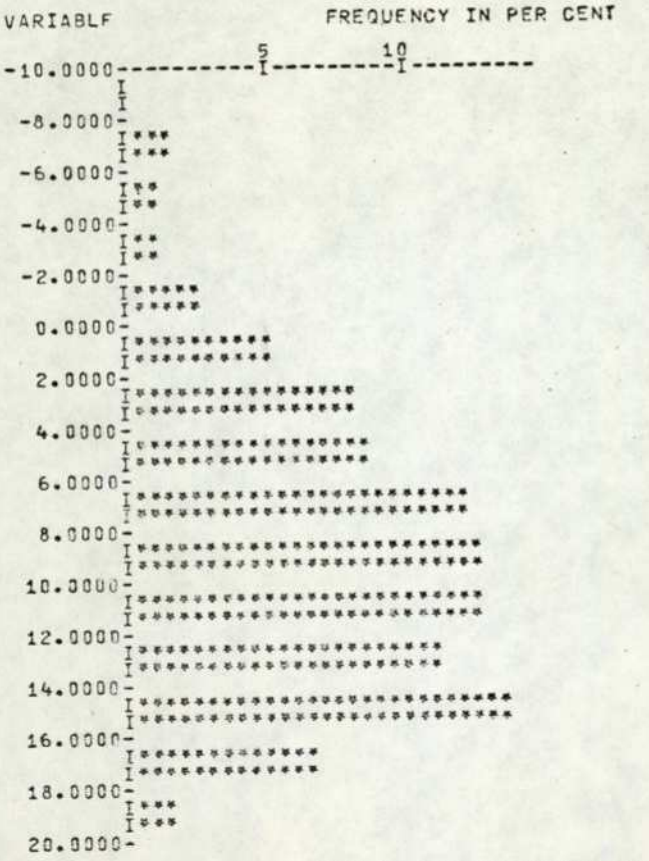
Appendix 7.7.1 : For 1973

Appendix 7.7.2 : For 1974

Z-SCORE HISTOGRAM FOR COMMON 1973+1974 COMPANIES.YEAR 1973

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

23.4430
27.7500
29.1070
-19.0580

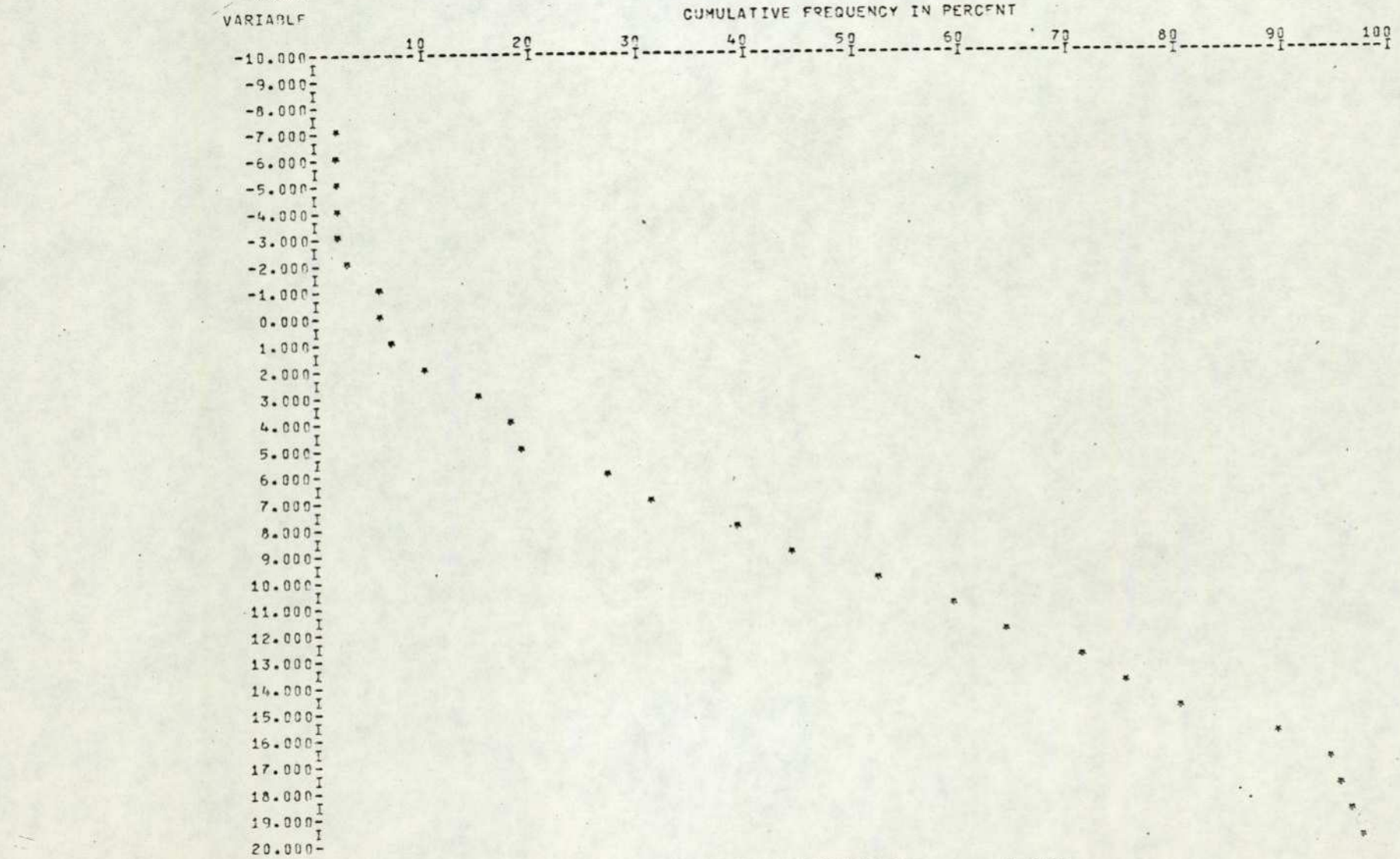


MEAN OF THE DISTRIBUTION= 9.2302
ST.DEV.OF THE DISTRIBUTION= 6.6442

Z-SCORE CUM.DISTN.FOR COMMON 1973+1974 COMPANIES.YEAR 1973

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

23.44
27.75
29.11
-19.06



MEAN OF THE DISTRIBUTION= 9.2302
ST.DEV.OF THE DISTRIBUTION= 6.6442

Z-SCORE HISTOGRAM FOR COMMON 1973+1974 COMPANIES.YEAR 1974

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

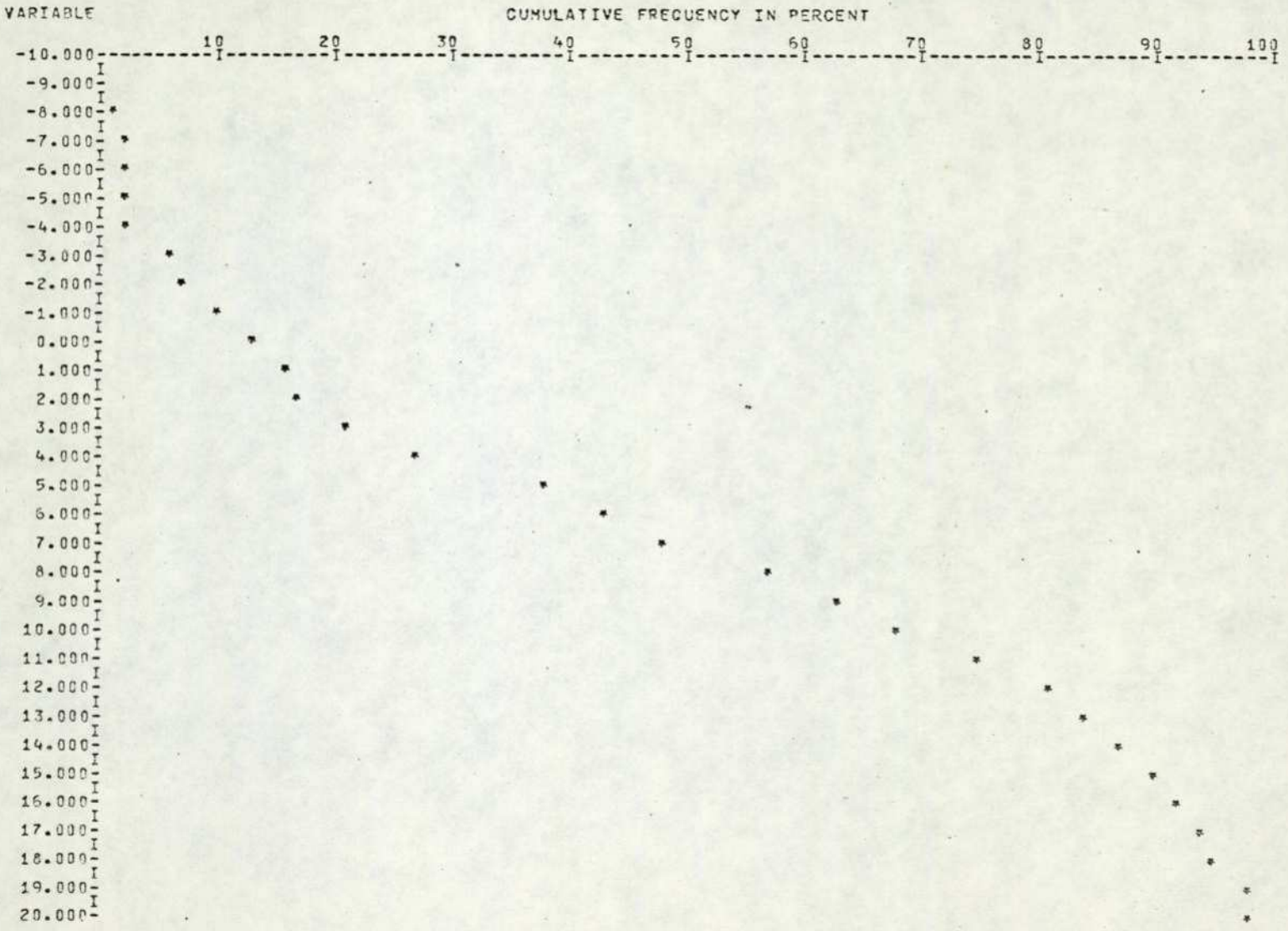
-10.2300
23.5880
20.0040

MEAN OF THE DISTRIBUTION= 6.9347
ST.DEV.OF THE DISTRIBUTION= 6.1619

Z-SCORE CUM.DISTN.FOR COMMON 1973+1974 COMPANIES.YEAR 1974

THE FOLLOWING OBSERVATIONS ARE
OUTSIDE THE SPECIFIED RANGE:

-10.23
23.59
20.00



MEAN OF THE DISTRIBUTION= 6.9347
ST.DEV.OF THE DISTRIBUTION= 6.1619

25.	Rexmore Ltd (62)	31.3.75	- 9.765	*
		31.3.74	- 9.153	
26.	Reyrolle Parsons (19)	31.12.73	5.594	
		31.12.72	- 1.729	
		31.12.71	- 3.068	appendix
		31.12.70	5.004	6.9.3
		31.12.69	10.062	
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		31.5.70	- 2.791	6.9.3
		31.5.69	3.218	
32.	Trianco Group (27)	31.12.74	-17.825	*
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		31.12.72	2.474	
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		30.6.73	- 3.392	
38.	York Trailer Co. (43)	31.12.74	- 3.504	*
		31.12.73	- 4.608	

Appendix 7.6: The 126 Companies for which Data was Available for both 1973 and 1974

(Note: * denotes the 1973 data is taken from appendices 6.9.2 or 6.9.3)

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Acrow Engineers
Adwest Group
Albright & Wilson
Amalgamated Power Engineering
Armstrong Equipment
Associated Biscuits
Associated Engineering
Associated Portland Cement
Associated Sprayers
Aurora Gear and Engineering
Avana Group
* Avon Rubber
Bath & Portland Cement
Beauford Group
* Beecham Group
Bibby (J) & Sons
Bifurcated Engineering Ltd
Birmid Qualcast
Blackman & Conrad Ltd
Bowater Group
B.I.C.C.
British Oxygen
Brockhouse (J) & Co Ltd
Brocks Group
* Brooke Bond Liebig
Brotherhood (Peter)
Brown & Tawse Ltd
* Brown (John)
B.S.R.
B.T.R.
Burgess Products Co (Hldgs) Ltd
Bury & Masco (Hldgs) Ltd
Caravan International
Carpets International Ltd
Central Wagon
Clayton Dewandre Holdings Ltd
Coates Bros
Compair
Cope Allman International
Critall-Hope Engineering
Croda International
Dale Electric International
Dickinson Robinson Group
Dobson Park Industries
* Doncaster (Daniel)
* Dowty Group
Duport
* Eastwood (J.B.)
* Ever Ready
Evode Holdings
Fairey Co Ltd
Fairfax Jersey Group
Fisons
Fox's Biscuits
Francis (G.R.) Group Ltd
French (Thomas) & Sons
* G.E.C.
Glaxo
Glynwed Ltd
Gripperrods Holdings
Guest, Keen & Nettlefold
Hall (Matthew) & Co
Hawker Siddeley Group
Head Wrightson & Co
Hepworth Ceramic Holdings
Hickson & Welch (Holdings)
Hollis Brothers & E.S.A.

Appendix 7.6 continued

Homfray & Co
* Hopkinson Holdings
Howard Machinery
Illingworth, Morris & Co
Johnson & Firth Brown
Judge International
Laurence Scott
Lee (Arthur) & Sons Ltd
Lesney Products & Co
Lucas (Joseph) Inds.
McKechnie Brothers
Macpherson (Donald) Group
Martonair International
* M. K. Electric
Morgan Crucible Co
Muirhead
Neepsend
Negretti & Zambra
Newall Machine Tool Co
Osborn (Samuel) & Co
Ozalid Group Holdings
* Pegler-Hattersley
Plessey Telecommunications
Portals Holdings
Rank Organisation
Ranks Hovis McDougall
Ransome Hoffmann Pollard
R.C.F. Holdings
Redland Ltd
Rowntree Mackintosh
Royal Sovereign Pencil Co
* Scapa Group
* Scotcros
Scragg (Ernest) & Sons
Selincourt
Serck
* Smiths Industries
Spillers
Staflex International
Staverley Industries
* Tunnel Cement
Turner & Newall
Unicorn Industries
Unilever
United Biscuits Holdings
United Gas Industries
Unochrome International
Vantona Ltd
Vosper
Wagon Repairs Ltd
Ward & Goldstone
Ward (Thomas W.)
Wedgwood
Weir Group
Westinghouse Brake & Signal
Westland Aircraft
Whessoe
* Yorkshire Chemicals

Appendix 7.7: Z-Score Histograms and Ogives for the 126 Common 1973/4 Companies

Appendix 7.7.1 : For 1973

Appendix 7.7.2 : For 1974

Appendix 8.1: Manufacturing Industries Selected Financial Data, Ratios and Z-Scores for 1969-1973.

(Source: DOI, Business Monitors M3.)

INDUSTRY	NOCS.	DATE	SALES	EBIT	CASH	DBTR	STCK	TASST	PPEF	LTL	ORDCP	TASS-1	STK-1	GR	EBIT/TA	TL/NCF	QA/TA	WC/NW	STKTURN	Z
DRINK	55	311270	2441	282	150	322	509	2681	68	679	1390	2482	454		.1136	.6240	.1761	.2531	5.0696	5.771
DRINK	46	311271	2249	279	129	286	494	2302	50	595	1703	2002	422		.1394	.6117	.1803	.3232	4.9105	7.615
DRINK	45	311272	2442	326	215	291	542	2523	50	642	1299	2253	484		.1447	.6306	.2006	.3454	4.7602	8.000
DRINK B	38	311272	2378	319	212	283	531	2465	48	627	1269	2201	474		.1449	.6308	.2009	.3470	4.7323	7.996
DRINK	38	311273	2703	367	207	358	621	2897	47	734	1505	2476	530		.1482	.6217	.1950	.3402	4.6968	8.065
ELEC.ENG.	63	311269	3061	284	103	939	877	3131	24	570	1402	2587	750		.1099	.8768	.3328	.5330	3.7628	6.184
ELEC.ENG.	61	311270	3391	294	125	1014	964	3363	25	588	1448	3030	853		.0970	.9406	.3387	.5268	3.7325	4.873
ELEC.ENG	57	311271	3661	319	198	969	952	3510	24	665	1600	3191	915		.0997	.8433	.3325	.5382	3.9197	6.287
ELEC.ENG	56	311272	3998	444	407	1027	963	3863	18	675	1814	3449	935		.1287	.8232	.3712	.5584	4.2129	9.020
ELEC.ENGB	40	311272	3236	365	381	848	798	3219	15	589	1555	2474	775		.1270	.7761	.3818	.6064	4.1144	9.925
ELEC.ENG	37	311273	3874	426	426	998	964	3718	15	641	1732	2974	736		.1432	.8369	.3830	.5970	4.5576	10.449
FOOD	41	311269	3964	224	101	528	610	2572	53	465	1208	2360	581		.0949	.8153	.2446	.2696	6.6566	5.737
FOOD	42	311270	4748	335	117	600	715	2988	55	503	1304	2556	616		.0931	.8766	.2483	.2583	7.1345	5.458
FOOD	38	311271	4804	234	170	598	717	3042	54	584	1358	2622	646		.0892	.8671	.2525	.2727	7.0492	5.473
FOOD	34	311272	5921	366	255	710	819	3529	56	678	1531	2714	640*		.1173	.9045	.2734	.2924	8.1165	8.070
FOOD B	30	311272	5108	320	242	592	674	3060	42	621	1347	2351	527*		.1183	.8704	.2725	.2995	8.5062	8.974
FOOD	30	311273	6496	387	284	784	974	3819	41	771	1469	3055	672		.1267	1.0491	.2797	.3066	7.8931	6.872
METAL	47	311269	1527	100	53	349	294	1098	15	213	504	939	239		.1065	.8295	.3661	.6069	5.7298	9.890
METAL	46	311270	1766	95	51	383	337	1238	14	257	523	1032	278		.0921	.9167	.3506	.5829	5.7431	7.776
METALMAN	43	311271	1676	92	66	336	329	1265	14	284	542	1183	322		.0778	.8757	.3178	.5252	5.1491	5.892
METALMAN	43	311272	1720	110	77	373	344	1403	14	309	569	1264	328		.0870	.9499	.3207	.4614	5.1190	4.986
METALMANB	38	311272	1660	107	66	359	331	1333	12	302	521	1201	315		.0891	.9866	.3188	.4615	5.1314	4.656
METAL MAN	35	311273	2133	178	66	474	429	1604	13	354	597	1239	309		.1437	1.0589	.3367	.5180	5.7805	7.921
N.ELEC.E.	159	311269	2468	203	106	754	575	2253	39	310	1021	1847	535		.1099	.9256	.3817	.5793	4.0760	7.160
N.ELEC.E.	159	311270	2702	196	83	814	772	2384	39	318	1031	2129	638		.0921	1.0045	.3763	.5907	3.8326	5.171
NON-ELEC	155	311271	2885	199	118	781	783	2424	39	334	1066	2353	760		.0846	.9700	.3709	.5955	3.7395	5.049
NON-ELEC	147	311272	3068	235	150	828	798	2597	39	372	1158	2298	739		.1023	.9405	.3766	.5923	3.9922	6.568
NON-ELECB	118	311272	2831	232	126	700	683	2207	32	315	1004	1953	632		.1188	.9121	.3747	.5994	4.0015	7.706
NON-ELEC.	115	311273	3157	275	172	875	910	2609	34	363	1177	2159	664		.1274	.9883	.3879	.5764	4.2836	7.604
PAPER	50	311273	2975	273	213	677	418	2458	37	569	955	1982	319		.1387	.9862	.3621	.3770	8.0733	10.276

NOTE:ALL UNITS ARE IN £M, ALSO TOTAL ASSET GROWTH >30 PC. IS DENOTED BY AN * IN THE ,GR, COLUMN

INDUSTRY	NCOS.	DATE	SALES	EBIT	CASH	DBTR	STCK	TASST	PREF	LTL	ORDCP	TASS-1	STK-1	GR	EBIT/TA	TL/NCF	QA/TA	NC/NW	STKTURN	Z
MAN.IND.	874	311270	31316	2306	1488	6754	6898	27438	390	5315	12222	24498	5998		.0941	.8677	.3004	.4154	4.8567	5.245
MAN.IND.	821	311271	32817	2543	1798	6491	7072	28288	368	5901	12709	25716	6548		.0989	.8371	.2930	.4346	4.8184	5.810
MAN.IND.	786	311272	36753	3223	2601	7276	7508	31384	357	6736	13826	27055	6764		.1191	.8539	.3147	.4627	5.1604	7.539
MAN.IND.B	624	311272	31884	2782	2331	6222	6600	27357	299	6063	12103	23583	5946		.1180	.8397	.3126	.4807	5.0827	7.684
MAN.IND.	605	311273	39850	3799	2939	7856	8406	33175	303	7179	14695	26540	6417		.1431	.8448	.3254	.5267	5.3768	9.738
BRICKS	72	311269	960	100	76	226	141	1051	10	216	516	914	119		.1094	.7309	.2873	.2357	7.3846	8.593
BRICKS	48	311270	1073	112	70	263	152	1131	9	237	535	984	131		.1138	.7720	.2944	.2316	7.5830	8.643
BRICKS	43	311271	1243	142	97	252	164	1196	8	257	569	1023	136		.1388	.7591	.2918	.2478	8.2067	10.845
BRICKS	43	311272	1428	179	110	292	181	1370	8	311	653	1191	165		.1503	.7438	.2934	.2678	8.2543	11.720
BRICKS B	35	311272	739	95	53	160	114	720	6	134	381	626	104		.1518	.6583	.2958	.3152	6.7796	11.555
BRICKS	33	311273	890	114	74	195	138	854	6	158	426	678	107		.1681	.7329	.3150	.3171	7.2653	12.363
CHEMICALS	57	311269	3226	373	257	808	606	3668	28	899	1696	3162	497		.1180	.7599	.2903	.3469	5.8495	7.952
CHEMICALS	56	311270	3263	344	229	922	684	4056	24	1015	1829	3496	580		.0984	.7831	.2838	.3362	5.1630	5.809
CHEMICALS	55	311271	3470	373	286	901	727	4328	24	1206	1876	3763	633		.0991	.7956	.2743	.3516	5.1029	5.609
CHEMICALS	49	311272	3800	447	331	1004	760	4617	23	1392	1939	3847	650		.1162	.8040	.2691	.4123	5.3901	7.390
CHEM.B	37	311272	3619	432	317	951	729	4435	22	1359	1844	3696	623		.1169	.8089	.2659	.4100	5.3521	7.253
CHEMICALS	36	311273	4525	565	502	1224	940	5293	22	1582	2147	4234	718		.1571	.8437	.3261	.5081	5.4584	10.362
CL+FOOT	45	311269	381	29	8	60	87	302	9	41	163	270	75		.1074	.6814	.2252	.3314	4.7037	5.876
CL+FOOT	45	311270	404	29	9	65	92	318	6	45	167	302	87		.0960	.7123	.2327	.3468	4.5140	5.029
CLOTHFOOT	40	311271	399	33	8	62	93	302	5	51	148	280	81		.1179	.7739	.2318	.3922	4.5862	5.819
CLOTHFOOT	39	311272	471	41	12	69	104	408	5	53	237	294	91	*	.1168	.5897	.1985	.2769	4.8308	6.607
CLTHFOOTB	25	311272	362	32	9	52	79	341	3	45	204	245	69	*	.1092	.5502	.1789	.2319	4.8919	6.063
CL+FOOT	24	311273	423	41	18	68	102	408	4	57	214	326	76		.1258	.7159	.2108	.2339	4.7528	5.379
CONSTRUCT	110	311269	1910	95	61	312	366	1086	15	112	387	970	308		.0971	1.4008	.3435	.3781	5.6677	.741
CONSTRUC.	104	311270	2169	95	59	355	430	1242	16	133	418	1043	353		.0911	1.4955	.3333	.3525	5.5402	-1.164
CONSTR	98	311271	2405	115	84	354	441	1347	15	144	471	1182	401		.0973	1.4244	.3252	.3025	5.7126	-.428
CONSTR	93	311272	2650	182	89	443	623	1721	15	198	603	1275	416	*	.1215	1.3958	.3091	.3803	5.0913	.743
CONST.B	65	311272	1763	113	47	319	372	1105	12	136	386	819	250	*	.1175	1.3774	.3312	.3894	5.6688	1.829
CONSTRUCT	61	311273	2205	161	66	385	533	1440	10	182	461	1205	350		.1336	1.5226	.3132	.3970	4.9943	-.001
DRINK	57	311269	2283	263	169	297	465	2560	72	668	1331	2226	391		.1181	.6148	.1820	.2637	5.3341	6.567

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INDUSTRY	NCOS.	DATE	SALES	EBIT	CASH	DBTR	STCK	TASST	PREF	LTL	ORDCP	TASS-1	STK-1	GR	EBIT/TA	TL/NCE	OA/TA	WC/NW	STKTURN	Z
TEXTILES	84	311269	1948	184	119	404	557	1805	27	391	797	1530	472		.1203	.8485	.2898	.5619	3.7862	6.564
TEXTILES	79	311270	2027	168	129	430	576	1912	25	429	828	1708	524		.0984	.8624	.2924	.5627	3.6855	5.303
TEXTILES	77	311271	2098	182	169	404	584	1937	24	436	876	1845	556		.0986	.8087	.2958	.5911	3.6307	6.204
TEXTILES	74	311272	2419	246	243	451	655	2157	23	482	971	1860	560		.1323	.8162	.3217	.6489	3.9819	8.953
TEXTILESB	62	311272	2131	214	206	390	581	1883	21	443	819	1623	497		.1319	.8431	.3155	.6619	3.9536	8.624
TEXTILES	59	311273	2607	319	297	464	706	2268	20	504	942	1786	552		.1785	.9170	.3355	.6705	4.1447	10.617
TIMBER	30	311269	246	13	4	61	54	166	6	18	64	146	46		.0890	1.2439	.3916	.5000	4.9697	3.037
TIM.FUR.	30	311270	267	14	5	66	53	177	6	19	65	165	54		.0848	1.3733	.4011	.4366	4.9907	1.550
TIMB.FUR	26	311271	267	19	4	61	50	169	6	18	66	160	48		.1107	1.2262	.3846	.4167	5.4490	4.437
TIMB.FUR	25	311272	336	39	7	78	56	213	6	22	90	162	48	*	.2080	1.0982	.3991	.4167	6.4615	11.477
TIM.FURN.	20	311273	307	34	7	67	58	219	5	20	90	171	35		.2281	1.1727	.3379	.3474	5.8835	9.393
VEHICLES	40	311269	2063	123	122	397	568	1609	25	224	594	1424	494		.0864	1.2408	.3226	.4782	3.8851	.504
VEHICLES	40	311270	2228	48	86	414	655	1717	25	192	583	1604	565		.0299	1.4632	.2912	.3503	3.6525	-6.503
VEHICLES	36	311271	2580	103	46	404	736	1747	25	240	595	1664	635		.0619	1.3796	.2576	.4419	3.7637	-3.710
VEHICLES	36	311272	2748	117	146	410	709	1844	26	274	660	1756	738		.0666	1.2677	.3015	.5175	3.7982	-.851
VEHICLESB	28	311272	2270	104	139	344	605	1562	18	240	563	1488	630		.0699	1.2441	.3092	.5663	3.6761	-.037
VEHICLES	28	311273	2683	148	193	403	694	1802	18	273	603	1567	604		.0944	1.3687	.3307	.5862	4.1341	.757

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Appendix 8.2: The Cluster Analysis Results

Appendix 8.2.1: Hierarchical Clustering Methods: Theory

(see Everitt, 1974 pp16/17)

Seven methods are available in the program GROUP (see ch.VIII pp298/9). The distance measures between groups used by these satisfy the following recurrence formula for the distance between a group k and a group (ij) formed by the fusion of groups i and j:

$$\alpha_i+\alpha_j+\beta = 1; \quad \alpha_i = \alpha_j; \quad \beta < 1; \quad \gamma = 0.$$

where d_{ij} is the distance between groups i and j and α_i, α_j, β and γ are parameters whose values for the seven methods are given below:

1 Nearest Neighbour: $\alpha_i = \alpha_j = \frac{1}{2}; \ \beta = 0; \ \gamma = -\frac{1}{2}$

2 Furthest Neighbour: $\alpha_i = \alpha_j = \frac{1}{2}; \ \beta = 0; \ \gamma = \frac{1}{2}$

3 Centroid: $\alpha_i = n_i/(n_i+n_j); \ \alpha_j = n_j/(n_i+n_j); \ \beta = -\alpha_i\alpha_j; \ \gamma = 0$

4 Median: $\alpha_i = \alpha_j = \frac{1}{2}; \ \beta = -\frac{1}{4}; \ \gamma = 0$

5 Group Average: $\alpha_i = n_i/(n_i+n_j); \ \alpha_j = n_j/(n_i+n_j); \ \beta = \gamma = 0$

6 Ward's Method: $\alpha_i = \dfrac{n_k+n_i}{n_k+n_i+n_j}; \ \alpha_j = \dfrac{n_k+n_j}{n_k+n_i+n_j};$

$$\beta = \frac{-n_k}{n_k+n_i+n_j}; \ \gamma = 0$$

7 Weighted Average: $\alpha_i = \alpha_j = 0.5; \ \beta = \gamma = 0$

Appendix 8.2.2: 13 Industry plus Aggregate Manufacturing Normalized Ratio Data and Euclidean Distance Matrix

(Source: Table 8.2 p295)

NORMALIZED DATA — RATIO

	1	2	3	4	5
1	-.13	-.54	.15	.59	-.11
2	.70	-1.01	-.04	-1.03	1.35
3	.33	-.55	.17	.45	-.05
4	-.71	-1.08	-1.98	-1.67	-.60
5	-.45	2.27	-.07	-.41	-.41
6	.04	-1.47	-2.27	-.85	-.65
7	-.13	-.58	1.23	1.14	-.75
8	-.68	.30	-.70	-1.11	1.84
9	-.06	.34	.36	.53	-.20
10	-.66	.05	1.32	.98	-.96
11	-.28	.04	.84	-.56	1.98
12	1.05	-.24	.34	1.78	-1.07
13	2.74	.83	.39	-.81	-.28
14	-1.76	1.63	.25	1.05	-1.08

EUCLIDEAN DISTANCE MATRIX

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0												
2	5.71	0											
3	5.24	4.53	0										
4	10.25	10.98	10.74	0									
5	10.53	9.45	16.49	0									
6	9.11	15.52	9.45	16.49	0								
7	9.84	9.63	8.98	1.47	19.25	0							
8	4.45	11.56	9.29	18.72	12.36	16.98	0						
9	8.57	8.29	8.49	9.81	9.84	12.35	16.50	0					
10	6.31	6.29	1.95	13.37	5.28	12.82	2.87	6.87	0				
11	14.15	14.15	3.77	19.25	9.10	19.08	.75	16.30	2.90	0			
12	3.44	13.43	6.32	17.22	11.53	18.98	10.89	2.89	4.72	11.40	0		
13	8.45	14.17	3.25	20.75	13.61	16.03	2.70	20.72	4.57	4.48	16.53	0	
14	12.31	8.90	9.43	22.65	13.10	20.52	15.75	15.66	9.84	17.73	12.87	12.15	0
	8.	23.28	10.52	21.01	4.80	22.96	8.56	16.99	6.45	4.84	16.99	11.80	26.18

Company	A/cs	Z-score	Reference (A denotes "Analysis" Section, R "Results")	Comments	Rating (see chapte
Cope Sportswear	31.12.74	-16.26	———		
Dimplex Industries	31.3.75	-11.45	18/7/75 p239 A	Comments: "Last year was disaterous for Dimplex" Share recommendation: Some measure of recovery should occur this year but until this is confirmed the shares are only for the brave.	E
Fairfax Jersey	30.6.74	- 5.83	22/11/74 p758 A	Share recommendation: The Shares are very speculative and the slim cover reduces the attraction of the yield	E
Fairey Co.	31.3.75	-5.11	29/8/75 p688 A	Heading: Fairey on Growth Tack Share recommendation: As further growth in profits this year, the shares are attractive.	B
General Engineering Co (Ratcliffe)	31.3.75	-14.54	19/9/75 p907 A	Share recommendation: There is a lot of potential in the group, but some evidence of better margins will probably be needed before the share rating improves.	C
Haden Carrier	31.12.74	-11.38	16/5/75 p632 A	Heading: Haden Carrier's Strong Points . Share recommendation: Some revision of the market rating has taken place since we suggested that should happen on April 25, the price having moved up from 75p to 90p. There should be further to go.	A
Mathew Hall & Co.	31.13.74	- 3.59	30/5/75 p821 A	Comments: "But prospects now look good ... the cash position is unusually strong". Share recommendation: Full benefit of the order book probably won't start coming through until next year, but the shares merit their strong recovery.	A
Illingworth, Morris	31.3.75	- 2.50	5/9/75 p756 A	Heading: Illingworth, Morris over the worst. Share recommendation: Profits are capable of rising very substantially when the group turns the corner, but on the short term the shares have little scope.	C
Jevons Cooper	30.4.75	-12.80	———		

Appendix 8.2.4: Industry Cluster Analysis Dendogram - Nearest Neighbour Method

Cluster(i)	Cluster(j)	Distance(d_{ij})
1	3	.242
7	10	.749
3	9	.940
4	6	1.471
9	10	1.647
10	12	2.704
8	11	2.889
2	11	3.434
11	12	4.530
5	14	4.797
12	14	4.843
13	14	8.903
6	14	8.905

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